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The **Journal of Biourbanism JBU** is a biannual peer-reviewed, interdisciplinary, international online journal. The journal takes an incisive look into the bios/life of urbanism through perspectives in architecture, planning, environmental studies, and other social sciences. The journal aims to critically review and define the notions of biourbanism. Assessing human-centered or need-based design sensibilities is a predominant concern, while attempting to address the disconnect between theory and practice in participating disciplines. The journal publishes cutting-edge research, methods, and innovative design approaches on biourbanism.

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Letter from the Editor

Kay Pallaris

The links between the environmental conditions and human health have long been known and reported. In the last few years, we have seen a resurgence of efforts to rekindle the disciplines of public health and planning. Our early preoccupation with ensuring a healthy population was concerned with ridding environments of the factors that allowed diseases to spread. While this is still important, we have come to better understand the complex interactions at play—especially the people-environment interactions in the urbanising world we are rapidly creating. Designing for human health has become a contemporary health focus for the built environment practitioners, albeit a challenging one.

"Safer-by-Design", "Active-by-Design," "Healthy-by-Design" and other manifestations of similar guides would have us think the answers are a given; and maybe they are. However, we have a long way to go before we can safely say that practitioners are actually implementing the learning in earnest. Worse still, our understanding of how the "designed environment" is impacting our physiological and mental wellbeing is still relatively in its infancy.

The field of Environmental Psychology is still relatively young, but has long been concerned with the interaction of people to their environment. More recently, the expanding studies of the senses (bringing together knowledge from various disciplines, including philosophy, anthropology, psychogeography) have presented a cultural inquiry into the sensory qualities of the material world and their social significance which have led us to speculate on how "Architecture of Senses" (Howes, 2005) can aid the creation of different place experiences.

We experience our surroundings through our senses; through what we see, hear; what we smell; how we experience temperature and balance in space. Understanding these sensory interactions offers an opportunity to design and arrange urban spaces and buildings in a manner that "fit the people who use them" (as Salingaros phrases it), much like the discipline of ergonomics did for creating healthier workplaces. The Flourish Model introduced by Clements-Croome (2018), begins to link design physical factors of buildings—such as temperature, lighting and ventilation controls and subjective factors like color, décor, aesthetics, natural views—as all playing an equal part in ensuring we create environments that are flourishing and provide buildings where people thrive for living or work. The model also considers the impact of these factors on feelings and value economics.

People's experiences of environments are mediated by physical mobility, state of mind, and cultural dispositions, bringing about perceptual conclusions that inform how we feel in those spaces and how we chose to use them. We know that the natural world has restorative qualities, but as we slowly redesign the natural world into an urban one, our connection to those natural design qualities of that world are progressively deteriorating. In Volume VI (1&2/2017), the *Journal of Biourbanism* took an in depth look at Biophilic Design. Biophilic Design, by its very nature is multisensory design.

Urban designers concerned with designing environments conducive to human health know that a place that is truly biophilic, or multisensory, is designed not only with access to nature in mind, but incorporate design qualities which exhibit analogues or geometric properties akin to nature, which our sensorial system favourably reacts to. Together nature and natural analogues create an environment that both excite and stimulate, as well as calm and heighten our attention, to create places, which help us meet our human potential.

More recently, E. Wilson's (1984) biophilic theory is being corroborated by empirical research, notably advances in neuroscience, which are now not just concerned with studying the brain for its own sake, but looking at these people-environment interactions using wearable technology. These studies are showing how we instantly become calmer and more attentive in natural landscapes. This provides an exciting research frontier, which potentially brings closer the medical sciences and the cultural aspects of sensory studies to help us better understand what exactly constitutes a "sense of place". We do not have to go too far into the future for this knowledge to know the true essence of this phrase; McHarg's (1969) "*genius loci*" somehow already captures the notion of how fundamentally important it is for us to consider the geographical/environmental context of a place when re-imagining it as an urban realm. When captured correctly, we create the "wholeness" that Christopher Alexander (1979) speaks of. In the contemporary discipline of urbanism this translates to the idea of creating liveable ambiances through the process of "place-making." The art and science of this over-used word is not just concerned with the visual physical environment, but that of the functionality, cultural, and the other scenescapes that come together.

A call for "sensorial urban futures" has been long postulated and so the call of this edition is not unique: cities are inevitably "*sensescapes—landscapes of sounds and sights, smells and textures, and the flavors of its characteristic foods. As we rethink urban design within a context of ecological sustainability, we need to look for urban models that can fruitfully sustain our sensory lives*" (Classen, 2013).

Multisensory design allows practitioners to, perhaps, think more holistically and broadly about the different dimensions of the designed "urban" environment, since biophilic design is (wrongly) often just associated with our access to the natural environment, whether visual or immersed within it.

The next question to grasp is "what is multisensory design?" While as practitioners we seem comfortable to accept an understanding of "good" and "high quality" design in policy and guidance, the use of "multisensory design" is less well recognised or understood. We need to go back to basics to understand what elements or qualities in our surroundings create a positive wellbeing response. "Good design" may lead to creative, unique places, but if we stick to this basic notion of design, we will not necessarily always get healthy environments. If we get the "multisensory design" elements right, then in theory, we can have environments that are creative, unique, and conducive to human health that nurture wellbeing. To some extent, there is a danger of over-interpreting the essence of the intention, in the same way we have come to widely and sometimes inappropriately interpret policy and guidance on "good," "high-quality" design. For example, cities are "multisensory", but they are mostly multisensory in the hedonic sense–creating embellished superficial environments that over stimulate and excite to the point of creating sensory overload. What we need is to design eudemonic sensory environments. If planning and health are to grow closer together again, the multisensory dimension must start to come to the fore.

The authors presenting papers in this edition are at the forefront of engaging in conversations about how knowledge on people-environment interactions is converted into a praxis that creates more human-centric, sensorial, and harmonious environments to ensure every living life can flourish. Whether we break down design elements into the fifteen properties of wholeness, or the fourteen

properties of biophilia, or the five plus properties of the senses, we need to do so with a greater knowledge of how these properties affect our basic biology.

We invited researchers and practitioners to showcase their research and how it can be embedded in professional practice if we are to deliver health-promoting, liveable environments. This small selection of papers highlights different dimensions in our knowledge about these people-environment interactions stressing the importance of such considerations in practice.

Sensory walks have become popular cultural props in participatory processes of place-making—revealing interesting stories about places. In Carolina Vasilikou's paper, we read an interesting account of participant sensory exploration of urban spaces. Such studies are becoming valuable phenomenological interpretations of the urban spaces we are developing, giving clues about how the designed elements come together to create different intensities and qualities of the visual, acoustic, olfactory, and haptic environments along the way.

Nikos Salingaros tells us that if design is to work for wellbeing, then it should follow the "rules" of our own biology and psychology systems. He invites us to stop thinking of building in the urban realm as isolated sculptural objects. No one questions the creativity of these forms, and potentially creativity equals good design, but it does not necessarily contribute to healthy design nor the collective of "healing environments." Salingaros provokes us to see the analogies between the complex biological system and why we are constructed in this way, and the designed city. He uses the analogy of the built environment as an "exoskeleton" for humans in the same way it is a protector for crustaceans and molluscs. Salingaros highlights how we are "intimately attached to the built exoskeleton", and so "what we build" should "perfectly fit our needs, both physiologically and psychological, our movements and daily functions". Salingaros demonstrates how, while we can and do adapt to our surroundings, we are likely to do so more favourably if the environment itself is already built to allow a functioning akin to our innate biology thereby ensuring a more welcoming fit between the city and its users. Salingaros goes further to define three sets of "design qualities" that elicit a positive sensory response, each with their sub elements. As with any rules however, interpretation is key to distinguish between a good "exoskeleton" and a device to manipulate people's senses and their experience of a place.

Natalie Bouchard's thought-provoking account on the need to integrate "smellscaping" as part of the urban design process brings to the fore the issue of how we design for mental health—which is very much still an abstract notion. The use of "aroma scapes" are still only thought of as temporary artistic installations, rather than an embedded design intervention. Bouchard presents a series of studies, which have linked olfactory dysfunction and mental disorders to smellscapes and suggests the possibility of using smells as mental health strategies in architecture and landscape urbanism. This paper is thought provoking and challenging at the same time. As planners and urban designers, we have long understood the restorative benefits of pleasant biophonic sounds in the natural environment. However, smells have always been associated with something negative. There is some evidence of this type of intervention, with the use of aroma fragrances to condition the air in offices to help people concentrate by feeling a sense of freshness to offset fatigue (Takenoya, 2006). However, the notion of pumping "aromas" invokes the need for a moral discussion. On the other hand, natural scents evoke a healthy walk through a pleasant place—the smell of fresh air, the sweet aromas of flowers, the earthy smells after a storm.

Rhianon Cocoran and colleagues' research begins to unpack evidence that tells us which type of residential images create positive or negative emotions and affect how long we chose to "dwell" or engage with images differing in subjective desirability. The paper importantly highlights that we need to further understand what these qualities of subjective desirability entail; particularly, we

need to understand the mechanisms through which urbanicity or green-ness might affect our wellbeing, instead of just accepting that increased greenery is good for us. While coming from different experimental and theoretical bases, both Salingaros and Cocoran's papers establish that there are certain physical characteristics in the urban environment that influence our emotional response. These qualities, such as disorganised chaos and clutter create negative emotional responses. Salingaros' design rules call for order in the geometric coherence of these physical spaces.

By understanding how we sense the environment, we begin to heighten our awareness of what makes "feel good spaces." If nothing else, studies such as these should call on all built environment practitioners to slow down next time they take a walk to or from the station for work and begin to interpret the environment through their senses. If we all just take the time to reconnect with our surroundings, and begin to hone into what we hear, see, smell, and feel, then maybe we will begin to reconnect our innate biology to how we therefore design places conducive to our wellbeing.

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Multi-Sensory Navigation in a Heritage City: Walking Atmospheres of Community Well-being in Canterbury

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ABSTRACT

Understanding and communicating the sensory experience of walking in the urban cityscape requires active participation and engagement. Through engaging diverse community groups in Canterbury, this paper re-defines the quality of the city's walking environment through the experience of the multi-sensory realm. The analysis is based on sensory narratives, collected from the Sensory Walks Project that took place in 2016 (funded by the Arts Humanities Research Council, UK). The project explores the dynamics of community engagement for the promotion of social well-being, with the input of mapping and visualisation of individual sensory narratives from over 50 Sensory Walks participants on their experience of everyday space. Further, the project sets the framework for a wider study on the sustainable exploration of the temporality of Canterbury sensescapes, using self-guided sensewalking and mapping. It will culminate in a series of sensory experiences and walking narratives for individual and community re-invention of the city centre.

***Keywords*:** sensory walks, mapping, sensory heritage, social well-being, heritage city

INTRODUCTION

"What are you doing out?"
"Walking," said Leonard Mead.
"Walking!"
"Just walking," he said simply, but his face felt cold.
"Walking, just walking, walking?"
"Yes, sir."
"Walking where? For what?"
"Walking for air. Walking to see."

Ray Bradbury, "The Pedestrian" (1951)

Sensory movement can be taken in a literal sense. Setting one foot in front of the other and walking is an indispensable function in the movement of atmospheres in the public realm of the senses; the displacement of a cultural, embodied, sensory experience from one urban space to another. The physical and atmospheric conditions of movement at the level of the street—the laid-out path; the urban frontage; the obstacles; the "otherness" of people; the signs; the shop fronts; the colours; the sounds; the smells; the temperature; the speed; the proximities—are all interconnected objects of analysis in the mapping of a heritage city. When sensory conditions related directly to urban walking are firmly grasped it becomes possible to fully understand the temporal and metaphorical movements of atmospheres in the public realm: between high street and secondary paths of movement; the sites of heritage and common dwellings; order and irregularity; remembered and experienced space. In an effort to define the role of mutlisensory navigation in the formation of atmospheres, almost all these intangible movements will be understood to involve physical, spatial and temporal displacement.

Walking as a series of conspicuous sensory movements is governed by the physical expression of expectations, sense of belonging and discovery. Here again it would be well to begin with the literal sense: the moment when urban sites come into sight, are then concealed by change of position, but also by the envelope of the everyday, the familiar, the commonly visited and re-visited that is disguised by subtle adjustments of light and form, sound and smell, temperature and colour. We could also investigate the cultural mechanisms through which architectural features, arrangements, and sites of heritage are rendered virtually and sensorially invisible; untouchable; inaudible; neutral.

Through a series of sensory walks (Vasilikou, 2016) and walking interviews (Evans & Jones, 2011), we aim to apprehend the sensory experience of local culture, the localness, and create an understanding of heritage through the definition of sensory assets. And the fact that these local cultures may in fact be recent formations in an old urban shell of a heritge city, constructed out of elements that an earlier generation struggles to recognise, makes very little difference. Engaging the community to walk in the city and capture its atmosphere in mental mapping exercises and walking interviews is used as an enabling condition in the interpretation of a heritage site as a conceptual model of urban space and collective interpretation of its multisensory realm.

CANTERBURY AND THE HERITAGE CITY: A BRIEF HISTORIOGRAPHY

The mention of Canterbury to a stranger is inevitably followed by the words Canterbury Cathedral and pilgrim routes. This small market city carries a load of expectation and disproportionate resonance in terms of its size and function in the East part of Kent. Dotted by a long history and literary praise from Medieval times, the city of pilgrims, like a living organism, has adapted to recurrent disasters – from the Roman period to the Second World War. Periods of prosperity created an array of historic landmarks, which were preserved relatively intact through the centuries.

Canterbury was recognised as world heritage site in 1998, with the inscription of three landmarks, the Canterbury Cathedral, St Augustine's Abbey and St Martin's Church. The Cathedral is located at the heart of the city, the two other monuments being in an ancient extra-mural suburb (Canterbury City Council, 2002). Canterbury retains a high quality historic environment in the city centre. Residents mingle with the 7 million visitors who visit each year, mostly for the day. Visitors are a substantial contributor to the local economy, attracted primarily by the heritage and cultural environment that the city offers. The heritage experience of Canterbury is confined to within the city walls, curtailed by a dual-carriageway ring road around three-quarters of the city, which presents a significant disincentive of exploring beyond. The Cathedral and St Augustine's Abbey are close together, for example, but separated by the ring road, so that visitor numbers to the latter are low (Green Balance, 2015). The ring road has eliminated though-traffic within the walls, where some pedestrianisation has enhanced the experience, but the road is itself host to either congestion or fast-moving traffic and to poor air quality.

Current policies based on the Canterbury Local Plan (Canterbury City Council, 2017) emphasize economic growth as a priority, but include an environmental theme which would "conserve and enhance our beautiful towns" and ensure that "plans and activities give sufficient protection to heritage sites and the built […] environment," promoting the city as "a […] cultural and heritage place to live, work, learn". Plans for future housing (up to 4,000 units) in the next years call for particular attention to the quality of public realm that is preserved and designed anew. In this policy context, the study of multisensory navigation takes a critical role in identifying the collective interpretation of the public realm and how high quality public space for pedestrians can become the driver of economic, social and environmental value (Woolley, Carmona, Freeman, Rose, 2004).

NAVIGATION AND SENSING THE PLACE: SENSORY WALKS

Designing urban spaces seems to be almost purely visually oriented (Cross, 1982; Franck & Lepori, 2007) for architects and planners. However, research related to the sensescape of outdoor urban spaces has shifted its focus from the visual quality of the designed environment, to studies concerning sound (Axelsson, 2011; Bruce & Davies, 2014), olfactory experience (Henshaw, 2013) and haptic perception (Herssens & Heyilighen, 2007; Lenzholzer, 2010; Vasilikou 2015). Urban space is a place for many senses: sight, sound, touch and the uncountable things that happen in between. The actual experience of urban spaces while navigating in the city is based on the overlapping of sensory experience for all moving bodies (Degen & Rose, 2012). This overlap in sensory perceptions has presented an array of methodological problems in its assessment and evaluation. There are many ways of investigating walking atmospheres and sensory assets and although this project experimented with many approaches, here it focuses on the sensory mappings of participants in the streets of Canterbury city centre.

The starting point for the project of Canterbury sensory walks was a challenge and opportunity related to environmental quality of the built environment and community engagement. The first

sensory walk was commissioned for the Canterbury Society, an amenities group and designed specifically for its members in November 2015. After the success of the pilot walk another commission by the Chartered Association of Building Engineers in January 2015 led to a grant proposal for a larger community engagement project. Funded by the Arts and Humanities Research Council (UK) a series of 12 two-hour sensory walks workshops, with over 50 participants were carried out in collaboration with the Canterbury Cathedral, as cultural partner.

I designed three different trails that engaged the participants with the landmarks of the historic core as a place of experiential observation, based on sensory perception of atmospheres (visual, acoustic, olfactory, thermal, and haptic). Participants of the sensory walks were invited to cross spatial thresholds and engage with different qualities of the public realm in the quest for "hunted" sensory observations (smells, sounds, visual cues, thermal sensations, etc). The sensory walk activities were based on a structured route followed by a group of 5–10 participants, based on an observation notebook that engaged the participant with focused observations about the walking trail they followed. Participants were asked to focus on the sensory interpretation of the urban space around them as they walked and to note down the intensity and quality of different visual, acoustic, olfactory and haptic sensory cues that were identified along the way. Following the walks, participants were provided with workshop space at the Beaney Museum were they created mental maps of the multisensory experience of the public realm of Canterbury historic core. The work presented here focuses on the analysis of the mental mapping, presenting the dynamics of walking in the creation of mobile atmospheres and collective perceptual paths in a heritage city.

MENTAL MAPPING OF WALKING ATMOSPHERES

The process of forming urban images is a cognitive process based on perception, through which we gather knowledge about our environment. This mechanism can lead us to conclusions about evaluating the environment around us, narrating the experience, representing it based on multi-sensory cues. The result of this constant sensorial perception and evaluation of the environment is the reference to meaning in space. It creates spatial expectations and sensory empathy towards the image of the city. The city is a symbol that is unraveled thanks to the perceived multi-sensory image of its narration. In this context, we define these intangible spatial expectations as sensory assets.

One of the methods to overcome any sensory dominance (with the visual prevailing) is to conduct a survey that evaluates the individual senses, in order to understand how each sense affects the participants' perception of a given space. At the same time, we acknowledge the multisensory effect of overlapping sensory experiences, through different intensities and qualities that reflect the quality of spatial environment. If an urban square or a city street can be perceived as a spatial enclosure, then the intangible visual, aural, olfactory, haptic and thermal elements that define the experience of being in space can be perceived as the sensory assets of these enclosures. The heritage character of the city centre of Canterbury presented a potential in testing the multisensory experience due to its variation in urban layout, use of materials, and social activities to stimulate the senses and interpret the atmosphere of place.

The analysis here is based on the mental mapping workshops of the sensory walks that form an analytical tool to understand the interchange between multisensory navigation and atmospheres and provide a collective interpretation of environmental quality through the sensory channels of bodily movement in urban spaces. The mental mapping was complemented by a hybrid methodology that aims to capture the multi-sensory experience of walking: in exploring how participants experience urban spaces along a chosen route, a range of methods was used:

- group survey during organised sensory walks;
- mapping of overlapping uni-modal sensory experience;
- questionnaire for multi-sensorial perception during self-guided walks;
- multisensory notation;
- photographic documentation by participants;
- environmental monitoring of microclimatic conditions (air temperature, relative humidity and light levels).

From the above methods, engagement with members of community was creatively enhanced during the mapping activities and the use of questionnaire during self-guided walks. Photo elicitation contributed in providing representative features in environmental and architectural conditions of the space.

Here the first findings of the mental mapping workshop are presented (fig.1). Participants used different techniques to create a mental map, resulting in a wide taxonomy of mapping representation of sensory assets, including:

a) Typology A: notations based on separate sensory cues;
b) Typology B: word-based narratives, and paths of memory;
c) Typology C: treating sensory experience as landmarks of atmospheres, and
d) Typology D: diagrammatic depiction of sensory trails (adding information about everyday experience and showing purely sensorial qualities of paths).

Using the map during walking, provided a series of challenges. Some used the map to textually and spatially depict their own knowledge of the history of the place or the memories from other people's narratives. Others focused on the actual conditions with a particularly practical approach, analysing each sense in its components and bringing to the forefront the poetics of space. Overall, the content from mental mapping provided a collection of sensory experiences in the city centre of Canterbury, presenting the diversity of perceptual awareness between participants. For example, Figure 1 below shows the interpretative sensory maps based on participants' perception, where the overlap of sensory assets is depicted with an improvised notation.

The mapping exercise also revealed the potential for narrative and story building around the experience of space through the senses. This understanding of the quality of space through storytelling can become a powerful design tool in creating a collective place identity. Typology B of sensory mapping reveals sensory assets that are site-specific and at the same time reflect the wider image of the city, in identifying qualities of "Canterbury" as a place. Emotional attachment to place, historic references and environmental qualities were included as seen in Figure 2.

The combination of mapping notation and narrative revealed a more dynamic understanding of the overlap of the sensorial realm that captures the reality of walking and the passing of perceptions and interpretations of the space. Qualities and assets are therefore directly site-specific, analyzing the micro-level of sensory assets, focusing on the architectural detail, the intensity of a specific smell, the functional aspect of using a trail for cycling and the change of perception related to the change of speed in movement. This dynamic set of sensory assets presents an opportunity for a more active engagement with city space, where linear spaces of movement (streets, canals, blue and green ways and cycling paths) are brought to the forefront (Figure 3).

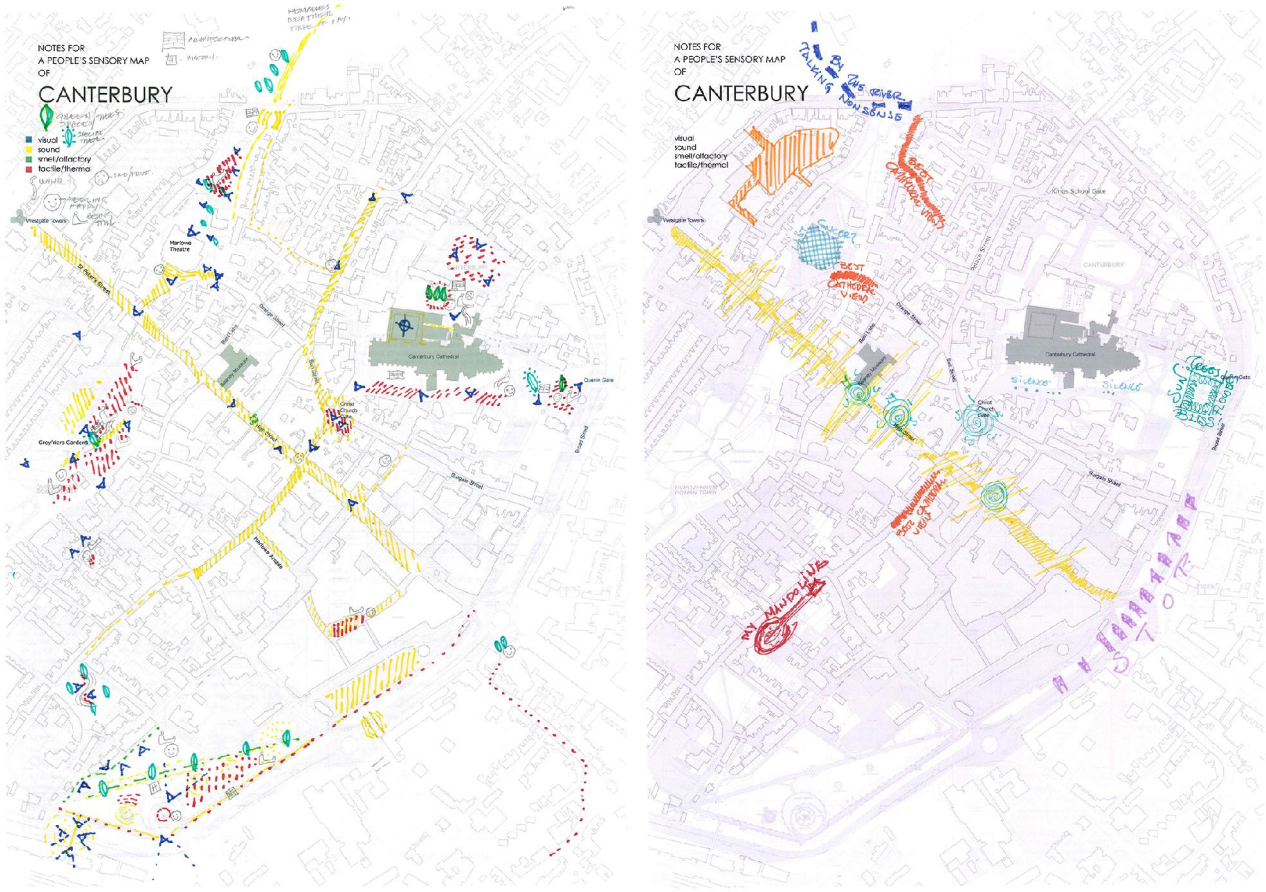

Figure 1. Typology A of Sensory Mappings: using improvised sensory notation to represent perceived experience and quality of environment. (Image by author).

Figure 2. Typology B of Sensory Mappings: sensory assets include narratives of experiences in place that build the collective imagery of a place. (Image by author).

Finally, Figure 4 shows the understanding and representation of the sensory experience as a continuous flow of interchanging intensities. Surfaces and places take on a specific prevailing quality that defines them. The moving body seems to be able to perceive sensory cues in specific rhythms, continuous, focused, syncopated, overflowing and contained.

Figure 3. Typology C of Sensory Mappings: the dynamic qualities of sensory assets that present a different image of the city, one that is based on linear spaces of navigation as main descriptor. (Image by author).

Figure 4. Typology D of Sensory Mappings: rhythm and flow of sensory cues while walking. (Image by author).

THE MULTI-SENSO-REALITY OF WALKING

The narrative of the maps (visual, textual, hybrid or graphic) focus on the overlapping of uni-modal perception of walking atmospheres. It is critical to note the continuity between lived experience and perceptual trails that shows how the intangible realm of the sensory assets can influence directly decisions about selecting a trail over another in navigation.

Through the textual analysis of the material collected, it is shown that participants focused on the visual experience at street level, referring to the presence of people, materials, shop frontage and signage. They commented on the "stark contrasts between materials", the difference between the homogeneity and harmony of building and facades that was lost in the colours of the shopfronts and the shop signs, creating a sense of disparity. Some participants found the ground floor conditions discordant with the upper floors, pointing out that looking at the architecture of the street was "difficult". The crowdedness and level of pedestrian traffic seemed to provide opportunities for different ways of engaging with the space, both positive and negative.

Text-based descriptions of mobile atmospheres based on visual perception included “totally mixed”, “clustered” and “mustered”, “baffled”, “busy”, and retail focused characteristics. Prompted to recommend a change on the street environment, the majority of respondents identified the shop fronts and shop signage as obtrusive to the overall visual perception of the street.

It was pointed out that the urban layout of the streets allowed for a pleasant sky view and presented opportunities to discover buildings that could go unnoticed, such as the Cooper Gallery, the Methodist’s church, views towards St Peter’s church, the new Marlowe Theatre and Canterbury Cathedral. View cones of the latter were identified as places of sedentary activity, or places of lingering. The mixture of contrasting textures, colours and materials provided a level of diversity that was welcome for a public space.

Atmospheres of sound and noise were characterised by the proximity to the crowded High Street and the mixed street use by vehicles and pedestrians. Participants focused on the sounds that differentiate these two experience. Side streets were described as “suddenly quiet” space, sounds of “murmuring, tree leaves, laughter, wind breeze, birds and ducks” and the “silence of the flood water in the river”. The walking activity seemed to enhance a mobile sound experience. Distant noises were mingled with close one, such as sounds of car horns, sirens, cars approaching, car door closing, passing individual conversations, building doors opening and closing, footsteps and high heels approaching, Crossroads were identified as busy hubs of the city centre, the majority of participants pointing out the “background chatter”, “people going by”, “loud conversations”, and the ringing of the cathedral bell.

According to their expectation of the place, participants noticed the dominance of people-generated noises over the presence of cars. The sounds that were found most invasive included vehicle-related sounds and sirens. Reference to childhood and past memory of the place included the location of a monument that was removed (“Kitty Marlowe playing the lyre”) and the historic use of the space as the reed market. The most pleasant sounds were natural ones, including the trees and leaves in the wind. The experience of the place in terms of acoustic perception was overall comfortable and “safe” for the majority of participants. The boundaries of the city centre were perceived as impermeable and noisy, showing a distinct fragmentation of the heritage site.

Tactile and thermal experiences while walking identified “sunny” and “warm” whereas as the majority of them found that the height of the buildings and use of brick fences contributed to that effect. The width of streets was commented in a positive way, as “sun-catcher”. Although the openness of squares “made it more windy” the thermal sensation was found still “pleasant” because participants could “stand in the sun”. This aspect was accentuated by the building materials, in particular that of crack timber in historic buildings and secret gardens in the Cathedral precincts that were found by the majority of participants to evoke a “feeling of warmth”.

Olfactory experiences were divided in two distinct categories: one category acknowledged no significant ability to discern a specific smell during the walk whereas the other category experienced an array of smell qualities. Where the former found the smell along the route as neutral, the latter noted the “smell of food”, “wet hair”, “havana cigars” [next to a tobacco shop], “bread making”, “people smoking”, and “fragrance”. Negative smells included “disinfectant”, “plastic”, “car exhaust”, and “dampness”. However, the majority of them identified experiences of more pleasant sweet smells and floral odours in the Cathedral precincts. The wetness of one of the walks had a direct influence of participants’ olfactory experience, whereas the sunny conditions intensified the pleasantness of smells.

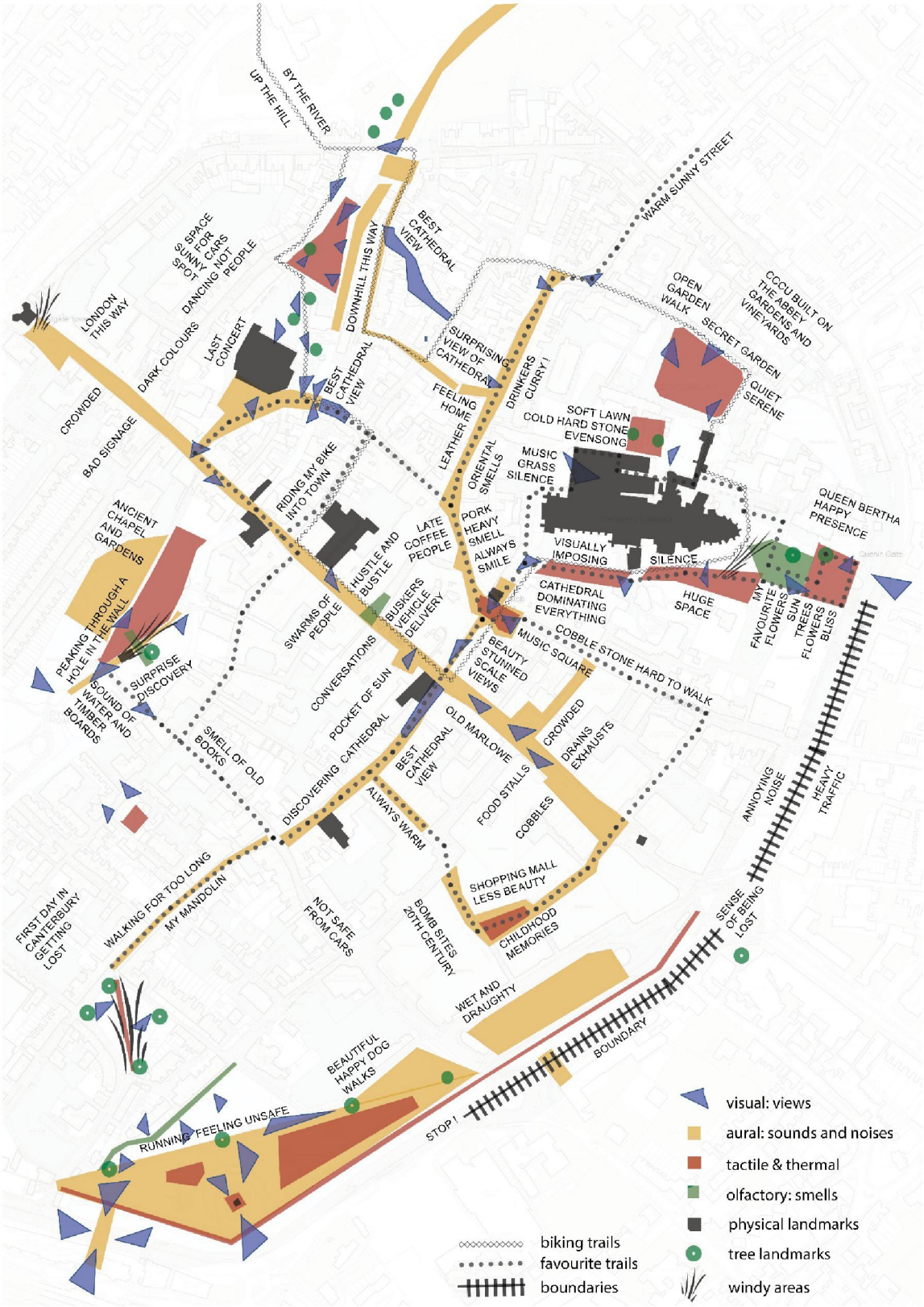

Figure 5. Sensory Map of Canterbury city centre, based on the mental mapping content of 10 participants during a sensory walk, showing sensory experiences, perceptual trails, relationship between place and memory and landmarks. (Image by author).

All the above sensory atmospheres were attributes to the urban everyday use and memory of the spaces intertwined with the expectations of participants. The depiction of favourite paths and biking trails reveals the creation of multisensory atmospheric landmarks in the heritage city (figure 5) and creates the need for a discussion around the sensory assets of a place. This generates a body of narratives of sensory heritage where the destination is an embodied experience, a path, a point of sensory interest in the traditional townscape. The network of collective interpretation of multisensory experiences can contribute to the understanding of quality of place in its everyday use, disembodying the heritage city from its normative touristic and consuming function. The design of urban spaces and the practices of placemaking would benefit from a design tool that takes into consideration sensory assets that have been revealed through common community engagement practices. The rich and multi-faceted set of findings can steer future projects seeking to use sensory navigation in the context of urban redevelopment towards the well-being of community places, where everyday experiences are empowered as a tool for controlling the qulity of public space.

CONCLUSIONS: NOTES FOR A PEOPLE'S SENSORY MAP OF CANTERBURY

In the quest for social well-being at the level of the community in a heritage city, public participation becomes paramount. This project aimed to take a more holistic view of places and their sensory identity and to draw on users' experience in evaluating environmental and spatial quality of place, using sensory walks and mental mapping as an empowering tool of community engagement in the maintenance and redesign of city spaces. Within this context, the project had the objective to engage city users in research and help create a community-designed map of the city centre of Canterbury.

A sensescape map of a city area describes the common everyday qualities of walking as an indicator of health and well-being and experiencing an open space, green, grey, public or private. While people navigate in the cityscape apparently based on their visual perception, the actual experience of wayfinding is multisensory. Sensory assets may be attributed to uses of space, climatic conditions, people interaction and characterise uniquely a particular node, street or neighbourhood. There are many opportunities to explore by applying the tool of mapping of sensory assets for place making and local governance. This approach imbeds the engagemnet of the community in a direct dialogue with urban change and development.

The new sensory map of Canterbury, with Canterbury Cathedral as the main cultural landmark (figure 5), provides the opportunity to inform cultural debates on urban exploration and engagement, navigation and route planning as well as build a network of knowledge transfer between the Cathedral and a diverse range of community groups. Finally, its sets the foundations for further exploring how responses to sensescapes can enrich a shared vision of walking atmospheres and interpretation of sensory assets in a heritage city.

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Design Should Follow Human Biology and Psychology

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ABSTRACT

A built environment that promotes human health is adapted to user needs and non-obvious sensibilities. This paper brings together new design techniques that achieve this goal. Do post-war buildings and urban spaces give appropriate psychological responses for encouraging human life? How do structures adapt to our bodies, to the psychological spaces that groups and individuals crave, and to our complex range of movements? Do the hard places we build for our soft bodies work optimally for our senses? Scientific evidence from environmental psychology, evidence-based design, and post-occupancy evaluation suggests not. Industrial surroundings do not "belong" to us. The reason is because we — the current and future users — never contributed to creating them, and even if we find them terribly aggressive and hostile, we are often legally prohibited from modifying them. We can never "belong" to such spaces if their geometry and surfaces are contrary to what our sensory system seeks.

Keywords: biophilia, design patterns, architecture, urban design, complexity, neuroscience, environmental psychology, biological structure

INTRODUCTION

For much of the twentieth century, mainstream architects applied formal design criteria having to do with severe and simplistic forms. Practice focused primarily on the exclusive use of industrial materials such as plate glass curtain walls, reinforced concrete, etc. Those typologies and design approach have a totally distinct goal from adaptive tools such as Design Patterns, which seek human wellbeing and health through an accommodating geometry (Alexander, Ishikawa, Silverstein, Jacobson, Fiksdahl-King, & Angel, 1977; Leitner, 2015; Mehaffy & Salingaros, 2015; Salingaros, 2016; 2017a). Human-oriented design relies on useful interaction among the elements of architecture, therefore a building's image as a formal statement is never our top concern.

If we decide to build our environment as an extension of our own biology, then its design must obey geometrical rules for living structure. A group of us proposes using rules discovered in nature, not invented or imposed by aesthetics, design ideology, or formalism. The rules we seek come from our knowledge of the mutual interaction of humans with their environment. One of these models is Biophilia — our instinctive love of life and its geometry (Browning, Ryan, & Clancy, 2014; Kellert, Heerwagen, & Mador, 2008; Mehaffy & Salingaros, 2015; Ryan, Browning, Clancy, Andrews, & Kallianpurkar, 2014; Salingaros, 2015). A large body of evidence on how users interact sensorially with their surroundings highlights what makes environments healing. Experiments reveal how we are drawn to organized information, but not to blank surfaces; how we prefer curves in our environment; how colors impact our psychological state; how we expect an emphasis on the vertical axis, etc. These and other preferences will be explained in detail below. Such factors arise from our biological nature, and impact human health, often in subtle physiological and psychological ways (Salingaros, 2017b).

As long as practitioners, professional groups, the media, and academia consider buildings primarily as isolated sculptural objects, it is difficult to introduce Biophilia and Design Patterns for designing the human habitat. Hopefully, enlightened clients, public and private, will grasp the enormous long-term benefits of a healing environment, and will start to demand it from architects. The new defining paradigm of our technological society is connectivity, not isolation. Adaptive design establishes an essential healing connection between people and the environment, through human biology.

BIOLOGICAL DESIGN USES PATTERNS

Traditional buildings and structures on the urban scale show recurring similar typologies. This similarity is due to fundamental invariants of human physiology and anatomy. Christopher Alexander and his colleagues discovered and documented invariant socio-geometric constraints as Design Patterns (Alexander, Ishikawa, Silverstein, Jacobson, Fiksdahl-King, & Angel, 1977). Traditional typologies evolved within distinct societies, yet their selection criteria depend on human senses and sustainability, and are independent of any specific geography and time. Particular socio-geometric solutions arose from a process of convergent evolution of designs. Similar climates will tend to independently evolve similar typologies (but not finished designs), even when the populations are geographically distant.

Physical settings that make us feel secure from threat elicit a positive emotional response. Our brain is reassured on a subconscious level. There are many layers of creation and pleasure above this baseline of emotions. Going beyond the basic and necessary feeling of security, our imagination produces Art in seeking to satisfy our craving for sensual pleasure. Art beyond ornament is part of biophilic design (Salingaros, 2012). This has been an inseparable aspect of the built environment

ever since the first humans invented architecture. People from the most impoverished settings, to those belonging to a social class with power and wealth, used biophilic design to inject delight, personal meaning, and serenity into their living spaces. We experience a sense of wonder in our most glorious (usually religious) architectural creations.

Adaptive design works very much like our immune system. There, an invading pathogen triggers the production of an enormous variety of antibodies. Those few that are effective (even just one) are recognized for their success, and are subsequently produced in large numbers. The failed varieties in the first response are experiments to find what works, which are subsequently discarded. In the same way, adaptive design generates an enormous variety of solutions, which are then tested before or even during implementation. The ones that survive and are built are those that conform to practical constraints, such as available space and materials, climatic adaptation and energy savings from directional orientation, and, in general, the feedback loop maximizing the wellbeing of the user/builder in the actual created spaces.

Today, however, it is not evolved solutions so much as simplistic geometries that are re-used. Those are far easier to implement, because they do not adapt to context. An architect is not required to combine tried-and-true adaptive solutions to generate the large scale: monotonous repetition is enough. Regardless of the expressed intention of individual architects, buildings within the industrial-modernist rubric do not approach the complex articulations on many interlinked scales that one finds in traditional architecture and urbanism (Alexander, 2001-2005; Salingaros, 2005).

Even those recent buildings that embody complexity contain the wrong type: disorganized instead of organized complexity. Disorganized complexity results from having many components that are not linked. The brain has to process each unit individually, leading to informational overload (Salingaros, 2018). The task of organization is performed by connections established among all the elements. In the architectural context, elements are connected by using many different types of spatial symmetries (reflectional, translational, rotational, etc). Coherence on the large scale is taken care of by having scaling symmetries (where similar units in a composition exist at distinct magnifications).

The continuing dominance of minimally-satisfactory and even unhealthy typologies in design contradicts the process of historical selection that normally would favor the healthiest living patterns. Today's dominant typologies also preclude sustainability (Mehaffy & Salingaros, 2015). How is this so? Selection stopped after nobody was interested in testing adaptive design variants. Architectural culture accepted an extremely limited industrial-minimalist typology, and the profession seemed happy with that (but not the users). The reason that unhealthy design typologies now thrive all over the world is because they have been institutionalized as building codes, standardized materials and dimensions, standardized mass-produced building components, etc.

Once non-adaptive design typologies became established, convention and regulations decreed what designers are allowed to use. Risk-averse clients want the most economical budget, while unimaginative designers either cannot or do not want to go outside the familiar box. More enlightened building codes and standards (for example, the New Urbanist form-based "Smart Code") could be used as a stepping-stone towards adaptive designs. But introducing them meets stiff resistance from the establishment. And society as a whole becomes numbed as it gets used to hostile spaces and urban dysfunction, and cannot imagine anything different. People simply accept an unhealthy *status quo* now almost a century old (Alexander, 2001-2005). On the other hand, signature buildings get erected precisely because they embody design variants — but unfortunately those are of an unhealthy kind. Our ability to build any shape and dimension we want, if unchecked, can easily lead to an inhuman environment.

THE BUILT ENVIRONMENT AS AN EXOSKELETON

Industrial Modernism has spread (in many cases, imposed) an inflexible homogeneity on the built environment worldwide. This typology, strongly promoted by globalization, is very poorly adapted to context, the environment, or local culture (Mehaffy & Salingaros, 2015). The biophilic model, together with complementary adaptive design tools, provides a basis upon which a more human-oriented design practice can be built.

Let us try to bypass formal discourses on architecture going back decades, and approach the discipline as part of biology. We need to apply scientific analysis to understand the problem, but should not fall into superficially copying biological forms (Alexander, 2001-2005; Leitner, 2015; Mehaffy & Salingaros, 2015). Human beings create families and societies, and those groupings represent living structure at one or more levels of scale larger than the individual. Those living human scales need protection and physical support, which is the reason why we construct an exoskeleton consisting of buildings and cities out of available materials.

The geometry of the built environment is the exoskeleton of living structure. In much the same way as insects, crustaceans, and mollusks, humans are intimately attached to their "built exoskeleton". What we build could perfectly fit our needs, both physiological and psychological, our movements and daily functions, etc. A variety of environments will satisfy these criteria, as long as we can easily adapt our behavior to the built geometry. Moreover, our immediate shelter is an organic part of us, without which we would perish sooner rather than later. We can no more *arbitrarily* change our exoskeleton than a lobster can radically modify its own shell. The infinity of allowable perturbations that maintain fit is still a restricted set. Yes, the lobster molts, but then builds a slightly larger shell that is otherwise the same. This way of thinking about the shells that enclose our activities is not new: Gaston Bachelard and Constantine Doxiadis used these terms.

We certainly adapt the built environment to our needs whenever we can (and where permitted to do so). Ironically, informal settlements are the most adaptive, whereas living and working spaces created within formal design are the least adaptive (Salingaros, 2005; Mehaffy & Salingaros, 2015). The do-it-yourself building process uses available materials, adapting economically to environmental conditions, and is driven by social conditions and religious beliefs.

The construction of a single room, a house, or an entire city district seeks to satisfy requirements for shelter that arise from the interactions and exchanges of human society. Adaptive forms and typologies channel spontaneous movements and flows via interaction and cooperation rather than by adhering too strictly to a formal plan. Very specific indoor and outdoor spaces should be shaped so as to adapt themselves to, not to dictate, human activity. In a process of organizing myriads of different needs according to a set of constraints such as Design Patterns, there is no top-down artistic "design" *per se*. This approach represents the opposite of modernist social engineering.

The largest scale in an adaptive design is influenced by the arrangement of its internal components and the smaller scales. Room shape, dimension, and volume, when successful, depend upon both the perception of coherence and the accommodation of physical activities. In achieving adaptivity, geometrical forces coming from both the large and small scales have to compromise the least possible way with human neurological responses. Whenever spaces and surfaces are imposed by following formal concerns exclusively, or as an arbitrary artistic flourish, they become irrelevant for containing human activity. Traditional architecture, which can be both artistic and formal, is based on inherited biophilic design principles understood subconsciously. Those practices constrain a building or urban space to adapt to flows, and to nourishing visual complexity.

Another biological analogy also proves helpful. In most animal bodies, free components — e.g. blood cells — move about internally. Those mobile components are essential to living structure, while the framework through which they move is essential for their survival and the survival of the entire organism. People moving about their private domestic spaces and public urban spaces remind us of blood cells flowing in the circulation system. No part is independent: container and contained form one system. Organisms represent complete, tightly-dependent components of biological processes that define living structure in the systemic sense.

Twentieth-century transportation systems mimicked organic circulatory systems, but made several errors, thus getting the analogy wrong. Bodily fluids flow through a hierarchy of channels of decreasing capacity: the blood flows from arteries down to capillaries, with an inverse-power law distribution — i.e. few arteries, but an enormous number of capillaries. This is fractal scaling, which is found in many complex systems (Salingaros, 2005). Highway engineers, however, cut expressways through city centers, thus wiping out the equivalent of the capillaries. Promoting fast flow through streamlining, they skewed the network towards the largest scale. In the sprawling suburb, there is only one oversize type of road, hence no path intimacy in the network. That unnatural situation contributes to the pathology of suburbia.

RESILIENCE OF MULTI-SCALE SYSTEMS

Designing with human senses, and knowing how different built elements affect them, vastly improves the fit between a city and its users. As an important bonus, this practice makes a city more sustainable for several reasons. First of all, a city that is loved by its users will be taken care of and survive normal wear and tear. Second, adaptation to human senses skews the built system towards the lower-dimensional human scales, thus making it less fragile from the systems theory point of view (Salingaros, 2005). It is only when a system becomes dependent upon its largest scale — e.g. new skyscraper cities built in the desert — that a disturbance can knock out the entire city.

Sensory feedback has implications for how cities deal with change. A city is a complex system composed of people interacting with the built environment. This urban system becomes more resilient when it acquires analogous biological characteristics (Alexander, 2001-2005; Salingaros, 2005). For several decades, many cities have failed to obey the mechanisms of living structure, except perhaps for small pockets. Gluing a techno-solution on top of a rigid anti-natural system cannot solve problems of fragility. The technocratic approach to resilience continues to rely on a dangerously limited perspective. Fundamental philosophical and systemic changes are needed.

The “metabolism model of cities” has proven useful in pushing urban planning towards sustainability (Decker, Elliott, Smith, Blake, & Rowland, 2000; Newman, 1999). As we have learned from ecosystems, responsive networks of resilient systems embody inherent diversity and redundancy. Diversity comes from linking system structure and processes together at many different scales — a complex system never runs on a single scale. Unless living systems had built-in redundant connections, they would die from minor injuries. Redundancy is the opposite of optimization for maximum efficiency for a single process, which instead creates fragility. Yet, planners have been doing exactly this (Salingaros, 2005).

A variety of structural and response mechanisms are needed for the city to recover from shock. As in the human immune system, threats are fought by generating as large a variety of responses as possible, until the effective one is found. A discovered response is then stored in memory, providing immunity from a specific pathogen. Our society needs to anticipate this process through adaptive scenarios and stored learning. However, we seem to have no memory, since the ephemeral pursuit

of fashion erased past learning as contained in Design Patterns. Trashing lessons of the past forces people to live in an eternal present without accumulated resources of knowledge.

Our responses to system threats are handicapped by inertia, intellectual confusion, and stubbornness. Architects and planners optimized city form for one goal — fast automobile traffic — thereby neglecting all other subsystems. Industrial Modernism pushed fluxes as well as forms onto the largest scale, and eliminated all the smaller scales (Salingaros, 2005). The resulting system is extremely fragile because it lacks mutual support from linked structures on different scales. Even more alarming is that most people associate modernity with how this fragility "looks", thus encouraging endless construction in this same style.

Top-down architectonic expressions impose unnatural scales but do not attempt to adapt. The arrogant stand-alone "look at me" building isolates itself from context. Buildings as giant sculptural forms represent reductive, shallow simplicity that drastically shapes the way we think. It is not that biophilic design principles were unknown before: they were internalized into traditional design practices, but those are now discarded. Sleek, mechanistic images pose a problem. The modernist form language trains the brain not to see the complex reality of living systems. Current design philosophy tends to oppose natural multi-scale systems, for stylistic reasons. Design driven by irrelevant artistic fashions disorganizes complexity, loses useful Design Patterns, and leads away from healthy environments.

FIRST SET OF DESIGN GUIDELINES: SHAPING THE ENVIRONMENT

A new design practice — or re-orientation of current design practice — utilizes sensory responses in building rapidly growing cities (Alexander, 2001-2005; Salingaros, 2017a; 2017b). These same principles can be used to repair unresponsive portions of a city, and individual buildings. The aim is to use minimal interventions in what already exists, and re-shape it into a more humane environment. Even in the developing world, where competing needs such as health care, social services, clean water, sanitation, housing, transportation, safety and security seem to overwhelm available resources, healing design is not a luxury but a necessity. Once this goal becomes a priority, it is not difficult to implement a living connection between users and built structures in a sustainable way, with no additional cost. All we have to do is to fill in some too-large open spaces, re-structure spaces (interior and exterior) that are unwelcoming, replace or re-finish "unfriendly" surfaces, etc.

General design guidelines address the existing barriers towards promoting human health necessary for creating thriving neighborhoods. The following list is useful for designing environments that can have a positive impact on the experience and perception of place. Most readers will not be familiar with the background material from which these generic points are summarized: please see the references for details.

Table 1: Design elements that elicit a positive sensory response.

1. Built elements intimately linked to pieces of nature in which we feel comfortable and reassured. A building embraces trees and gardens — not flat lawn.

2. Structural information intrinsic to natural forms and materials. Their small and micro-scales usually contain richly-ordered complexity.

3. Geometrically coherent structures and spaces built from artificial and natural materials. This coherence is achieved from an uncountable number of links and symmetries.

4. “Safe” spaces, as determined by our neurophysiology. Many spaces make us feel anxious, but we are discovering the geometry of those that do the opposite: make us feel at ease and welcomed.

5. “Friendly” surfaces, perceived neurologically. Experiments are underway to determine why we feel attracted to touch a particular surface, and are repelled by another.

6. Mathematical symmetries that cooperate on all levels of scale. A high density of subsymmetries of all types that overlap in a mathematically harmonious manner.

7. Different structural scales linked to each other through scaling symmetry. Similar elements at different magnifications co-exist in proximity.

8. Colors that harmonize and do not clash. Artists working up until the end of the 19th Century knew how to achieve this effect.

The key to adaptation is that large scales subdivide into smaller scales: not arbitrarily, but to accommodate human senses and dimensions. This helps to understand how nature adjusts dynamically and acts on all interconnected levels of scale. Formal approaches to design that suppress the intermediate and smaller scales create unnatural results (and perhaps this is their unstated intention). But that is not adaptive to living processes.

Using Biophilia and Design Patterns has radical consequences. First, a building mixes intimately with nature, with views onto real trees, mini-gardens enclosed or semi-enclosed by the building, a crenellated building footprint to join with gardens, etc. Second, geometries employing fractals, scaling symmetry, similarity-at-a-distance, nested sub-symmetries, and reference to a vertical axis trigger positive physiological and psychological responses from users. (Deviation from the vertical axis is sensed by our inner-ear mechanism, which responds by generating nausea.) This novel approach to contemporary design merges the building with its immediate surroundings. Context, position, orientation, main approach, paths, and connection to the urban fabric are all essential features.

Contrary to what some readers may hastily conclude, one does not need to go back to the Classical, Arts and Crafts, or Art Nouveau form languages to benefit from healing environments. Any project today can make either a small or large move towards satisfying the design guidelines proposed in this paper (and detailed in the references). Even a minor change towards the direction of adaptive design could prove enormously beneficial to the users, since the effects are cumulative in the long term. Small adjustments to otherwise conventional design can be easy to implement, yet help far beyond their size or extent. Ideally, the design will benefit most if adaptive techniques have a chance of influencing the process beginning with its first steps.

SECOND SET OF DESIGN GUIDELINES: HOW WE LOOK AT THINGS

Here we use the latest findings from visual tracking, which confirm the insights coming from Biophilia and Design Patterns. Ann Sussman and her collaborators observed which geometrical features draw the visual interest of pedestrians (Sussman, 2018; Sussman & Hollander, 2015; Sussman & Ward, 2017). Sensory information decides how people navigate and use a place, without being conscious of the reasons driving their behavior. This groundbreaking research reveals how a user's sensory system reacts with the built environment. Unlike older experiments that used questionnaires to determine environmental preferences, this data measured gaze fixation directly. Results from many participants were superimposed to show subconscious preferences. Those findings lead to practical tools and methods for planning and urban design practitioners (listed below in Table 2).

Table 2: Guidelines for adaptive design from eye tracking.

1. No large undifferentiated walls, either opaque (bonded brick, stone, or concrete) or transparent (curtain glass). Those present a void in the visual field.

2. A person's biological navigation system requires a sequence of visually focused goals, each one defined by coherent complex elements. The complexity and intensity of those visual goals have to match examples from nature.

3. Recognizing our evolutionary need to see faces implies an attraction to façades and individual design components with bilateral symmetry (about the vertical axis) suggesting abstract eyes, mouth, and nose. This preference is verified by the data.

Visually seeking the "face-like" suggestiveness of a building façade is built into our biology: it is part of Biophilia. The attraction goes beyond a preference for abstract bilateral symmetry about the vertical axis, to an effect apparently due to specific facial-recognition neurons in the brain. A recognizable entrance may appear as a mouth, with windows and other features distributed in a bilaterally symmetric manner (Sussman & Hollander, 2015). Its opposite, an ambiguous entrance and either the absence, or monotonous repetition of windows and other design elements creates alarm and disorientation. We evolved to seek safe paths, to recognize other animals, and to interpret the emotions in a human face; therefore, we try to find similar features in a building as we approach it. Of course, we are capable of adapting to and approaching any non-toxic environment, but the further that diverges from what our evolution leads us to seek, the higher the cognitive burden we have to overcome.

The above design rules implement a built geometry that is consonant with our senses, but which at the same time differs radically from formal design practices applied throughout the world for the past several decades. Without getting into polemics here, it should be obvious that the industrial-modernist vocabulary eliminates most of the techniques we support. Elsewhere, we argue that a certain type of visual innovation that runs through early modernism right to contemporary architectural styles achieves its "look" by violating our proposed design rules (Alexander, 2001-2005; Alexander, Ishikawa, Silverstein, Jacobson, Fiksdahl-King, & Angel, 1977; Mehaffy & Salingaros, 2015; Salingaros, 2016; 2017a; Sussman, 2018; Sussman & Hollander, 2015; Sussman & Ward, 2017). The negative qualities of architectural design practices do not work to establish empathy with the user because they are perceived as unnatural, hence threatening.

Design rules for urban spaces that will actually be used with visceral pleasure come from specific Design Patterns (Alexander, Ishikawa, Silverstein, Jacobson, Fiksdahl-King, & Angel, 1977; Salingaros, 2016; 2017a). An enormous amount of information correlates frequency of use with spatial dimensions, access, entry points, transverse paths, types of boundaries, urban functions in the immediate perimeter, and population density in several surrounding blocks. That practical information will not be detailed here (Salingaros & Pagliardini, 2016). Suffice it to say that the design of urban space became a lost art after it was intellectualized. Yet dysfunctional places affect human health in subtle ways, and keep people from ever using them. Potential users approaching an urban space pick up visual cues: certain design elements attract, leading to entry and lingering in the space; other elements repel, making it more likely that someone will avoid crossing the plaza. A correctly-designed urban space can have a profound and positive impact on the users' perception of place.

THIRD SET OF DESIGN GUIDELINES: GRASPING OUR ENVIRONMENT

A combination of experimental research and theoretical conjectures produces a picture of a healing environment that has very particular geometrical features. Those design elements, which should naturally be incorporated into any new designs and in retrofitting older structures, arise from neuroscience (Salingaros, 2017b). Insights result from practice-based research into how architecture and urban spaces affect our wellbeing both on the short and long terms.

Animals use all of their senses in navigating their environment, and we do the same (Pallasmaa, 1996). Vision, smell, hearing, and touch help us to establish our position in a place. We have a primary need to situate ourselves in our immediate environment. Most important is that our tactile sense has two distinct components: actually touching a physical object, and the visual estimation of whether some object is touchable/graspable or not. The second mechanism of "virtual touch" and "virtual grasping" is underappreciated in design. Nevertheless, it determines much of our behavior in the built environment. We can summarize some recent findings in the following list (Salingaros, 2017c):

Table 3: Guidelines for adaptive design from virtual grasping.

1. We seek graspable elements of a size that fits our hand because those reassure us about a place.

2. Their shape should invite comfortable hand contact and grasping, whether that can actually occur or not.

3. Their material (opaque, not transparent) should invite grasping.

4. An object that would appear to cause discomfort or injury when physically grasped repels us instead.

5. Virtual grasping acts more strongly at short distances within physical reach.

The psychological mechanism underlying the effect of prehension (grasping) is called "object affordance". Our brain is continuously assessing whether our immediate surroundings "afford" such physical supports for our body. Juhani Pallasmaa first discussed this in an architectural context

(Pallasmaa, 2009). It does not have to be an actual physical object (though those arguably provide a stronger connection), but could also be a visual representation of graspable objects. This observation validates ornament that presents necessary graspable dimensions to a user. "Object affordance" acts subconsciously and can be satisfied by ornament and moldings.

The above guidelines have far-reaching implications for design. Smooth, minimalist surfaces neither present, nor even suggest prehensile design elements. On the other hand, architects wishing to apply the suggestions listed above in Table 3 are led to bring back surfaces with specific articulations into the core of design. Traditional architectural components provide the required prehension effect: these include frames, trim, moldings, baseboards, window grilles, mullions, and muntins, door levers instead of doorknobs, etc. Hand-size graspable components enter the architecture of the future not as an old-fashioned, nostalgic throwback to past times, but as a necessary design feature that satisfies essential conditions for our neurological wellbeing.

CONCLUSION

Good architecture should be gauged by what it does for the common good —for all of us. The combined set of design guidelines presented here contributes to creating a healing environment. This is immediately perceived as "welcoming", "compassionate", and "friendly"; yet experiments have shown the long-term effects to be beneficial to our health. People connect to a building through its spaces, surfaces, and details much as they will connect cognitively but subconsciously to a tree, a domestic animal, or to another human being. Physical material, if it follows the correct healing geometry, engages us on a visceral level so that we feel at home with our environment. This deep sense of connection has come to be misrepresented (and condemned by some) as "traditional". It is traditional only in the sense that for millennia, humankind strove to achieve it as intensely as possible in everything it created.

Professional practice has to apply only tested design methodologies for health-promoting urban environments. Industrial-modernist architects chose to break away from the human need for a healing environment by dropping adaptive design rules. The end result ranges from being psychologically neutral (non-nourishing), to alarming and hostile. Architecture has been stuck in this unhealthy direction for decades, so that it is now very difficult to find any healing qualities in mainstream contemporary buildings. Nevertheless, smaller firms that use Biophilia and Design Patterns, working outside the limelight, and thinkers at the margins of architectural culture are spearheading improved living conditions. Political forces, professional organizations, the official media, and our educational system will all have to join in this effort towards generating more responsive environments.

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Smell(e)scaping: Can We Use Smells as Psychiatric Strategies in Architecture and Landscape Urbanism?

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ABSTRACT

Our environment plays a big part in our paths to mental well-being. What design strategies can the person creating spaces take to help people build a healthy mind? A large number of scientific studies suggest a close relationship between olfactory and affective information processing. Odors seem to offer a great opportunity to restructure the reality of the individual and help change their moods; despite this, the olfactory dimension is rarely taken into account by architects and urban designers. When they do, it is generally to avoid and/or control potentially unpleasant emanations. Nevertheless, smells have the potential to become a strategic tool to reconfigure the experience we have of a place and help people in mental distress. So here I am, calling for a new division within architecture and landscape urbanism: *Smellscaping*.

***Keywords*:** smellscaping, environmental design, olfactory design, spatiotemporal perception, chemically dynamic spaces

There is now a solid set of studies and empirical evidence on the relationship between olfactory and affective information processing (Lundström, Arshamian, & Olofsson, 2017; Hummel, Fark, Baum, Warr, Hummel, & Schriever, 2017; Hoenen, Wolf, & Pause, 2017; Herz, 2016; Ferdenzi, Joussain, Digard, Luneau, Djordjevic, & Bensafi, 2016; Kadohisa, 2013; Soudry, Lemogne, Malinvaud, Consoli, & Bonfils, 2011). Smells seem to have a certain power in modulating mood, cognition, and behavior. As a designer, learning about this raises a number of questions:

- if architects and environmental designers wanted to use smells to help people to cope with the normal stresses of life, what strategies could they adopt when conceptualizing a space?
- how can smells be used to create structures that have the power to interact with mental states?
- how does landscape urbanism impact mental health?
- which materials that are used in construction and in planning could be used for scent compositions?
- how can a designer create a chemically dynamic space for the treatment of psychological problems?

This, without forgetting,

- what can be conceptualized to reach individuals whose sensitivity to odors have diminished, or those whose have lost their sense of smell? Because there is a high probability that someone with olfactory dysfunction will experience depressive mood disorder, major depression episodes (Soudry, Lemogne, Malinvaud, Consoli, & Bonfils, 2011, p. 20), even going as far as up to having the urge to commit suicide (Joo, Hwang, Han, Seo, & Kang, 2015).

These questions and many others regarding the impact of smells in the environment have remained unanswered for too long. Considering the power that they seem to have on human behavior, it is surprising that smells have not yet been exploited by architects and urbanists in the same way as any other building material. This is most likely due to the hegemony of vision over the other senses. As designers, we learn to compose with shapes, shapes that we see on paper and that will be seen when constructed. But designing ambiances and other intangible structures requires a different dexterity and an alternative approach.

This research note however does not lay out design rules on how to incorporate smells into architectural programs and urban planning; rather, it sketches a panorama of recent scientific studies related to olfaction and offers some line of thought on the possibility of using smells as psychiatric strategies in architecture and landscape urbanism. My only claim is to draw attention to a sensory dimension that has been “swept under the carpet” for too long.

THE WORLD IS ME

The intangible part of the environment is like a sensory sea whose waves lap tirelessly against our skin, our nose, our tongue, and our ears. Whether we are asleep, awake and alert, or inattentive, this sea continually brings us clues to help us understand our surroundings, and it is up to us to pay attention to them and to keep them in the nets of our memory. In searching to translate a range of signals accessible to our sensory organs in the moment, our brain choses to not take certain ones into account; otherwise, we would be overwhelmed by the weight of sensory information to process. In this multisensorial world we live in, it is familiarity that allows us to identify landmarks and objects. Familiarity guides our actions and navigation, and directs our spatial awareness and attention. Furthermore, if cognition arises through a dynamic interaction between an acting

organism and its environment (Thompson, 2010; Noë, 2004), it means that we are not passive receivers of inputs from the environment, and it implies that there is an ongoing loop between perception, attention and action (Clark, 2016). Even at rest, our neurons are in a flurry of activity, dashing off thousands of predictions of what we might encounter and preparing our body to deal with. We are thus constantly sketching various scenarios in our mind. They may be incoherent, unreal or true to reality, but still, they are narratives, and it makes our world unique.

Different parameters define the person that one is. Individuals raised in a different cultures will acknowledge the environment through the lenses of their ethno-cultural group. Persons from the same cultural group may even sense the environment differently. People who live in forests or in rural areas, for example, seem to sense crooked and slanted lines more accurately than people who live in urban areas (Segall, Campbell, & Herskovits, 1966). Because human brain wires itself in response to caregivers, culture, and social environment during infancy and childhood (Atzil, Gao, Fradkin, & Feldman Barrett, 2018), its circuitry differs from one person to another. With this in mind, it is easy to imagine how much the environment can play a part in affecting an individual, even an entire society. Furthermore, a place, a building, a street corner, will affect us in a different way from one day to the next according to a whole range of factors that will interact in varying degrees with our perception. For example, what we have experienced just before the present moment, the temperature, the noise surrounding us, the state of our health, our expectations, our level of attention, are all parameters that can shape our perception accordingly to their intensity. Still, what gives particular color to our reality is our emotions. An emotion harmonizes everything in the moment, and even afterwards. The olfactory system and emotional systems are highly interwoven and share common neuronal structures—the amygdala, the hippocampus, the insula, the anterior cingulate cortex, and the orbitofrontal cortex (Hoenen, Wolf, & Pause, 2017; Soudry, Lemogne, Malinvaud, Consoli, & Bonfils, 2011). Smells that evoke positive autobiographical memories can increase positive emotions, decrease negative mood states, disrupt cravings, and reduce physiological manifestations of stress (Herz, 2016). The emotional quality of scents can also increase memory performance (Bestgen, Schulze, & Kuchinke, 2015). Smells can even play a role in shaping moral choice (Cecchetto, Rumiati, & Parma, 2017). So, if smells have indeed the ability to affect our emotions, it is our duty as designers to elaborate strategies that take this dimension into account, or at least to ponder the question.

I SMELL, YOU SMELL, WE SMELL, OR NOT

According to scientists, humans can discriminate at least 1 trillion olfactory stimuli (Bushdid, Magnasco, Vosshall, & Keller, 2014). However, human perception of smells is highly variable. Our genetic traits weigh heavily in the balance of defining our capacity to sniff. Olfactory acuity correlates with age, gender, race, smoking habit, and body type (Keller, Hempstead, Gomez, Gilbert, & Vosshal, 2012). Social economic factors also seem to have an impact. In a recent study, researchers looking into the prevalence and risk factors of smell impairment among the US population concluded that people with low educational attainment, low family income and a history of asthma or cancer were the most at risk to have smell impairment (Liu, Zong, Doty, & Sun. 2016). Another study, where researchers looked at the relationship between olfactory dysfunction and depressive symptoms in South Korea, found that advanced age, alcohol consumption, waist circumference, job education level, and rhinitis were often factors associated with olfactory dysfunction (Joo, Hwang, Han, Seo, & Kang, 2015). Olfactory impairments are a trait marker of major depressive episodes (Naudin, El-Hage, Gomes, Gaillard, Belzung, & Atanasova, 2012). It can also be a sign of schizophrenia, as peripheral olfactory structural abnormalities seem to be the norm of this condition (Taalman, Wallace, & Milev, 2017; Turetsky et al., 2017).

Researchers have suggested recently that three driving forces make it so that people around the world differ in their ability to detect, discriminate, and name odors: one's biological makeup, one's experience, and the environment (Majid, Speed, Croijmans, & Arshamian, 2016). At the same time, a momentary condition or a different way to approach something may also influence our perception of smells. For instance, active sniffing can affect our ability to localize odors (Frasnelli, Charbonneau, Collignon, & Lepore, 2009); odors emanating from our oral cavity during eating and drinking (retronasal route) can evoke different sensations when sniffed through our nose (Frasnelli, Ungermann, & Hummel, 2008); hunger or satiety may influence how we perceive odors (Ramaekers, Verhoef, Gort, Luning, & Boesveldt, 2015); and increased anger may result in being bad at identifying an odor (Hoenen, Wolf, & Pause, 2017).

While this may present a complex picture of the "user", it is only a matter of clearly identifying the audience for whom to prioritize, and incorporate lateral ways to reach others. It is possible to conceive of a space as having a chemically dynamic side that can help ease someone in psychological distress, someone with depressive moods for example. What must be developed are design responses that agree with psychologists' and cognitive scientists' findings. However, it is only by first understanding the perception of people affected that we can think about conceptualizing and realizing spaces whose experiences could possibly help the ones in distress feel better, or at least calm their struggles a little.

SENSORY PLAY

Our perception of smells is evidently influenced by other sensory inputs present at the same time. In that matter, sight has probably the most important hold. If we associate visual stimuli as having an emotionally positive valence to us to a particular odor, it will increase the pleasantness of the olfactory stimuli (Hummel, Fark, Baum, Warr, Hummel, & Schriever, 2017). Our vision has such a strong influence on our perception that it can lead us to believe that a smell not present in the environment is actually there because it is bounded, for whatever reason, to the sensory cues that define our reality of the moment. I gathered evidence of this response in a study I conducted in 2011 (Bouchard, 2013, pp. 105-106), as well as the one I conducted in 2018 (Bouchard, forthcoming, 2020). Participants imagined smells by linking what they saw with what they expected to smell, even if these odors were not there. Furthermore, regularly during the field survey, those who perceived an odor that was actually present in the environment, but whose visual connection with it was lacking, doubted the identification of what they were perceiving, or they felt the need to imagine a plausible scene to put into context the origin of the smell: "*over there, there were lots of smells but… I don't know what. Ah! Oil! There must be a car… a car in a garage."* Some even persuaded themselves that what they were smelling was emitted by the most probable source they were seeing. A participant walking in a residential area where there were several trees and shrubs along the sidewalk said: "*Aaah! Lilacs. I don't know where they are but the scent is very strong. No… it might not be lilacs finally, but anyways, it is the scent of flowers. There are no lilac trees! Maybe there were some… or the white bush over there maybe? But it is a very strong smell, very present."* The ascendancy of sight may be explained by the fact that we learn from a young age to take in the world principally by sight; it is therefore natural for the sighted to seek visual confirmations to make sense of what we perceive.

When vision is missing, other modalities can become hyper-developed. That is called sensory compensation. On that note, and contrary to belief, olfactory memory in blind people seems to be no better than that of those with sight (Sorokowska & Karwowski, 2017). As for the relation between audition and olfaction, evidence was presented that after unilateral olfactory stimuli or mixed olfactory/trigeminal stimuli, the performance of an individual in auditory localization was

enhanced (La Buissonnière-Ariza, Frasnelli, Collignon, & Lepore, 2013). Auditory cues can also modulate odor pleasantness, according to scientists (Seo & Hummel, 2011), and a background sound can modulate the performance in an odor discrimination task (Seo, Gudziol, Hähner, & Hummel, 2011). In one study, Alzheimer's participants showed better specificity, emotional experience, mental time travel and retrieval time after odor and music exposure (El Haj, Gandolphe, Gallouj, Kapogiannis, & Antoine, 2017). Therefore, olfactory cuing could serve as a useful tool to stimulate autobiographical memory in people with Alzheimer's disease, at least in the mild stage of the disease.

THE REDOLENT SEA

The olfactory fabric that surrounds us is molded by the geographical environment, climatic conditions, economical practices, and human activity. All these parameters also define and set in motion the space of propagation of smells which can change drastically from moment to moment. Like a sea, the olfactory fabric is always fluctuating, and this incessant flux of smells immersing the environment draws upon our memory. The mobilization of memory being particularly significant to us humans, olfactory ambiances could thus be a strategic tool to restructure the reality of an individual by simply calling on his/her olfactory memory.

Our memory allows a continuous journey in a subjective time (Tulving, Nyberg, Kim, Habib, Levine, 2010). By conscious or distracted mental projections, the *theatrum memoriæ* that is our olfactory memory stages, in the structure of the present, a timeless reality that is specific to us. Each complexity of smells we encounter entices our mind to travel in the temporal thickness of the environment, whether in the past, the present, or the future. As a structure composed of numerous chemical entities, a smell can recall different memories in our present from the notes that we find in the smell present on the instant. This then adds a new "color" to the smell. However, let us underline that a memory is not a true copy of what we have previously experienced, nor the recall of a mental representation of a past event. In fact, we distort the episodic circumstances we live by accentuating or deforming some parts so it makes sense to us. For example, if we ask someone to remember a particular event, that person could either eliminate certain elements that are less emotionally charged and/or distribute differently the role of the protagonists that were present in the event (Van der Maren, 2010). A memory can also reflect a reality entirely fabricated because another person strongly suggests it (Loftus, 1997), or because of an acute desire to belong to a group (Olick, 1999). In short, a memory is essentially a narrative.

Our olfactory memory plays its part in defining the structure of our reality. Smells play as much as a role in the impromptu appearance of memories in the individual as they do in the imagining of possible scenes, and in inspiring future actions. From the same field study I conducted in Montreal in 2011-2012 (Bouchard, 2013), a participant expressed the following during the route: "*It's funny how the sidewalks collect everybody's waste. It seems like someone spilled a beer*…." He assumed that someone had spilled a beer on the sidewalk because he thought that he smelled beer while passing in front of a bar (though there was no smell of beer). This scene, however briefly stated by the participant, could have developed into a more complex story in his mind and/or even made him want to stop to have a beer somewhere if he had not had to continue the route. This example demonstrates how easily the context can trigger the apparition of an imaginary smell in our mind. It also shows how easily a phantom smell can add a sequence of meaning and call upon the mental narratives we keep in our mind. What we are thinking about on the moment can also influence our olfactory perception. Another example from the same study illustrates the idea: "*It smells of the afternoon! when children… come home after school. They stop at the corner store, to get some candy. I smell the chewing-gum*!" (Bouchard, 2013:112). Some perfumers are even able to mentally

reproduce an olfactory sensation in the absence of any stimulus (Béguin, 2000:30). This obviously requires good training, but it is fascinating to note that by repeatedly associating an olfactory memory with various contexts where the scent is not chemically present, this memory of a smell can become independent of any context.

Scents are usually connected to the milieu where they were smelled. To express what I have smelled, I would most probably use evocative expressions by referring to a semantic field defined by time and space (David, Dubois, Rouby, & Schaal, 1997; Boisson, 1997); for example: *Ah! This is the smell of an old house that is rrrrrrrreally taken over by mold. It smells of the basement, a humid cellar. I imagine… that it is beginning to rot somewhere, and it smells strong, bad, and your clothes take on the smell. Vampires live in houses that smell like that! You know, like a dungeon* (Bouchard, 2013:156). On the other hand, semantic information may have a unifying action on olfactory perception that overrode the influence of cultural background (Ferdenzi, Joussain, Digard, Luneau, Djordjevic, & Bensafi, 2016). Our perception of smells can even be affected by how we describe them, as odor labels may affect pleasantness and edibility perception (Manescu, Frasnelli, Lepore, & Djordjevic, 2013). Nevertheless, if odors are intimately linked to time and places (Engen & Lawless, 1977), it is because we keep in our memory sensory impressions of moments that has been significant to us. But still, since the brain pathways for spatial and temporal cognition involve overlapping and interacting systems that converge on the hippocampal region, space and time are integrated in the representation of memories (Eichenbaum, 2017a; Eichenbaum, 2017b).

THE SMELLSCAPER

Considering the wealth of knowledge presented in this paper, smells can be used as a strategic tool to reconfigure the experience of a place. So how should a designer go about incorporating the dynamism of smells at a specific space? It is already challenging enough to take human diversity into account when designing a city corner or a building. Age, physical capabilities, sensorial acuity, mental abilities, as well as memory sharpness, are a few of the factors that vary from one individual to another. How, then, can one create olfactory spaces to help people get through an episode of emotional distress? How can smells be used to create structures that have the power to interact with mental states?

Few researchers from the fields of planning and architecture have studied the olfactory dimension of the environment. Ohno and Kobayashi (1997), Balez (2001), Grésillon (1998, 2010), Diaconu (2011), Henshaw (2011, 2013), and Fraigneau (2016) are the ones I am aware of. Some have studied the use of odors in the built environment, others the hedonic impact of their presences in space, or looked into the link of olfactory ambiances with perceptual, cultural and social constructions. The architect Suzel Balez, to take one, studied olfactory ambiances in the constructed space in order to define technical and architectural devices for the control of olfactory fluxes. Following her study, she emphasized that controlling urban olfactory ambiances requires knowledge of atmospheric pressure regimes and prevailing winds in relation to the spatial configurations. Because the volumes of the city are, from an olfactory point of view, only obstacles or corridors for the circulation of air (Balez, 2000). Balez also points out that our sense of smell has also the peculiarity of adapting after a few minutes in a fragrant atmosphere. Consequently, to avoid the weakening of our awareness due to habituation, a designer needs to figure out ways of keeping the smell alive to the nose of the ones who will stay in a place for a long time.

Architects and environmental designers who want to use the power of smells in their project should first consider several parameters, the most important ones being: 1- the physiological state of the individual to whom the space is addressed; 2- the faculty of transformation and mutation of the

chemical composition itself, as the shape of an olfactory flow varies as it unfolds over time; 3- the dynamic of temperature, atmospheric pressure, and degree of humidity of the site throughout the day, the seasons: heat gives a smell a heady presence; cool weather diminishes its definition, until blurring it almost completely, if all elements that contribute to shape the smell are covered in ice and/or snow; and humid weather is not the only thing that interacts on the character of an odor, as our olfactory perception is also affected by barometric pressure and humidity. Our olfactory functions, for example, will decrease greatly at high altitude (Altundağ, Salihoglu, Çayönü, Cingi, Tekeli, & Hummel, 2013).

Some combinations are also to be considered. For example, since a pleasant smell will activate the amygdala, it will reduce depression markers and lower anxiety (Warden-Smith et al., 2017; Dong & Jacob, 2016). And according to Dong and Jacob (2016, p. 94), a clever combination of light and smell will reduce anxiety and depressive moods. In their study, "*human subjects were given smell (lemon, lavender or peppermint) and light stimuli in a triangular wave (60s cycle) for 15 min.* […] *The light-smell stimulus lowered blood pressure, both systolic and diastolic, and reduced heart rate for all odors compared to control. Of the two sensory stimuli, the odor stimulus contributed most to this effect. The different aromas in the light-smell combinations could be distinguished by their different effects on the mood factors with lemon inducing the greatest mood changes in Dejection-Depression, Anger-Hostility, Tension-Anxiety. In conclusion, combined light and smell stimulation was effective in lowering blood pressure, reducing heart rate and improving mood. The combination was more effective than either smell or light stimuli alone, suggesting that a light-smell combination would be a more robust and efficacious alternative treatment for depression, anxiety and stress*."

Designers should start to think seriously about how to compose with the smell potentiality of construction materials and to think about shaping spaces where ambiances have the potential to put at ease the mind of someone in mental distress or simply stressed by the vicissitudes of life. The goal is not to diffuse scents, but to stage a dynamic narrative in the space. Like a stage director who creates a play with volatile odoriferous materials, the smellscaper would offer people a dynamic experience where each olfactory note plays a role in the *odorific* symphony he/she composed. Like a perfumer, the smellscaper's goal would be to temporally harmonize a scented narrative. But for this to be possible, a compendium of the olfactory character of materials used in construction and urban design must first be drafted. In a world that takes the olfactory dimension of materials into account, we would find the description of the scent identity on the data sheet of every product available in construction and planning. Designers would therefore have a palette with which to compose. There is obviously a lot of work to be done to reach this point.

In summary, olfactory fluxes exert a significant influence on our definition of space by maintaining close ties with imagination and memory. The fragrant harmonies we perceive continuously allow us to evolve, by conscious or distracted mental projection, between the virtual planes of countless places we have encoded in our memory. Therefore, the objective of the smellscaper would be to conceptualize structures where olfactory ecosystems can live and expand at the beat of atmospheric turbulences. In this way, olfactory ambiances would take shape and stir up our mind to follow distinct narrative tracks in the temporal thickness of the environment. It is time for smellscapers to tell us stories.

Translation from the French by Amelia Facchin.

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To Dwell or not to Dwell? Attentional and Emotional Responses to Residential Places differing in Subjective Desirability

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ABSTRACT

There is currently little research exploring the psychological mechanisms that might underpin the urbanicity effect. Consequently, psychology has had little to say about how our experience of urban areas affect our mental health and wellbeing. This study used two methods to gather emotional and attentional information from young adults about their responses to residential images differing in perceived desirability. Using eye tracking and sentiment analysis we explored how, to what, and where attention is drawn as participants appraised residential place images with different questions in mind. Participants viewed images for a significantly shorter time when asked to appraise the images according to how threatening they seemed compared to how nice they looked. Further, both shared and distinct features of the photos were attended to depending on the question considered. Sentiment analysis conducted on written place appraisals confirmed that more negative emotions were elicited as participants contemplated residential images considered to be less desirable. Converging evidence such as this allows psychologists to build an understanding of how our living environments affect us. As greater ecological validity is built into these methods they can provide evidence for urban planning, governance and design aimed at the improvement of population level health and wellbeing.

Keywords: eye-tracking; sentiment analysis; urbanicity effect; selective attention; psychology of place

INTRODUCTION

Urbanicity

A substantial body of research has suggested that the quality of the living and built environment affects mental health and wellbeing (Weich, Blanchard, Prince, Burton, Erens, & Sproston, 2002; Honold, Lakes, Beyer, & van der Meer, 2012; De Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003). The phenomenon known as the "urbanicity effect," refers to evidence that living in urban areas contributes to the prevalence and incidence of poorer mental health and wellbeing (Faris & Dunham, 1939; Gallea, Ahern, Rudenstine, Wallace, & Vlahov, 2005; Sundquist & Sundquist, 2008) with elevated occurrences of mental health disorders being associated with urban compared to rural environments (e.g. Krabbendam & Os, 2005; Peen, Schoevers, Beekman, & Dekker, 2010).

This evidence suggests that specific characteristics of the urban environment facilitate the urbanicity effect such as over-crowding (Baum & Paulus, 1987), poor neighbourhood safety, (Honold, Lakes, Beyer, & van der Meer, 2012) and high-rise, dense buildings (Evans, 2003; Mitchell, 1971). However, Ellet, Freeman, & Garety (2008) showed that even brief exposure to a harsh urban environment can increase feelings of anxiety, persecution and negative beliefs in a clinical sample. In a study using an experience sampling method during a neighbourhood walk Corcoran, Mansfield, de Bezenac, Anderson, Overbury, & Marshall (2018) argued that it is the perceived quality and quantity of resources within the environment that contributes to psychological distress by affecting the sense of trust and threat experienced while in the area. Using sentiment analysis of descriptors gathered along an urban walk, Corcoran et al. (2018) revealed that descriptions of neighbourhood features were marginally more positive in the less deprived neighbourhood while sentiments of anger and fear were more marked in the more deprived neighbourhood along the walking route. Other than this study there has been limited research investigating what sensory cues inform our perception of, our psychological responses to, and our judgements about urban living environments. However, there is broad acknowledgement that defensive design, traffic density, distance between and designs of buildings, maintenance, cleanliness, evidence of criminal activity and weather conditions could all be informative.

One physical feature that typically distinguishes urban from rural environments is the amount of green space. Research consistently reports that the existence of accessible, good quality green spaces in neighbourhoods is associated with general positive mental health and wellbeing, reduced anxiety, and negative mood (Alcock, White, Wheeler, Fleming, & Depledge, 2014; Strum & Cohen, 2014; Nutsford, Pearson, & Kingham, 2013; Kaplan, 2001). It is now commonplace to hear public health and planning professionals agree about the importance of vegetation-rich green spaces for good health and positive wellbeing (Jennings, Larson, & Yun, 2016; Lee & Kim, 2015).

However, the mechanisms through which "green spaces" might affect health and wellbeing are not well understood and, in the rush to endorse a solution to poor urban health and wellbeing, a considered understanding of the "how" questions is often overlooked. It is clear that the relationship between green space and mental health is layered, complex and partly indirect, mediated for example, by social cohesion (De Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003). In a pair of experimental studies involving brief and remote exposure, Corcoran, Mansfield, Giokas, Hawkins, Bamford and Marshall (2017) showed that it was the perceived quality of the living environment, rather than its urbanity or green-ness, that was the key factor determining the change in anticipation of threatening occurrences (a psychological mechanism robustly associated with feelings of anxiety and paranoia) that arose following the contemplation of residential place images.

While the perceived quality of environment is a typical confounding variable in research exploring the effect of green spaces, the biophilia hypothesis has gathered support from research using diverse methods including virtual reality (Ellard, 2017) and neuroimaging (Martinez-Soto, Gonzales-Santos, Pasaya, & Barrios, 2012). For example, in a study using functional magnetic resonance imaging (fMRI), Kim et al. (2010) purported to show that images of "natural" environments activate brain regions associated with positive mental outlook, emotional stability, altruism, empathy and love. By contrast, images of urban environments showed preferential activation in the amygdala, an area associated with the processing of fear and threat suggesting a possible neural basis underpinning the urbanicity effect and preference for rural environments. Regardless of whether we support the contested idea of a universal preference for nature and the notion that all individuals and cultures prefer the same kinds of "natural" environments (Snaith, 2015), the finding that environments perceived to be harsh trigger a threat response is consistent with Corcoran et al.'s (2017, 2018) research.

Selective attention

Overall, attention is influenced by a range of bottom-up and top-down processes. Bottom-up approaches suggest that attention is affected by the saliency of the image, including low-level components of, for example, brightness and spatial frequency and that these contribute to attentional bias (Mannan, Ruddock, & Wooding, 1995) and automatic basic emotional responses. On top of this, and related to limitations in rapid and efficient processing capacity, we tend to consciously attend to specific aspects of our environment, focussing our attention in a top-down manner on aspects that are particularly pertinent or salient to us (Rensink, O'Regan, & Clark, 1997). This idea has been supported by eye movement research in scene viewing, because, rather than fixating on every part of the scene, individuals selectively attend to aspects that are considered to be important to them at the time of viewing (Rayner & Pollatsek, 1992; Antes, 1974). Moreover, top-down processing models argue that attention is also influenced by "higher order" cognitive influences (Henderson, 2007) such that prior cognitions and beliefs drive attention. Evidence suggests that our state of mental health and prevailing mood affects our attention by biasing information processing (Macleod, Matthews, & Tata, 1986). Specifically, anxious individuals exhibit heightened attention to threat and selective attentional bias to negative and threatening stimuli (e.g. Bennett & Corcoran, 2010). Similarly, consistent with the enduring cognitive model of depression (see Beck, 2008), mood congruent information processing biases feature in depression such that individuals heightened attention to negative stimuli effectively filters out positive stimuli. In support of this, eye tracking studies have found that depressed individuals have fewer fixations of stimuli regarded to be positive and selectively attend for longer periods of time to "negative" stimuli (Eizenman, Yu, Grupp, Eizenman, Ellenbogen, & Gemar, 2003; Kellough, Beevers, Ellis, & Wells, 2008).

Thus, one strand of a psychological model of the urbanicity effect proposes that it is the acquisition and interpretation of information gleaned from our surroundings that drives the effect of harsh urban environments on mental health and wellbeing. Specifically, attentional processes, directed by prior experience and beliefs, prevailing mood and temporary salient matters, as well as deep-seated emotional responses to particular cues selectively determine our responses to environments.

Theoretical Understandings

In relation to processing of information coming from the living environment, Gilbert's (1992) evolutionary model of human emotions provides a theoretical basis upon which to develop hypotheses to advance the psychological understanding of the urbanicity effect. According to Gilbert (1992) there are three main systems of emotions: drive, soothing and threat. In this model, the threat system is dominant because it allows the individual to quickly identity threats, whilst creating feelings of anxiety, fear or aversion. Identifying a potential threat triggers a

neurophysiological response that re-organises the brain's resources and attention. Thus, this model demonstrates how humans have evolved to focus their attention on potential threats to enhance their survival. While the threat system is a cornerstone of information processing for survival, an over productive threat system makes one vulnerable to experience everything as stressful, anxiety-provoking and exhausting. In Corcoran et al. (2018) neighbourhood walking study sentiment analysis was used to identify the core emotions and valence associated with descriptors of salient features identified and described in writing by the participants at the designated stops along the urban walking route. This method of analysis enables the identification of basic emotions associated with places, or place images, objectifying our implicit emotional responses to place as reflected in written descriptions. As such, it is a useful tool to help to unpack the psychology of the urbanicity effect.

Another model, consistent with Gilbert's theory and with biourbanism's understanding of the urban environment as a complex system featuring over-laying dynamic functions, purposes and human affordances (Serafini, 2014) provides further useful ideas about how we appraise novel environments. Coming from human geography, Appleton's (1975) Prospect-Refuge theory proposes that that we assess environments in terms of the balance of prospects and refuges within them. This theory proposes that the places where we prefer to dwell are those where we can identify both ample opportunity to support a thriving life and those with clear safety features to support withdrawal when required.

Finally, it has been argued that the complexities of the modern urban environment mean that attending to urban environments is more attention-demanding compared to natural environments. The so-called attention restoration theory (ART) proposes that "natural" environments provide restoration from fatigue caused by an overload of directed attention associated with complex urban environments (Kaplan, 1995), thus potentially explaining the seeming preference for "green" environments. A recent systematic review of the evidence for attention restoration after exposure to natural environments by Ohly, White, Wheeler, Bethel, Ukoumunne, Nikolaou, & Garside (2016) provides some support for ART but illustrates the uncertainty about which aspects of attention are affected by natural environment exposure. Some eye movement research by Rayner (2009) may shed some light on this. This research found that visual search is more difficult and challenging when the environmental scene array is cluttered, including dense objects and distractors, compared to a simpler array with inherent structure. Consistent with Vlaskamp and Hooge (2006), Raynor postulated that the increased cognitive demand associated with busy and disorganised arrays sets in motion a selective attentional style which reduces the number of fixations while increasing the duration of each fixation as the array becomes more complicated.

In addition to selective attention prompted by clutter and unpredictability of urban scenes, we propose that part of the psychology of the urbanicity effect exists in the fact that the urban environment also includes physical cues, that influence our individual psychology and regulate our social attitudes, and, by doing so, they contribute further to psychological distress. Furthermore, individuals influenced by basic emotional responses, prior beliefs, prevailing emotional state, and temporally relevant matters will selectively attend to those aspects of an environment that are most pertinent to their survival. Thus, it is assumed that focused attention, elicited by particular prompted search questions, will differ in terms of distance travelled by the eyes during scanning and the number of fixations identified during the visual appraisal.

The current within-subjects experiment used eye-tracking to explore participant's different attentional responses to place images when they thought about the same images in different ways. Sentiment analysis was also used to determine the level and type of affect generated by the place

images in order to cross check the allocation of images by subjective desirability. We tested the following specific hypotheses:

Indicative of bottom-up attention, we expected to see positive correlations between the perceived desirability of the place image and distance scanned by the eyes and between perceived desirability of the image and number of eye fixations. Tapping into top-down processing strategies we anticipated that contemplating how threatening a place is will be associated with less scanning distance and fewer fixations, compared to contemplating how nice a place is.

Demonstrating the differential effects of selective visual attention prompted by the contemplation questions, we expected that the fixation clusters associated with the two contemplation questions would be distinguishable and would align to either or both of the biophilia hypothesis and prospect-refuge theory. Descriptions of the place photos will differ according to the sentiments expressed within them in a way that relates to the corresponding subjective ratings of desirability.

METHOD

Participants

Data was gathered from 22 participants (male *N=4, females N=18*) of whom the majority were undergraduate students from the University of Liverpool ranging in age from 18–21 years. To maximise the power of the study we used a within participants design so that all participants provided data for all conditions. To be eligible to take part in this experiment, individuals needed normal or corrected-to-normal vision but they could not wear eyeglasses during data collection because of interference with the eye-tracking headset.

MATERIALS

Image selection

The 24 place photographs came from Corcoran et al. (2017) photo contemplation study in which, during a pilot study, participants, different to those involved in this study, considered the desirability of the images. 5 images were rated as the most desirable of the set (referred to here as desirable condition), 5 as the least desirable (referred to here as the undesirable condition) and the remaining 14 images were in a broad middle range being neither most nor least desirable (referred to here to as the “middle” condition). None of the photographs included people and none showed extremely impoverished or clearly very wealthy areas. Overall, the photos within each condition had similar amounts of green space and number of vehicles. However, the images did vary in residential structure, having been selected to represent typical residential areas in the UK. None showed high-rise housing. All of the residential place images used can be seen in Figure 3.

Stimulus presentation

The images were presented in random order. A fixation cross appeared for 2 seconds before every image after which the images themselves were presented on the screen for 5 seconds each immediately followed by the next fixation cross. The experimental testing environment had consistent lighting and conditions across participants. In order to reduce any effects of memory on the different contemplation conditions, the 2 conditions, presented in counterbalanced order, were separated by another unrelated eye-tracking task that involved participants reading different kinds of texts. In total, each session lasted approximately 30 minutes including the gaining of consent, set up presentation of the stimuli and debriefing.

Eye-tracking software
Eye tracking research enables the quantification of visual attention through metrics, e.g. fixation or gaze points (Trukenbrod & Engbert, 2007; Majaranta & Bulling, 2014). In this research eye movements were recorded by the Pupil Lab eye-tracking system, which included a headset (Pupil), recording software (Pupil Capture) and visualising software (Pupil Capture). In addition, the open source Pure Data (see https://pupil-labs.com) was used to present the stimuli as it enables researchers to create software graphically without writing lines of code.

The Pupil headset incorporates a world camera, 60 degree FOV, a wide-angle 100-degree FOV lens and a 120 Hz eye camera. The headset, worn like a pair of glasses, lightweight and easily adjusted, connects to a computing device that uses a modular system—Pupil Capture. Pupil Capture uses the stream to detect the individual's pupil, track the gaze and detect and track markers in the environment. The individual's gaze is then recorded as a video, streaming data in real time. The recordings from Pupil Capture software are visualised and exported through Pupil Player.

PROCEDURE

Participants were seated approximately 0.5–1m away from a computer screen and the computer screen was adjusted so that the centre of the screen was at eye level. Participants were provided with written and verbal instructions and then fitted with the eyeglasses. Camera adjustments were made to best capture each participant's right eye and then the eye tracking system was calibrated.

Following successful calibration, participants were asked to look at the 24 place images in two blocks whilst contemplating two separate questions "how nice does this place look?" and "how threatening does this place look?" in counterbalanced order. They were instructed to look at the fixation cross prior to each image, to standardise the starting location of their gaze. Depending upon which contemplation question they first received, they were then instructed to view the same 24 place images with the other contemplation question in mind.

After the eye-tracking was complete, participants were again presented with each place image on a separate computer screen and asked to rate "how much they would like to live in this place?" (1=not at all; 5=very much) and to provide 4–5 sentences describing what helped them to make their judgment. These descriptions provided the data for the sentiment analysis.

ANALYSIS

Fixations
Fixations are characterised by a series of gaze points that occur in close time and range, resulting in a gaze cluster. A custom R script was used to process the data and generate fixations. Identifying fixations minimises the complexity of eye tracking data whilst retaining the essential characteristics required for understanding information processing.

Distance Scanned
Distance scanned was determined by the absolute difference between the current X position and the previous X position plus the absolute difference between the current Y position and the previous Y position. X and Y positions were normalised in accordance to the surface markers and ranged from 0 to 1. So, X=0 is far left surface while X=1 is far right; Y=0 is bottom of the surface while Y=1 is the top of the surface.

Metrics of eye tracking
Surface heat maps were generated. These are static between subject aggregations of gaze points and fixations, revealing the distribution of visual attention through colour coded schemes. Red areas suggest a high number of gaze points, thus, indicating high levels of interest compared to yellow and green, showing fewer gaze points.

Low-level saliency maps
Eye movements in decision making are partially driven by stimulus properties that bias information. Since low-level components of the image affects attention, we aimed to control for this. Low-level saliency maps are computational models that highlight generalised eye movement prompted by these stimulus properties (Findlay & Walker, 1999). We controlled for eye movements in response to these stimulus features when examining the distribution of fixations on a given scene in response to the contemplation questions.

Sentiment analysis
The sentiment analysis, conducted through the R package Cognizer, wrapped function calls to IBM Watson services. Sentiment analysis codes words within sentences in terms of their corresponding emotional score. We specifically looked at the overall valence score for words, wherein a score of 0 indicates very negative valence and a score of 4 indicates a very positive valence. We also generated sentiment scores for the specific emotions of joy, sadness, anger, fear and disgust.

Statistical analysis
Data was analysed using Statistical Package for Social Sciences (SPSS) 24. Pearson's correlations were used to test hypothesis 1. Paired samples t-tests were used to test hypothesis 2. Hypothesis 3 was explored inspection of the fixation patterns associated with the contrasting contemplation questions. Hypothesis 4 was tested using repeated measures analyses of variance.

RESULTS

All data were found to be normally distributed and met the necessary assumptions of homogeneity to allow parametric statistical testing.

Table 1 provides the descriptive statistics for desirability rating, distance scanned by the eyes and number of fixations by photograph condition.

Contrary to hypothesis 1 that explored bottom-up processing by examining the relation between the subjective desirability of the images and the associated scanning pattern collapsing across contemplation question, neither the Pearson's correlation between the desirability rating and the distanced scanned ($r(24)=.22$, $p=.155$) nor the number of fixations ($r(24)= -.17$, $p=.208$) were found to be significant.

Our second hypothesis proposed that there would be a difference in how photographs were scanned according to the contemplation question used to selectively regulate top-down attention. The descriptive statistics relating to distance scanned and number of fixations by contemplation question are provided in Table 2.

Condition	Desirability rating	Distance scanned (cm)	No. of fixations
Desirable	3.99 (+/-010)	0.21(+/-0.01)	6.82 (+/-0.21)
Middle	2.97 (+/-0.80)	0.21 (+/-0.16)	6.86 (+/-0.30)
Undesirable	1.92 (+/-0.47)	0.20 (+/-0.01)	6.85 (+/-0.10)

Table 1: Descriptive Statistics (mean (+/-sd)) of desirability rating (1 = undesirable; 5 = desirable), distance travelled and number of fixations for each image condition (desirable, middle, undesirable)

Contemplation question	Distance scanned (cm)	No. of fixations
How nice is this place?	0.20 (+/-0.01)	6.95 (+/-0.15)
How threatening is this place?	0.21 (+/-0.01)	6.70 (+/-023)

Table 2: Descriptive Statistics of distance travelled and number of fixations for each image when contemplating how nice and how threatening (1=niceness and 2=threatening).

The second hypothesis was partially supported. A paired samples *t*-test showed that significantly fewer fixations were associated with contemplating how threatening the place was (*M*=6.70, *SD*=0.23) compared to contemplating how nice the place was, (*M*=6.95. *SD*=0.15), (*t*(9) =3.54, p=.003 (one tailed). *r*=.54) This significant difference in number of fixations by contemplation question is depicted in Figure 1.

However, there was no significant difference between distance scanned by the eyes when contemplating the photo in terms of how nice the place was compared to contemplating the photo in terms of how threatening it was (*t*(9) = -0.95, p=.185).

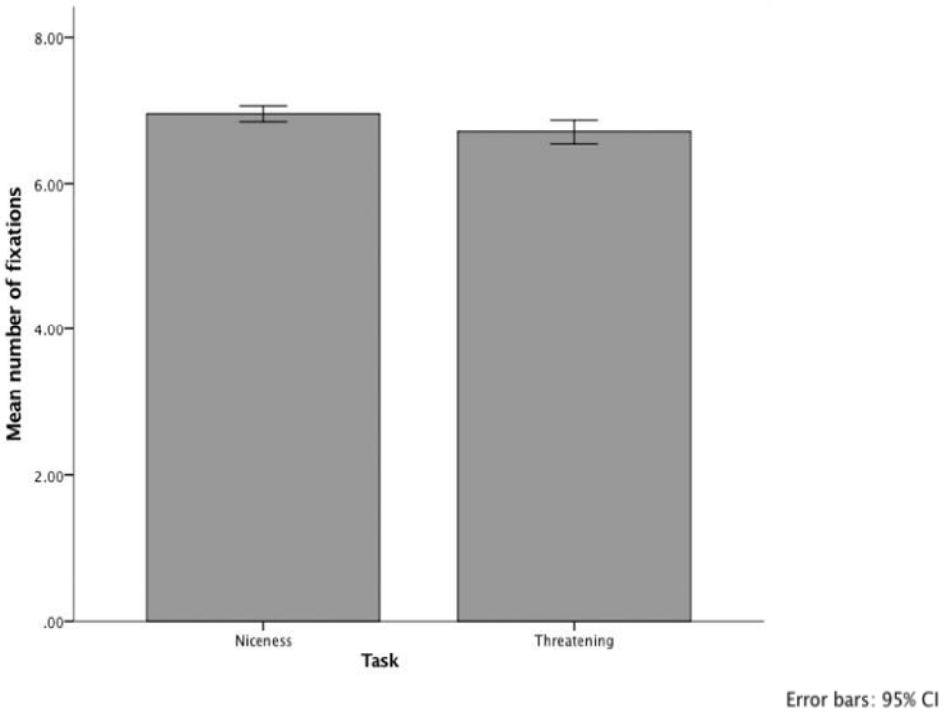

Figure 1: A bar chart showing the significant difference in number of fixations by contemplation question

Our third hypothesis proposed that the different fixation patterns associated with the 2 contemplation questions would be distinguishable and could be understood with reference to either or both of biophilia hypothesis or prospect-refuge theory. Figure 2 provides example heat maps that represent the different areas of focused attention when the participants were asked to contemplate the place photos in terms of how nice versus how threatening they considered them to be. In these heat maps, the blue fixation areas indicate clusters of focused attention when contemplating how nice the place is while the red fixation areas indicate clusters of attention when contemplating how threatening the place is.

Figure 2: Example heat map images representing the different areas of focused attention when the participants were asked to contemplate the place photos in terms of how nice versus how threatening they considered them to be. Blue areas = fixation areas for how nice is this place? Red areas = fixation areas for how threatening is this place?

Although only an impressionistic analysis, distinguishable patterns associated with the 2 selective attention scanning strategies were apparent. In general, we noted that the blue fixation clusters were more frequently around vegetation than the red fixation clusters were. We also noted a tendency for blue fixations to cluster higher up the images but not in the zone of sky, rather on the upper level of the houses while red zones tended to arise more at street level with a noticeable focus on cars and on vanishing points. However, house windows and doors seem to be areas of interest regardless of question.

Our final hypothesis focused on the sentiment analysis where we proposed that descriptions of the place photos would differ according to the sentiments expressed in them in ways that relate to the subjective ratings of desirability provided for each image.

A within subjects ANOVA revealed that there was a significant effect of image condition on overall valence scores ($F(2,63) = 37.03$, $p<.001$). Post hoc comparisons, using Tukey's test, indicated that the overall valence scores of place descriptions were significantly lower for the undesirable condition compared to both the desirable condition ($p=.002$) and the middle condition ($p<.001$). Furthermore, overall valence scores were significantly lower in the middle condition than desirable condition ($p<.001$). The heat maps associated with each of the 24 images can be seen in Figure 3 where they are labelled according to condition and Sentiment Analysis emotional response.

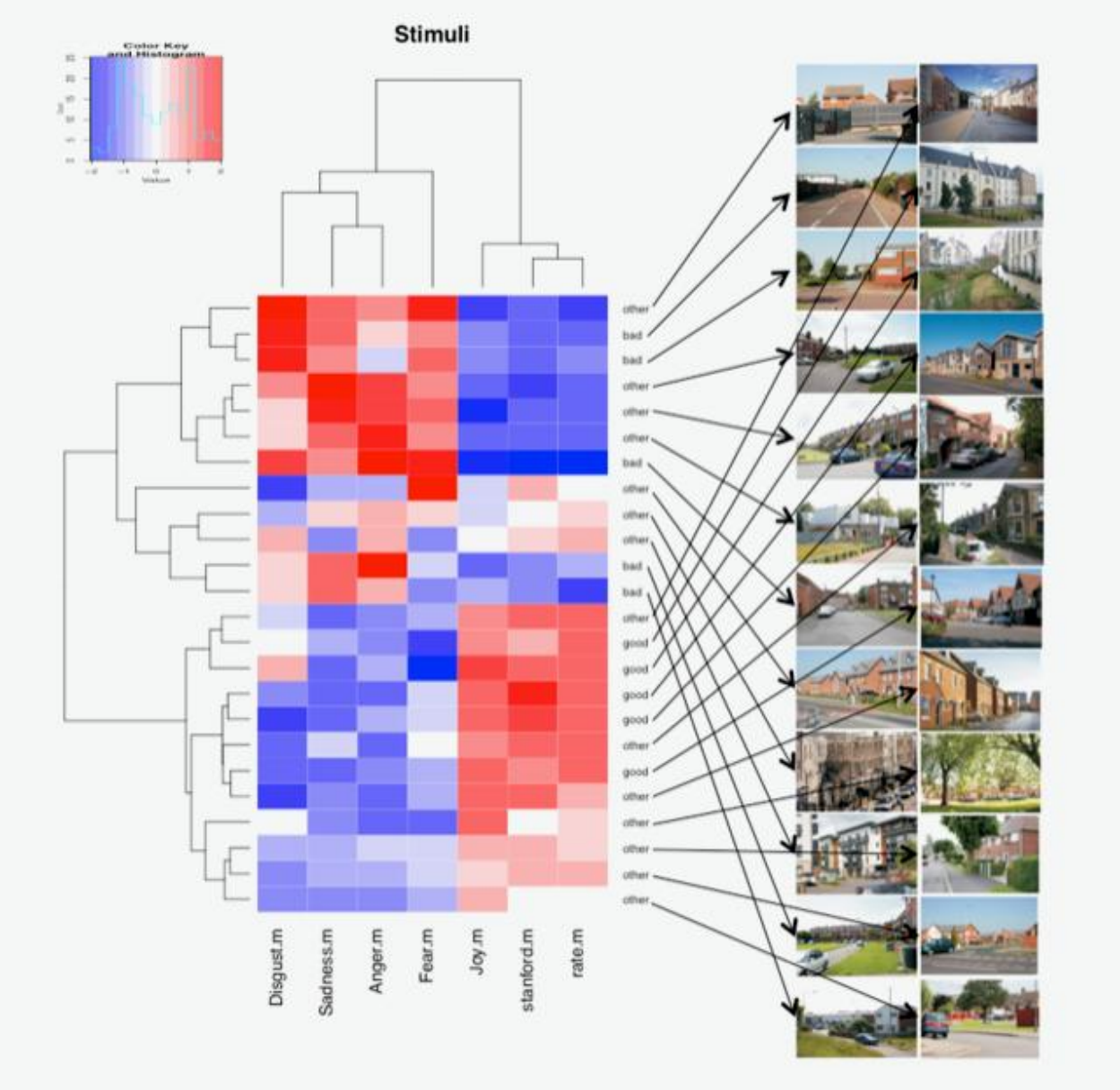

Figure 3: Heat map showing the relative emotional responses and overall sentiment scores (Stanford.m) for all 24 photographs labelled according to condition (good = desirable, other = middle, bad = undesirable) established by the pilot data of Corcoran et al. (2017)

The specific sentiments expressed in response to image conditions are represented in Figure 4 which shows the expected patterns in relation to the desirability condition. Joy, the only expressly positive emotion that sentiment analysis deals with, and sadness are the emotions that most convincingly contribute to the statistically significant differences between the conditions in terms of overall sentiment score. As expected, joy is more strongly represented in the desirable place photos and sadness in the undesirable place photos.

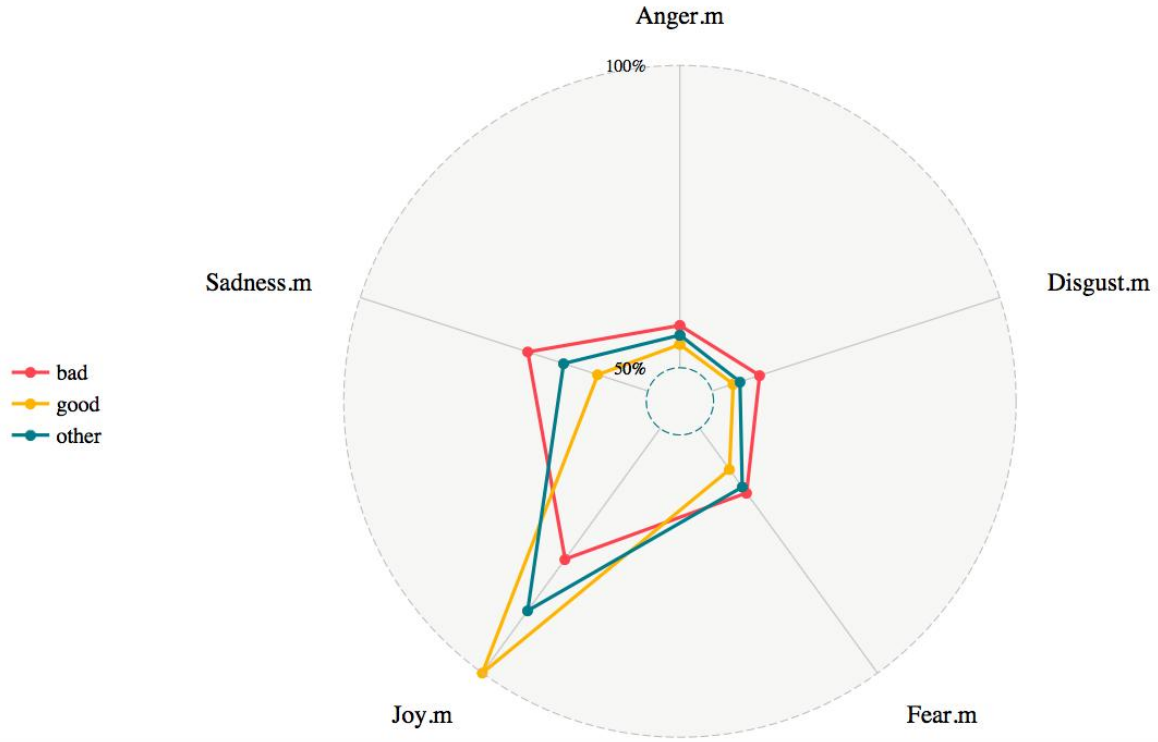

Figure 4: Representing the mean emotional responses (joy, sadness, anger, disgust and fear) from the descriptions provided for each image condition (good = desirable; bad = undesirable, other = middle)

DISCUSSION

This study explored how information is acquired as we contemplate different residential environments taking into account the low-level image-related features that naturally draw our attention (i.e. the low-level saliency modelling described in method). Through eye tracking and sentiment analysis, we aimed to uncover some of the psychological processes that underpin the urbanicity effect assuming that it is, at least in part, determined by how and to what we attend within the urban living environment.

As recent evidence points to the importance of the perceived desirability or quality of place, rather than necessarily the level of urbanization in influencing our psychological responses (Ellaway, McIntyre, & Kearns, 2001; Evans, 2003), our first hypothesis investigated whether differences in subjective desirability were related to how we attend to place images. As places rated as undesirable have been shown to increase anticipation of threat (Corcoran et al., 2017), and to illicit more negative emotion (Corcoran et al., 2018), we expected images of undesirable places to be scanned less extensively and to be associated with fewer fixation points than images considered more desirable. Results did not support these predictions however, as there were no significant associations between perceived desirability and distance scanned or the number of fixations.

Whilst the current study failed to establish a relationship between bottom-up eye-tracking scan patterns related to overall sense of desirability, we should be cautious when drawing conclusions on the basis of this single study. We can be certain that methodological choices and the low ecological validity of the experiment will have influenced our findings in various ways such as the choice to use a 5-point Likert scale that restricted the true variability of desirability scores and curtailing the

likelihood of detecting a significant relationship. As it seems implausible to suggest that bottom-up attentional processes will not play a role in our reactions to places in situ, we therefore regard these findings as reflecting the imitations of the lab-based study design.

The second aim of the study was to examine the patterns related to top-down selective eye scanning to see how guided appraisal of the place photos influenced what we look at and so, what information is acquired. We hypothesized that when individuals scanned the photographs with the question of how threatening the places were, we would see reduced distance scanned and fewer fixations, due to the selective focus on the matter of potential threat activating the threat system and determining primed behavioural responses. While we found no evidence of differences in distance scanned between the two contemplation conditions, there was a significant difference in the number of fixations. In summary, there was a medium sized effect of search question on focused attention, such that significantly fewer fixations were made when contemplating how threatening the place in the photo was, compared to how nice it was.

Thus, our findings support the top-down allocation of attention as we scan place images (Henderson, 2007). Moreover, as these findings show that the same overall distance scanned was found between contemplation questions but with fewer fixations for threat compared to nice-ness judgments, the finding is consistent with the notion that focused attention is more concentrated on aspects that are pertinent to our survival, supporting the dominance of the threat system proposed in Gilbert's model (1992).

Finally, in this work we aimed to validate the image conditions and findings from Corcoran et al. (2017) contemplation study by showing how participants' emotional response is related to the perceived desirability or quality of the place. Using sentiment analysis, we assessed the corresponding emotional scores (overall valance scores), derived from participant's descriptions of the places, predicting that overall valance would be highest for the "desirable" places and lowest for the "undesirable" places. Our findings fully supported this hypothesis. Furthermore, the specific emotional responses of joy and sadness seemed to differentiate the image conditions. Joy was elicited the most by the desirable place condition while sadness was most strongly elicited in the undesirable place condition. This finding mirrors that from Corcoran et al. (2018) where groups of participants who walked through contrasting neighborhoods responded significantly more joyfully to the less deprived compared to the deprived neighbourhood. Interestingly, and no doubt related to methodological differences, the negative emotions that significantly differentiated the more from the less deprived neighbourhood in Corcoran et al.'s walking study were anger and fear not sadness as was the case here. We believe this reflects the actual immersion in place that was the core feature of Corcoran et al.'s (2018) study with fear being the most theoretically plausible response when one is immersed in an unfamiliar harsh environment.

STUDY LIMITATIONS

Whilst the current study has contributed psychological understanding the urbanicity effect, the results need to be considered in light of several methodological matters. It is worth noting first one key strength of the study which is the within participants design. The fact that all participants completed both tasks in randomised order does allow confidence that the differences seen were due to the different conditions and not to individual differences in the participants as would be the main concern of a between participants design. The within participants design also maximized the statistical power of the study because each participant produced data on the 2 contemplation conditions as well as on the rating and description tasks.

However, the sample was relatively small comprising young adults who were mostly female. As there seems to be a clear sex difference in vulnerability to urbanicity effects (Sundquist, Frank, & Sundquist, 2004), this could question the generalizability of our findings. There were also other individual difference variables that we did not measure. For example, we did not know if any of the participants had pre-existing mental health issues. Such unmeasured variables, even in a within participants design could have influenced the findings as previous research has illustrated the heightened negative attentional bias in those with mental health difficulties (Macleod, Matthews, & Tata, 1986; Bennett & Corcoran, 2010).

It is unclear if the same findings would have emerged if we had tested an older adult or a younger persons sample. The emphasis in the public health literature of the importance of early years in relation to later manifestations of health and wellbeing makes the establishment of children's responses to different living environments critically important. Similarly, with increasing emphasis on age-friendly cities the reactions of older people to different living environments is something that needs to be addressed.

FUTURE RESEARCH

Future research should address the issues highlighted above. To overcome sample bias, the study should be replicated in a larger, more diverse sample that ranges in age and includes individuals from a broader array of socioeconomic backgrounds as well as including those with pre-existing mental health difficulties. The ecological validity of this lab-based study of place photo contemplation is low and future research should attempt to use this mobile eye tracking system in the real world.

Future research should also explore more deeply the matter of what environmental cues are selectively attended to as we process and consider places in ways that inform us about whether it is sensible to dwell in or to flee from them. While we propose that these informative cues are related to harshness, deprivation or impoverishment—cues to potential threat to survival and also to abundance of resource or prospects, it is likely that factors such as prevailing weather and traffic density may be equally important cues. The photographs used in this research attempted to control for these variables across the three conditions and so their influence could not be judged. While the impressionistic findings in this study indicate that our participants attended to vegetation when thinking about how nice the place was, we contend that while this is certainly consistent with biophilic theory, it is equally compelling to argue that trees and plants are informative indicators of prospect and resource. Hence, these theories may not be mutually exclusive but instead complimentary. By exploring such theoretical overlaps we can build a more nuanced understanding of what a psychologically benign environment would be like as well as deepening our understanding of the mechanisms through which environments confer positive psychological impact and thus appropriately broadening the biourban narrative. Future experimental research using mobile eye tracking, particularly if used with sensitive qualitative methods and wearable monitors capable of measuring indices of arousal not detected by eye-tracking, could begin to deliver this more nuanced level of understanding.

CONCLUSION

This study should be considered alongside a growing body of others that provide information on some of the component parts of an over-arching psychological model of the urbanicity effect. It examined how we attend to environmental cues embedded in place images differing in levels of

subjective desirability and according to prevailing concerns. If we are to design and maintain neighborhoods to facilitate positive psychological states in residents and visitors, then we must gather as much information as we can about cues that elicit ill-being and cues that elicit wellbeing. To do this, it is important to expedite and facilitate collaborations between social scientists and living environment professionals so that scientifically derived evidence can be implemented and incorporated into place-making and place-stewardship guidance.

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Reviews & News

LIFE AS SEMIOSIS

Marcello Barbieri (1985). *La teoria semantica dell'evoluzione*. Turin: Bollati Boringhieri [*The Semantic Theory of Evolution*. London – New York: Harwood Academic Publisher].

Review by Antonio Caperna
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Emergence, evolution, and adaptation of life represent still today one of the mysteries science seeks to unveil. Marcello Barbieri, biologist from the University of Ferrara, Italy, proposed a new hypothesis about such a mystery in his *The semantic theory of evolution* by extending the Darwinian paradigm. In addition to the idea that "life is replication" and "life is metabolism" (or, according to Maturana & Varela, 1973 "life is autopoiesis"), Barbieri introduced a third concept: "life is semiosis".

According to Barbieri, semiotics is a fundamental principle of life: "… the aim of biosemiotics is an idea that all living organisms are semiotic systems and that semiosis is not a side effect, but the fundamental process of life" (Barbieri, 2002). Marcel Florkin coined the term "biosemiotics" in 1974 while studying semiosis (the production of signs) at the molecular level. Before him, also George and Muriel Beagle, in 1966, had underlined the link between biology and semiotics. They wrote that, "the deciphering of the genetic code has revealed our possession of a language much older than hieroglyphics, a language as old as life itself, a language that is the most living language of all—even if its letters are invisible and its words are buried in the cells of our bodies."

After a few decades where biosemiotics was characterized by distinct lines of research, in the early 2000s it became a more or less unified discipline around the common ideas that all living beings are semiotic systems, semiosis is fundamental to life, and semiosis and meaning are natural entities.

Let us try to figure out his thought and its relevance for biourbanism.

From a biochemical point of view, Barbieri's hypothesis added a third element to the canonical dualism of genotype and phenotype—the ribotype, a structure that represents a key element in the organization of living system. Barbieri suggested that the living organism (phenotype) with all its intrinsic and relational characteristics, both internal and external, is the result of a process of cooperation between genotype and ribotype. What characterizes such cooperation is an informational process. Right across the informational process a biological "meaning", necessary for the construction of a living system, "emerges."

Going beyond the definition of living organisms in terms of reproduction and metabolism (or, alternatively, as autopoietic systems) to introduce a semiotic process means analyzing the "signs" and the information coded in these signs, which appear on every level of life's organization. Thus, Barbieri added an informational paradigm to the chemical one, suggesting that life is not just energy and matter, but rather chemistry-plus-information-plus-code, i.e. combination and cooperation between chemical laws and the existence of codes. The so called "code paradigm" stresses that life is based also on copying and coding, yet it refers not only to information but also to its meaning.

Barbieri suggests that no deterministic relationship occurs between sign and meaning; there is rather the possibility of establishing a bridge between the rules of a code. Therefore, a semiotic

system is characterized by at least three distinct entities: signs, meanings and code. Further, it is made of two independent worlds connected by the conventional rules of a code.

In this framework, semiosis becomes a universal principle underlying the basic processes of life. In fact, it is necessary to see the development of an organism also as a process of informational interpretation. The comprehension of this process represents a fundamental step to understand the evolution of living systems.

What are the consequences of this approach?

First, the introduction of semantics originates a theoretical shift. In fact, the semantic element cannot be quantified, and it needs to be analyzed through its constituent elements, which are sequences and matching rules. In other words, it is not possible to quantify the semantic value of a system without describing from time to time its rules of correspondence, because information and meaning remain entities that cannot be reduced and expressed by anything but themselves. Theoretically, this implies the necessity of a new ontological category in order to study living structures effectively.

Second, semiotics shows that evolution is not a mere process of natural selection acting upon genetic variations; this leads towards a reformulation and reconceptualization of its general theory. Biosemiotics brings the realm of signification into the sciences of life. Likewise, this makes us think that no study of urban disciplines can be effective without focusing on the correspondence between forms, functions and codes on one hand, and their intrinsic meaning on the other.

Another aspect to be taken into account is the possibility of extending this framework to other fields, such as language where, according to Chomsky (1975), a universal grammar seems to exist, i.e. a mechanism that has the ability to retrieve the countless rules of any particular language from a limited sample of them.

In fact, the ability to create an unlimited number of new rules simply by applying the basic algorithm of a universal grammar can be observed also in urbanism. Traditional architecture shows a sort of universal mechanism that starting from basic bi-dimensional structures unfolds into a three-dimensional body. The forms of such a body are not planned in advance, and yet they have the capacity to adapt to their specific environment. Genetic algorithms transform simple structures into new, complex bodies, which have epigenetic properties that were not present at the beginning.

As affirmed by René Thom, the fundamental intuition of Barbieri was about the need for finding a bridge between genes and proteins. Nevertheless, the French scholar highlighted that the author still needed to fill some important gaps, especially with regard to the fact that “the geometric aspects of morphogenesis are [...] passed over in silence” (Thom, 1985, p. 12). As a response, Barbieri published *The organic codes* (Barbieri, 2002), which, in addition to deepening and widening the field of research opened with the 1985 work, seemed to satisfy the request of his colleague.

Barbieri’s theory opened a new field of research that, supported by experimental tests, provided new interesting lines of research on the origin of life and its evolution.

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CLIMAX CITY

David Rudlin and Shruti Hemani. (2019). *Climax City: Masterplanning and the Complexity of Urban Growth*. London: RIBA Publishing.

Review by Stefano Serafini
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Where are cities going? What share of real control do planners have on their transformation, which seems more and more a process independent by any human project and good will?

Besides usefully marking the state of the "subtle art" of masterplanning (and listing its failures), *Climax City* tries to answer such an honest and deep questioning that involves a subject wider than urbanism, i.e. our relation with nature and history, our freedom as human beings, and democracy.

The authors are two brilliant scholars and professionals who have observed the evolution of the urban world for decades. David Rudlin, Chair of the Academy of Urbanism and Honorary Professor at Manchester University says he became a masterplanner "by mistake" (p. 79)—a humble way to avoid saying he is first of all a philosopher of planning, i.e. an urbanist. Shruti Hemani is a Professor at the Aayojan School of Architecture in Jaipur and, in addition to planning, she researches the particularly fascinating phenomenon between physics, perhaps biology, and social sciences that is represented by informal settlements.

The work of Rudlin and Hemani has been triggered by two dramatic observations. First, despite their best intentions, planners' work tend to turn into urban disasters. Second, most unplanned cities, even with their defects, work pretty well and exhibit "an internal order and logic" (p. 1). The digestion of these facts came across what I would define as a geographer's instinct: Rudlin and Hemani drew many maps of different cities, taking advantage of satellite cartography that Saverio Muratori and other masters of the past could not access. Rudlin and Hemani thus focused on the structural organization of road and street networks. These life vessels can tell much about the condition of cities, their functionality, beauty, and stability as, on another level of connective dynamics, Damiano Cerrone had confirmed first with his analyses of mobile phone movements, followed by qualitative data from mobile social media users in the city (Cerrone, 2016).

By borrowing the concept of "climax vegetation" (the final and stable condition of a wild place that, passing through several changes, has been left to flourish naturally), Rudlin and Hemani coined the expression "climax city" for indicating the point of arrival of urban evolution, i.e. the stable pattern that is supposed to define the skyline of future humankind. They refer to the results of decades of complexity theories of city (CTC) (Salingaros, 1998; Portugali, Meyer, Stolk, & Tan, 2002; Batty, 2018) that, in a nutshell, see the urban *monstrum* (something indecipherably oscillating between an artifact and a natural phenomenon) as a self-organizing process emerging from collective (and packed) human behavior. In fact, such a vision of the city as "the human equivalent of the termite mound" (p. 2) puts the standard division of disciplines at unease because of the ambiguity of urban nature and jeopardizes the very concept of human ability to govern it. The structural similarity worldwide suggests the emergence of preferential patterns that tend to keep steady for long periods, and such a pattern (or group of patterns) became the goal of authors' research.

The authors accept the idea that not only self-organization but also natural selection has an important role in the emergence of robust patterns in biological structure as in cities' design. Nevertheless, they refuse any sociobiological reductionism (p. 291), because they believe in the

actual possibility for planners to participate in the process. Like an atlas of the urban world, the book presents three main types of cities: spontaneous, designed, and unruly. A final discussion, "The city and the planner," explains the wisdom of planning (one would say, "farming") the "natural urban growth," as Hemani calls it (p. xiii).

When observing how Syrian refugees reshaped the military-ordered Jordan Zaatari camp "into something resembling a traditional Syrian town based on extended family groups" (p. 4), the authors come close to Besim Hakim's observations on the millennial operating "codes" of a largely unwritten Mediterranean urbanism (Hakim, 2014) on one hand, and those of Robert Neuwirth, who writes how "all cities start in mud" (Neuwirth, 2006, p. 179), on the other. Their just fear of "romanticizing" slums is reflected by Neuwirth and Hakim in agreement that cities need not only the livelihood and freedom of the "foundational slums" (or of the "third generation city," according to Marco Casagrande, 2013) but also a top-down system of infrastructures.

Here, Rudlin and Hemani propose the interesting metaphor of the trellis and the vine: "rather than seeking to replace the process of natural growth with an imposed plan, the masterplan becomes a frame into which the city can grow." (p. 81). The deliberate activity of planning (and which activity could ever be more deliberative than planning?) enters the natural mechanism of urban growth to perfect and accompany it to the climax state. Acknowledging and accepting the impossibility of *total control* over the natural self-evolution of the city puts things in the right perspective.

To exemplify such a middle-out approach (Giuliani, 2017) a noteworthy discussion of the important planning failure of Masdar City is presented. The notorious project by Foster and Partners is first contextualized as a special kind of "climax urbanism of global capitalism, a world in which international business is transacted in marbled lobbies and air-conditioned malls" (p. 283) that is not by chance realized in a politically artificial place such as Dubai. In fact, "Dubai has created a model that all of the world's cities are trying to emulate" (ibidem).

Dubai represents a tremendous success that stands out from any other tax-free zone in the world because it gave up any political identity. In defiance of being built within an Islamic state, it does not apply Sharia law. International trade dominates and substitutes politics, hence the *polis* morphs into a market with urban features. Dubai speaks English, the U.S. dollar is its currency, money is its only god, and citizens are substituted by nomadic economic entities. Even its architectural style is a patch of unrooted memories from Asia, the U.S., and Europe, resulting in an impressive form of hyper-consuming global urbanism (pp. 283–284). Its masterplan envisions glittering, starchitects' towers, imposes a whole without taking in consideration the variables of time and life, and does not offer any real structure because, unlike society, capitalism does not need any. Global capital, the real lord of Dubai, "has no interest in place, or community but sees buildings as investment instruments to be stacked high or corralled into luxury gated communities and sold to the highest bidder." (p. 284).

One hour and half of car from Dubai, Masdar City has been established accordingly. The once-trumpeted deliverables, by failing to be achieved one after the other, expose the incoherence of the compromise between finance and environmentalism (or rather, the hypocrisy of a global advertising strategy): no carbon neutrality, no Personalized Rapid Transit system, no end of car commute, and not even the more traditional rail train connection to Abu Dhabi. The enlightened design, the many brilliant ideas, the up-to-date technical solutions, the noble aspiration for a zero-emission city—all miserably fell under the weight of reality. According to the authors, this failure depends on the incapability of understanding that no one can design an entire city and its complex multidimensional life out of thin air and expect a linear result.

Like in economics, we should rather accept that when approaching the problem of a city, we are dealing with a system that is not entirely within our control. “We therefore need a new form of planning that works with rather than against the natural process of urban growth, that understands incremental change as something that is inevitable. We need a form of planning that accepts that it can influence the way that a city develops without being able to determine the outcome.” (p. 292).

Rudlin and Hemani think we need to “rediscover the process” of traditional masterplanning, which does not mean “a particular style of development” (p. 294) but rather a set of general constraints for creativity and individual solutions of concrete needs to flourish independently. This is very similar to the proscriptive, not prescriptive, character of the urban codes studied by Hakim (2014), the physical “trellis” designed by Casagrande for his *Paracity* (2016), and the intuition of Marwa al-Sabouni caring for the reconstruction not just of the urban infrastructure of Syria but of its civic society (al-Sabouni, 2016).

At the end of the book, the authors return home and devote some pages to the British planning system that they see plagued by poor quality of development, drawn into a system of interests that is not the fault of architects, planners, nor developers. We definitely agree with their conclusion: “the way to bring about radical change is to change the system” (p. 295).

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FARMING STARS: IN MEMORY OF PROFESSOR GIUSEPPE SERMONTI

by Stefano Serafini

While editing the current issue, the geneticist and writer Giuseppe Sermonti died at the age of 93. Member of the scientific board of the *Journal of Biourbanism*, he has been Professor of Genetics at the Universities of Palermo and Perugia. His most important discoveries in biology deal with parasexual recombination of *Penicillium chrysogenum* (with Bruno Pontecorvo) and the genetic recombination of *Streptomyces* (with his wife Isabella Spada). The first one eventually led him to open the door to the industrial production of penicillin and thus to found and establish the industrial genetics of microbial breeding (Sermonti, 1961; 1969). Friend of the late historian and architect Saverio Muratori (1910–1973), he contributed his urban morphology with discussions on the form and the city as a living organism during the early '60s when the latter was working on the *Storia urbana di Roma* (Muratore, Bollati, Bollati & Marinucci, 1963; Cataldi, Maffei, & Vaccaro, 2002).

Sermonti stressed the roles of self-organization, emergence, form, and cooperation in nature. Accordingly, based on epistemological, sociological, and biological arguments, he used to criticize Darwinism severely, deconstructing the sociological bias beneath the ideas of "evolution" and "selection of the fittest"—an attitude that, for a biologist, resembles heresy. His journal *Rivista di Biologia / Biology Forum* published works by worldwide biologists unsatisfied with the neo-Darwinian mainstream. These included researchers from the structuralism and the nomology schools, and thinkers inspired by the work of von Baer, von Uexküll, and De Rosa (Serafini, 2007). Despite his lively cooperation with scholars from several countries, including the USSR, and the success of his books, Sermonti paid for his non-conformity by being ostracized in Italy. Typically, such hostility came from both sides of the fake opposition between the "Catholics" and the "materialists" (later on the "creationists" and the "dawkinists"), as he refused to take part in what he considered a puerile discussion, because "how low must a theology be in order to be supported or denied by science?" He also noted, "I have been accused of being a creationist. I am not. I rather long to be a creature." It is noteworthy that the only English translation so far of one of his works came by the creationist Discovery Institute (Sermonti, 2005) and that the same book was then translated into Chinese by a Marxist publisher (Sermonti, 2017).

In the last, fertile period of his life, Sermonti moved his attention from life sciences to culturology. He focused on the emergence of forms in science, seen as a "narration of the world", fairytales, and mythology (Sermonti, 2004). Very interesting is his study on the origins of Semitic alphabets that he derives from the most ancient calendar of humankind, i.e. the constellations (Sermonti, 2002).

Sermonti has been a scientist, a radical epistemologist, and a marvelous writer. He hunted forms in the cracks of established culture where the boundaries of "facts" melt into endless possibilities and indecipherable meanings. Under his elegant hands, biology, theoretical science, culture, and traditions turned to their glorious humility, becoming tools for farming thoughts where stars can sprout and give us light.

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