BIOPHILIC DESIGN, RESTORATIVE ENVIRONMENTS AND WELL-BEING

Ana Karinna Hidalgo
PhD student, Faculty of Environmental Design, University of Calgary
✉ akhidalg@ucalgary.ca

ABSTRACT

Well-being in cities can be addressed from the perspective of multiple disciplines. Urban design can contribute to creating built environments within nature with tangible elements to provide psychological restoration that releases stress and mental fatigue. To do so, many design approaches, such as biophilic design, biomimicry, and eco-cities can make a contribution to this topic. This paper is focused on biophilic design as an urban design approach aimed at understanding connections between natural and built environments in relation to psychological restoration. Important inputs from environmental psychology and public health are also considered to understand people's responses to different natural and built environments. This paper consists of an extensive literature review of these disciplines and approaches in order to provide designers with elements to be considered for the design of restorative environments. These elements may include natural water features, natural light and colors, vegetation, and well-designed buildings to improve people's well-being.

KEYWORDS: *well-being, psychological restoration, biophilic design, environmental psychology, restorative environments*

INTRODUCTION

Biophilic environments in urban spaces can provide people with psychological restorative experiences by releasing mental fatigue and decreasing their levels of stress. This restoration process in turn improves people's well-being. Public urban spaces should be considered as restorative places where more people could benefit from biophilic elements.

Urban spaces are constantly changing over time. The uses of urban spaces depend not only on their function but also on the historical, cultural, social, and economic aspects of a city. Nowadays, urban researchers are focusing on the social and cultural aspects of cities and the interconnections of people within urban places (Gehl, 2010; Madanipour, 2010). However, this is not the only direction that urban theories are taking. For instance, UN-Habitat (2013a) is challenging city leaders to design good cities and to consider the streets as public spaces and drivers of well-being where all users can be engaged in different ways (UN-Habitat, 2013b).

Well-being has been studied from different perspectives. Urban design historically relates the concept of well-being to comfort status that people obtain in public places. This does not imply that this objective was always achieved, but that this field is in the search for promoting well-being and the understanding of the urban components of it. Most of the theories related to well-being in public spaces refer to the way people understand, experience, and perceive a space because of its legibility (Lynch, 1960; Appleyard, 1976), or the way people enjoy outdoor activities (Jacobs, 1961; Madanipour, 2010; Gehl, 2011).

How people experience the environment and how they are related to it is twofold. On one hand, the built environment is a result of its physical characteristics, whereas, on the other, the quality of the urban space, as a result of the wealth, culture, social issues, and age of the city, also takes part in people's perceptions (Steg et al, 2013). All these variables identify a city and influence its residents, who in turn are able to change the environment both positively and negatively. The environment influences each individual differently; what is common ground is the set of elements suggested by environmental psychology based on experiments and evidence from this field.

Kopec (2006), Gifford (2007) and Steg et al. (2013) offer a wide range of evidence from several research studies on natural and built environments. From these results, and in order to promote people's well-being, environmental psychologists suggest the use of natural features within urban spaces that can provide positive outcomes at different stages and for different purposes, such as forest-like playgrounds, green roofs, edible gardens, and tree lined boulevards. These features are developed by approaches different from urban design theory,

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for instance, ecological cities (Register, 2010), biomimicry (Benyus, 2002), and biophilic design (Wilson, 1984; Kellert et al., 2008).

One of the main benefits of nature is the psychological restorative effect that will be addressed in this paper. Firstly, this paper presents the definition of well-being and restoration as outcomes to be achieved by design, and the definition of stress in order to understand one of the factors that is threatening people's well-being. Secondly, the concept of biophilia and biophilic urban design spaces will be provided. This section presents the state of the art of this approach based on the work by prominent researchers in the field. The third section addresses the relationship between psychological restoration and biophilic design, and discusses the positive outcomes from natural environments based on relevant evidence. Finally, some suggestions about further research are proposed, as well as the need of an interdisciplinary approach to offer more appropriate responses to urban stressors.

WELL-BEING, STRESS AND RESTORATION

For the purpose of this paper, it is important to define some interdisciplinary keywords in order to maintain a common language. Well-being, stress and restoration will be considered from a psychological perspective with insights from public health, which will be later understood in the context of the urban design field.

The pursuit of well-being is a goal for people around the world. The lack of well-being is an impediment not only for individual development but also for the development of an equal society. One of the factors that negatively impacts well-being is stress. For the purpose of this paper, and based on the definitions from other fields, well-being is understood as the condition of being healthy from a psychological perspective (NWIA, 2011), and having social interactions of good quality (HRSDC, 2013). Subjective well-being (SWB), widely employed in psychology and economics, refers to people's mood and emotions that result from being exposed to events or stimuli of different nature (Diener, 2000). Subjective well-being is defined as good mental states that include positive and negative self evaluations reported by people about their lives and the affective reactions to their experiences (OECD, 2013).

Cities aim to provide people with environments that improve their quality of life. However, cities, and specifically streets, produce urban stressors that threaten the ability of people to restore themselves from stress and mental fatigue (Kopec, 2006; Gifford, 2007). In this context, stress is a state of mental or emotional chaos that results from adverse or challenging circumstances that affects people's mental and even physical health. Psychological stress occurs when a person's perception of the environment is above or below her capacity of adaptation, which challenges or threatens well-being (Ulrich, 1986; Cohen et al., 2007). Psychological restoration is, in general, the ability of a person to overcome stress and mental fatigue, and experience mental rejuvenation.

Stress establishes links to health by affecting the immune system and provoking psychological problems (Bilotta & Evans, 2013). The ability to balance all aspects of life such as social, physical, spiritual, economic, and mental domains, can reduce the level of stress (CMHA). From an environmental perspective, stress is a human response to the imbalance between environment demands and the capability of human response (Steg et al., 2013). A continuous exposure to stress may influence and also affect physical health because of the biological processes or behavioral patterns that influence disease risk. Stress is a process where the person responds psychologically, physiologically and even behaviorally to a specific situation that challenges or threatens well-being (Ulrich, 1986).

From a psychological perspective, a person can be restored from stress by being exposed to nature. Restoration (from Latin *recreation*, *recreationis* = restoration, refreshment, and recovery), refers to the experience of both psychological and physiological recovery that is activated in specific environments (Joye & van den Berg, 2013). The capacity of people to recover their health status from illness or stress in urban environments is related to a successful achievement of well-being and the main concern of urban design.

Virtual and direct relation to nature and other features such as water, music, and colorful surfaces can be beneficial for psychological and physical health because of the reduction of the stress they promote. Robert Ulrich (1984; 1986) shows, for example, that even if healthcare facilities are stressful by themselves, patients and visitors get benefits from the presence of vegetation and green landscapes. He finds that patients recover more rapidly from a surgery if the window of their healing rooms shows green landscape compared to those that have a wall instead. His findings are acknowledged and used as a basis for stress restoration theories (Kopec, 2006; Gifford, 2007; Joye & van der Berg, 2013).

Psychologists define two main theories about restorative environments that, despite focusing on different aspects of restoration, are related to each other because restoration is a multi-faceted process (Roe & Aspinall, 2011; Gifford, 2007; Kopec, 2006). Therefore both theories, attention restoration theory (ART), and stress recovery theory (SRT), are considered here in order to have inputs for the development of a theoretical framework from an environmental perspective.

The ART focuses on the fatigue provoked by the active attention that people need during most of a workday. According to Rachel Kaplan & Steven Kaplan (1989), people need to go through four phases to overcome mental fatigue: fascination, directed attention to the fascinating environment, contemplation, and deeper restoration experience. Ulrich et al. (1991) propose the SRT by focusing on stress reduction from an affective and aesthetic response to the environment. People's preferences for natural landscapes, shown by their choices about where they live and recover, constitute the scientific evidence for this theory (Ulrich et al., 1991). SRT considers that restoration from stress occurs when it positively impacts people's well-being (Joye & van den Berg, 2013).

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Restoration and well-being are concepts related to each other. From an urban design perspective, restorative spaces are ideal to provide people with stress recovery and mental fatigue release. Specific urban places such as parks, museums, spiritual temples, and healing buildings usually provide restorative experiences. Most of the elements that constitute these spaces include nature and the possibility to personalize the environment.

BIOPHILIA AND DESIGN

Edward O. Wilson, a well-known biologist, coined the term biophilia in his book *Biophilia* (1984). He defines biophilia as the innate urge of humans to affiliate with nature and other forms of life and life-like processes. The desire of having more livable habitats obeys this urge and is called aesthetic criteria (Wilson, 1984). Biophilia, 'the innately emotional affiliation of human beings to other living organisms' (Wilson, 1993, p .31), is an integral part of the human development process and of the physical and mental growth. As a consequence individuals look for opportunities to enjoy nature outside cities because these are places that are usually not offering this type of refuges, such as tropical forests, the savannah of human ancestors (Heerwagen & Orians, 1993).

Even if biophilia has its origin in biological science, Wilson (2008) is aware that this term unites disciplines as a cause-and-effect explanation, for instance among biology, social sciences, and design. The inclusion of social aspects can be grounded on biophilia complexity by considering also cultural and ethnic differences among individuals and communities (Soulé, 1993).

Historically the built environment has been integrated with the natural environment, and traditionally local materials and processes constitute the local aesthetics and heritage of society. Nowadays, neither local materials nor local vegetation that protects endemic flora and fauna, which is vital to the biophilic approach, are used as they were before. Kellert et al. (2008) argue that biophilic design takes advantage of an intrinsic human affinity to incorporate natural and local systems and processes into the design of the built environment. People have given different values to nature according to its functions, for instance physical sustenance, experience and curiosity of people in contact with nature, the understanding of its systems and structures, communication and expression, mimicking its mechanics, and spiritual reverence and affiliation ties (Kellert & Wilson, 1993; Kellert, 2008).

Different biological perspectives of design have been developed in the last two decades inspired by the Brundtland Report (United Nations, 1987) that challenges future development to grow sustainably. Initiatives on closed-loop industrial cycles, for example by considering buildings as living organisms ('Cradle-to-Cradle', McDonough & Braungart, 2002), or biological inspiration for mimicking natural structures and processes to develop efficient and aesthetic innovative designed objects ('Biomimicry', Benyus, 2002), are just a few examples of these revolutionary approaches. These perspectives are aimed at searching for energy efficiency, clean industrial production, product innovation and design methodology based on biological mechanisms and interactions of living things. However, the environment itself is not the topic of study of these approaches. As part of the same biological design approach, biophilic design is focused on environmental issues and psychological effects of nature on human's well-being with special interest on how biophilic environments can provide people with restoration.

According to Beatley (2011) biophilia shows that the evolutionary and biological contact with nature cannot be avoided, even if people believe that life without nature is feasible. Janine Benyus (2008), the lead author of the biomimicry approach, points out that there is wisdom in bringing nature back into the building process by incorporating elements inspired by biophilia into the built environment. These elements include organic forms and structures, daylighting, natural ventilation, an environment quiet enough to enjoy natural sounds, a changing palette of colors, bringing working ecosystems indoors, and bio-inspiration gardens.

Biophilic Urban Spaces

An urban space is where the interactions between people and the urban environment occur producing a variety of different experiences (Jacobs, 1961; Gehl, 2010). The concept of urban place goes beyond the physical characteristics of the built environment. According to Macdonald (2011) the urban place is the public realm that needs to shift its direction in public values in order to take advantage of ecological opportunities that each particular environment may have. The concept of meaning is incorporated into the concept of urban space where thoughts, behaviors, activities, and life emerge and occur. The experience with the natural environment consists of views of nature and landscapes, whereas attitudes and emotions towards wildlife constitute part of this meaning (Gifford & McCunn, 2013), which in turn is related to the concepts of sense of place and place attachment.

Gifford (2007) suggests that it is important to define the city, the specific group, and tools to be used in order to study a place. The peculiarities of the natural and built environments make a huge difference in the outcomes expected from a specific site. One of the issues that urban environmental researchers are looking at is how natural environment and its complexity influence people's well-being. An approach that takes advantage of these concepts in a positive fashion is therefore biophilic design (Wilson, 1984; Kellert et al., 2008). Biophilic design in urban places can help promote protect and strengthen favorable climate and microclimate conditions in cities (Beatley & Newman, 2013). A biophilic environment is about understanding the spirit and sensibilities of a built environment.

In the quest for principles of biophilic design, Benyus (2008) suggests a set of biophilic design elements inspired in nature: organic form and structure, daylighting, natural ventilation, natural sounds, a dynamic palette of colors, mimicking and

restorative landscapes, and bio-inspired gardens. Benyus (2008) proposes physical elements and processes from nature that can be applied to design products and artificial processes. The way in which animals and plants behave and adapt in wild environments are examples she uses to describe the considered restorative elements (Figure 1).

Kellert (2008) defines six elements and attributes that go from natural features to social relationships in cities. These elements consist of environmental features, natural shapes and forms, natural patterns and processes, light and space, place-based relationships, and evolved human-nature relationships (Figure 2). His proposal also incorporates a comprehensive study of the context that includes historical, geographical, and cultural components that affect individual's perceptions of the space and therefore the relationship of people with their affiliation to nature. Not all of these biophilic design elements however constitute restorative components, but as they are part of the urban space, they affect to some extent mental restoration.

Using similar physical elements of nature to build the urban space, Bentley (2011) focuses on strategies for the integration of nature into the built environment. To do so, he proposes the following levels for the elements of biophilic design in the urban environment: building, block, street, neighborhood, community, and region. He argues that both political and social decision-makers should take part in the process of implementation of biophilic cities. This regional scale focuses on green elements and green urban spaces as components of a biophilic environment (Figure 3). Other biophilic components that provide restorative experiences such as diversity of color, daylight, natural water features, and organic structures, are not included in Bentley's proposal.

Figure 1. Biophilic design elements inspired in Biomimicry (Benyus, 2008)

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"Dimensions, Elements, and Attributes of Biophilic Design"

Environmental features	Color, water, and air Sunlight Plants and animals Natural materials Views and vistas; façade greening Geology and landscape; habitats and ecosystems Fire
Natural shapes and forms	Botanical and animal motifs Tree and columnar supports Shells and spirals, egg,oval, and tubular forms Arches, vaults, and domes Shapes resisting straight lines and right angles Simulation of natural features Biomorphy, geomorphology, and biomimicry
Natural patterns and processes	Sensory variability Information richness Age, change, and the patina of time Growth and efflorescence Central focal point Patterned wholes Bounded spaces and transitional spaces Linked series and chains Integration of parts to wholes Complementary contrasts Dynamic balance and tension Fractals Hierarchically organized ratios and scales
Light and space	Natural light and shadow Filtered and diffused light; reflected light Light pools, warm light; light as shape and form Spaciousness, space as shape and form Spatial variability and harmony Inside-outside spaces
Place-based relationships	Historic, geographical, cultural and ecological connection to place Indigenous materials Landscape orientation and ecology Landscape features that define built form Integration of culture and ecology Spirit of place and avoiding placelessness
Evolved human-nature relationships	Prospect and refuge; security and protection Order and complexity; information and cognition Curiosity and enticement; exploration and discovery Change and metamorphosis Mastery and control Affection and attachment; attraction and beauty Fear and awe Reverence and spirituality

Figure 2. Biophilic design elements and attributes (Modified from Kellert, 2008)

Figure 3. Biophilic green urban design elements in cities (Adapted from Beatley, 2011)

Biophilia focuses on natural elements to be incorporated into urban environments. From a psychological perspective, nature provides people with restorative experiences to overcome stress and mental fatigue that improve their health status. From an urban design perspective, nature provides aesthetics, shelter, and a sense of place (Jacobs, 1961; Register, 2010). The richness of biophilic design therefore stems from the combination of nature and urban design.

RESTORATION AND WELL-BEING AS A RESULT OF BIOPHILIC DESIGN

How nature helps improve health and well-being is in fact a historical topic of interest. A Greek text 'Airs, waters and places' by Hippocrates establishes the relationship among climate, geography, sun and heat, water quality, and a scenic environment that can be perceived by an individual and the way in which these characteristics affect people's health (Hippocrates, n/d; Steg et al., 2013). Weather conditions and their effects on people's behavior are currently widely studied by social and environmental psychologists who suggest that the relationship between natural conditions and human well-being remains vital for people. It is important to mention that wildness and nature of the cities are not only related to green space. According to Beatley (2011), the use of trees on streets, courtyards, rooftops, creeks, and hydrological features should be considered and showed in cities rather than hiding them as is usual. The presence of nature also includes microorganisms, aquatic species, vegetation, and animals (Beatley, 2011, Register, 2010).

Even if a consensus about the effects of nature on people's health exist, Gifford & McCunn (2013) argue that the effect of having nature indoors can be negative in terms of the productivity of workers. Although having plants in the office could increase people's psychological health, these authors found that

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having many plants could decrease people's labor productivity. Even though this paper is not focused in indoor spaces, it is clear however that other studies can provide insights about possible outcomes in different environments that need to be taken into account. The impact of nature on people's well-being, emotions, and health depends on the distance between the location of nature and people, and how biologically impoverished a particular environment is. However, an indirect contact of people with nature could be enough to have a restorative experience (Heerwagen & Orians, 1993). The use of windows with a green landscape view or even pictures of a preferred natural forest can improve human psychological conditions.

Restorative environmental design can be considered as a new design paradigm where a low-environmental impact strategy could avoid damage to the natural environment, and where a positive environmental impact, or biophilic design, brings benefits to human health (Kellert, 2008). There are two dimensions in this paradigm, an organic or naturalistic dimension, that includes shapes and forms in the built environment reflecting the intrinsic human affinity for nature (Wilson 1984; Kellert, 2008); and, a place-based or vernacular dimension that considers the culture and ecology of a specific geographical location that constitutes the social and ecological dimension of design (Papanek, 1984; Register, 2010).

The conditions of modern life decrease people's ability to keep focused on daily activities. However, the built environment can promote psychological health and well-being by also increasing social ties that facilitate recovery from mental fatigue. Mental fatigue can affect anxiety and depression, which in turn contribute to aggression and violence (Sullivan & Chang, 2011). The proximity to open green spaces in urban areas is associated with the reduction of stress levels. The way in which environmental settings are designed can produce positive or negative outcomes as suggested below (Table 1).

Social support and sense of community need to be addressed by design. Designers can promote social interaction within urban spaces and protect people from crowding that may cause stress and depression. They can do so by considering, for example, that living near heavy traffic is not a desired condition for commuters nor by neighbors, that high rise and multifamily housing may cause anxiety and depression, especially among children, or that the daylight is important to avoid seasonal affective disorder (Sullivan & Chang, 2011). Other facts include the following: the lack of quality in urban design can produce distress; drivers can experience road rage because of stress, as well as difficulties associated to the increasing length of the commutes. Cities need to reduce automobile commutes, prioritize walking and biking, and improve their quality of design that can be measured by the extent at which a city is legible. A legible city provides residents with a sense of emotional security as well as an invitation to explore it (Lynch, 1960; Kopec, 2006; Gifford, 2007; Sullivan & Chang, 2011).

Since the use of nature, that includes flora and fauna, improves people's health status and social aspects of life, the biophilic approach considers these natural elements in both the indoor and outdoor built environment in order to reconnect humans to nature. A restorative environment, as shown in several urban case studies and psychological experiments, can be provided with natural elements (see Table 1 above) such as vegetation and forest-like landscapes (Ulrich et al., 1991; Hartig et al., 2003; Groenewegen et al., 2006), natural water features such as wetlands, stormwater ponds, and rivers (Korpela et al., 2008; White et al., 2010; Faggi et al., 2013), natural light and its relation to color and shadows (Kaplan, 2001; Kopec, 2006), and built environments that include well designed buildings (Gifford & McCunn, 2013), the use of local materials, community identity, and edible gardens and parks (Beatley, 2011; Beatley & Newman, 2013).

FAVORABLE SETTINGS TO MENTAL HEALTH		
- legible places - attractive, well-maintained, safe places - contact with green space - with privacy - appropriate contact with other people	Can produce	- well-being - life satisfaction - quality of life - social support - ability to concentrate - creative play in children - less mental fatigue
UNFAVORABLE SETTINGS		
- crowded places - noisy places - dangerous places	Can produce	- social withdrawal - reduced social ties among neighbors - smaller social networks - diminished social and motor skills in children - distress - anxiety - irritability

Table 1. Favorable and unfavorable settings to mental health

Source: Modified from Sullivan & Chang, 2011.

Psychological restoration can also be a result of the benefits of recreation. Cole & Hall (2010) study the restorative effects of wilderness on people's well-being that is negatively impacted by urban stressors such as crowding, human density, and congestion. Their experiment in wilderness environments shows that the exposure of participants to nature results in restorative experiences, mental fatigue release, and mental rejuvenation. Moreover, Mayer et al. (2009) argue that brief exposures to nature can help people improve their ability to reflect on minor problems. The participants in this experiment were asked to think about minor issues to be solved and then reflect about them while walking in contact with nature during ten minutes. They point out that further research on the impact of different lengths of exposure to nature is needed in order to understand what people require to solve major issues.

According to Ulrich (1993; 2008), the understanding of the link between biophilic design and restorative effects needs more research. However, Gifford (2008) argues that the extensive evidence from environmental psychology, based on field and lab experiments, can constantly inform environmental design to provide spaces that address people's needs. Duffy & Verges (2010) also suggest that further research is required to explore people's connection to nature and the role of seasonal changes in nature for people's behavior. According to their study, people have a stronger identification with objects that provide shelter during winter, while they show a positive association with nature during spring and autumn. Moreover, prevalent activities in different seasons are associated with seasonal animals' behavior. For Duffy and Verges (2010), these studies cast doubt on the implicit and innate connection of people with nature or the 'biophilia hypothesis'. Gifford (2008) argues that natural hazards and other natural forces do not provide people with restorative effects; on the contrary, they produce biophobia at different levels, from phobia to bugs, to constant insecurity about natural disasters in vulnerable places. These arguments do not imply that restorative impacts of nature are wrong or inexistent, but that there exist positive and negative outcomes to be considered when working with nature, and that historical evidence on city development and the continuous search of people to be protected from extreme conditions of weather make sense.

Much of the organization of a society depends on the functioning of cities and even on how streets function in a daily basis (Jacobs, 1961). Economic, social, and individual outcomes are the result of well-designed urban spaces that include natural and built features (Gifford, 2007). At the personal level, material realizations, health status, social life, leisure time, security, and environmental quality constitute components of well-being. Urban residents become users of city amenities on a daily basis and, therefore, their levels of well-being depend to a large extent on what the city has to offer. Commuting time, walkability, and the scenic beauty of streets are just a few contributors to well-being. Whether city amenities increase or reduce the level of people's well-being should be the main concern of urban design.

CONCLUSION

People need to preserve nature and the health of ecosystems to maintain and improve their emotional health and well-being. It is ironic that urban designers seek to incorporate nature into built environments, because it is the built environment that was incorporated into nature in the first place, losing the well-known benefits of natural settings. On the other hand, however, the built environment provides urban residents with a more comfortable life by protecting them from environmental conditions and natural hazards. Urban spaces, in particular streets, should provide city residents with refuges and be designed by considering both the positive and negative outcomes from nature.

In order to improve people's mental health, environmental psychology and public health have provided enough evidence on the link between nature and well-being. The challenge for designers is to incorporate these theories and evidence into spaces where people live. Since the achievement of well-being is a public goal, the design of public spaces as restorative places should be urgently addressed by urban designers.

The components of the natural and built environment that provide psychological restoration are studied by environmental psychology. Restoration theories mentioned in this paper consider nature as a main element to improve people's mental health. The attention restoration theory requires fascination as a process to help release mental fatigue, whereas the stress recovery theory suggests that people can recover from stress because of an affective and aesthetic response to the environment. This paper highlights the strong relationship between the benefits of the natural environment, the required processes and responses of restorative theories, and the principles of biophilic design.

Biophilic design consists mainly of providing not only strategies but also a set of principles to design built environments. As shown throughout this paper, biophilic researchers have proposed elements and components, favorable settings, and space attributes to create better places for people's health. Further research on how these elements can help the restoration process, as well as the quality and quantity, and possible combinations of them in different public landscapes is needed. The effect of weather, seasonal characteristics, and environmental conditions on people's perception and experience of the environment in relation to restoration and well-being remains also an open question for future research.

The social dimension of people's behavior, mainly studied by environmental psychology, should be considered in biophilic strategies. Moreover, a comprehensive understanding on how the environment and people relate to each other may make the difference between a single solution with a blind angle, and a complex solution where interdisciplinary approaches can reduce risks in the proposal and implementation of urban design.

The results of research from different disciplines related to urban design are still not connected to each other. This is the

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case, for instance, with the evidence on people's psychological health in urban spaces from environmental psychology and public health that has not been necessarily used by urban designers. The design of cities can take advantage of the research undertaken in disciplines other than urban design to incorporate, for example, biophilic design into the planning process at every stage. Biophilic design constitutes a promising field aimed at improving the design of cities to make a contribution to urban residents' well-being around the world.

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