URBAN AGE
a worldwide investigation into the future of cities

Urban stress and mental health

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Do we need to prepare ourselves for a more urbanised and, therefore, more depressed world? With the following article I wish to stimulate a conversation between urban planning, architecture and neuroscience, in the hope of facilitating a more nuanced understanding of how urban and rural living conditions differentially impact upon our mental health. At a first glance, there are enormous methodological differences between the disciplines of urban planning and neuroscience. None the less, considering the neuroscientific approach to the topic of cities is essential, as from it we can start to understand how city living affects inhabitants' brain biology and could therefore influence the risk for developing mental disorders. On the bright side, there are also indicators that show a protective aspect of large cities with regards to mental health. Cities, therefore, may lend themselves to facilitating new and appropriate health intervention strategies.

Urban living is on the rise whereas rural living is becoming the exception – in all parts of the world and at an ever-increasing rate. The rapid pace of urbanisation is an important marker of the societal transition at large that has occurred over the past thirty years. Our world is shifting towards an urban, small-family or single household, and at the same time, an ageing society. In the next thirty years we will be faced with the growing challenges specific to our cities' aged single urban populations.

But urban living is not only about getting older, it is also about getting stressed. Stress is the unspecific physiological and psychological reaction to perceived threats to our physical, psychological or social integrity. And urban living can be threatening if you don't have enough space of your own, if you experience insufficient security, or live under unstable economic conditions. Stress increases with the anticipation of adverse situations and the fear of not having the adequate resources to respond to them. From an evolutionary point of view, stress is the mechanism that prepares us for any 'fight-or-flight' reaction, and also causes us to evolve in order to better adapt to our environment. Although not harmful per se, stress may jeopardise our health when stress exposure is chronic or when complete recovery is not possible.

STRESS-RELATED HEALTH CONSEQUENCES

What does stress do to the body? Our organism has two major hormonal stress systems, the quick responding (within milliseconds) autonomic nervous system, which controls the release of noradrenaline and adrenaline, and the somewhat slower hypothalamus-pituitary-adrenocortical (HPA) system, which is responsible for the release of cortisol, the 'stress hormone'. Roughly speaking, the quick system prepares us to react immediately whereas the slow system's reaction depends on the perceived danger of the situation. Noradrenaline and adrenaline increase the heart rate and decrease the heart rate variability, dilate the respiratory airways and activate blood platelets to coagulate. Cortisol antagonises insulin and thus, under certain conditions of persistent stress-dependent dysregulation of the HPA system, results in a diabetes-like metabolic situation. It restructures body fat, promotes obesity, suppresses the immune system and may have a toxic effect on neurons in certain brain regions, particularly the hippocampus, which is important for memory functions.

Repeated exposure to social stress in rats leads to abnormal processing of the so-called 'TAU protein' in the hippocampus, a mechanism that plays an important role in the development of Alzheimer's disease. Stress also leads to the shortening of the 'protection caps' at both ends of our chromosomes, called telomeres. At the same time, stress also weakens the enzyme responsible for repairing these protection caps. When the telomeres get too short the cell can no longer divide and the tissue loses its regeneration capacity. The result is premature ageing of the organism.

URBAN LIVING AND MENTAL HEALTH

Living in an urban environment has long been known to be a risk factor for psychiatric diseases, such as

major depression or schizophrenia. This is true even though infrastructure, socioeconomic conditions, nutrition and health care services are clearly better in cities than in rural areas. Higher stress exposure and higher stress vulnerability seem to play a crucial role. Social stress may be the most important factor for the increased risk of mental disorders in urban areas. It may be experienced as social evaluative threat, or as chronic social stress, both of which are likely to occur as a direct consequence of high population densities in cities. As for the impact on mental health, social stress seems to outweigh other urban stressors such as pollution or noise. Living in crowded areas is associated with increased social stress, since the environment becomes less controllable for the individual. Social disparities also become much more prominent in cities and can impose stress on the individual. Further, disturbance of chronobiological rhythms is more frequent in cities than in rural areas and has a negative influence on mental health and beyond. A recent meta-analysis showed that urban dwellers have a 20 per cent higher risk of developing anxiety disorders, and a 40 per cent higher risk of developing mood disorders. For schizophrenia, double the risk has been shown, with a 'dose-response' relationship for urban exposure and disease risk. Longitudinal studies on patients with schizophrenia indicate that it is urban living and upbringing per se, rather than other epidemiological variables, that increase the risk for mental disorders.

As urbanisation of our world is inevitable, we urgently need to improve our understanding of the threatening – as well as the health protective – factors of urban living. Evidence is beginning to surface that indicates that the urban population shows a stronger brain response to stress, and stronger cognitive impairment under stress. A recent fMRI study in the journal *Nature*, conducted by a German research group, showed that these effects seem to occur irrespective of age, gender, general health status, marital or income status. In this study, the amygdala (a brain region that regulates emotions such as anxiety and fear) showed higher activation under stress in healthy individuals from large cities compared to their counterparts from rural regions. Interestingly, activation grew with the size of the current home city. Further, activity in another brain region associated with depression; the perigenual anteriour cingular cortex was positively correlated with the time that an individual had spent in a large city as a child. The more years someone had spent growing up under urban conditions, the more active this brain region tended to be.

URBAN STRESSORS DURING CHILDHOOD

There is an interesting finding against the converging evidence that adverse conditions in early life can severely impact the developing brain and increase vulnerability to mood disorders in adult life. It has been shown that adverse early-life events can alter the experience-dependent maturation of the stress systems, such as the HPA system. This again results in higher stress vulnerability later in life. Inducing early life stress in rodents (for example, by maternal separation) can result in persistent increase of anxiety-like behaviour and life-long hyperactivity of the HPA system in response to stress. Early-life stress may result in epigenetic changes, which means that the activity of certain genes is altered and may even be inherited by next generations. However, the majority of these studies focus on the effects of adverse experiences such as physical maltreatment, neglect or maternal separation, and not on urban stressors which may affect children's or parents' well-being (and therefore influence parental attachment). Thus, further research examining the long-term stress vulnerability effects of urban stressors during childhood is necessary.

SOCIAL STRESS IN THE CITY

Another recent study has reported that the size of the amygdala correlates with the size and complexity of an individual's social network. Other studies have demonstrated the correlation of amygdala activity with the spatial distance between two individuals as well as with anticipated social decline (for example, as a consequence of separation or job loss). What consequence does this have for urban planning? What does that mean in terms of the stress resilience of an increasingly urban population? What are the health consequences of higher social stress exposure and stress vulnerability of urban dwellers, given that stress is the most likely pathophysiological cause of many mental disorders, particularly depression? And from a political perspective, what actions can be taken to protect people living in dense metropolitan conditions from stress and its negative mental impact?

Our brains do not seem to be optimally designed for living in our generation's urban conditions, in the large, densely-populated metropolises of our world. However, there might be large inter-individual differences of stress vulnerability in an urban environment. For this reason, understanding more about stress-protective factors for city inhabitants might help us to plan appropriate public health strategies. If we assume that stress, most often of a social nature, is the major intermediate variable increasing the risk for mental disorders, then the

focus needs to be on identifying and improving our understanding of the most health-threatening social stressors, and how these stressors translate into brain disorders. A look into basic stress research might help: studies show that lack of control, social threat and the fear of losing one's social status strongly contribute to experiencing stress. These factors have been shown to affect the amygdala and the prefrontal cortex. On the other hand, there is interesting converging evidence that proteins that increase social behaviour, so-called pro-social neuropeptides, like oxytocine, can modulate these brain regions. We therefore need to better understand how these social stressors 'project' on urban populations in the conditions of city living, and under which conditions they overexcite the compensation and recovery potentials of the individual. How much, for example, does the subjective perception of an uncertain hierarchical order – a well-known social stressor – increase with population density, social disparity or housing conditions?

A LOOK AHEAD

Clearly, many inhabitants of large metropolitan areas do very well in terms of health and life quality as they benefit from better infrastructure, and a denser system of social, health care, cultural and educational options. So this leads us to ask, what are the biological, psychological and social prerequisites for healthy urban living? Answering this, and other, similar, questions by means of neurobiological studies on stress promoting and stress protective variables will be invaluable in helping politicians, city planners and health authorities to plan a healthy urban environment.

Extra risk may be associated with growing up in an urban area – as opposed to first living there as an adult – as stress vulnerability of the brain alters with age. The human brain has distinct periods of vulnerability. The neurobiological effects of experiencing urban stress in early childhood differ from those associated with the experience of urban stress later in life. Therefore, future studies should separate the impact of urban living on the maturing brain, and on the adult brain, and focus on if and how stress factors manifest under these conditions respective, and in conjunction of one another.

So many of us have left and are continuing to leave our rural environments. We seek the density of large cities for their variety of leisure activities, rich cultural life, better access to employment and anonymity; but this seems to come at a cost. We may be paying for it with our health.

Can urban planners benefit from neuroscience? Of course, urban living has many different facets, which again may have a variety of consequences for mental health and well-being. And naturally, the layout of our cities does not project 1:1 on our neurobiology. Cities are complicated structures, and the human brain is an even more complicated organ. These are no good prerequisites for the formulation of simple 'if-then' rules. None the less, if major social stressors, such as certain aspects of population density and hazardous social gradients, are proven to be health-threatening, we should be able to moderate population exposure and have an impact on the urban population's – or perhaps better said, on the majority of humankind's – increased risk of mental health problems. We should bear in mind that these factors apply to cities of the western world. The urban challenges in the megacities of middle- and low-income countries may vary, as they bear greater challenges in terms of poverty, steep social gradients, poor hygienic standards and poor safety. These factors may impose additional and potentially stronger stressors on the population. The World Health Organization has highlighted stress as one of the major health challenges of the twenty-first century. Urban living is quickly developing as a major contributor to this. The challenge can, however, be tackled by joint action between life sciences, social sciences, urban planning, architecture and politics.

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