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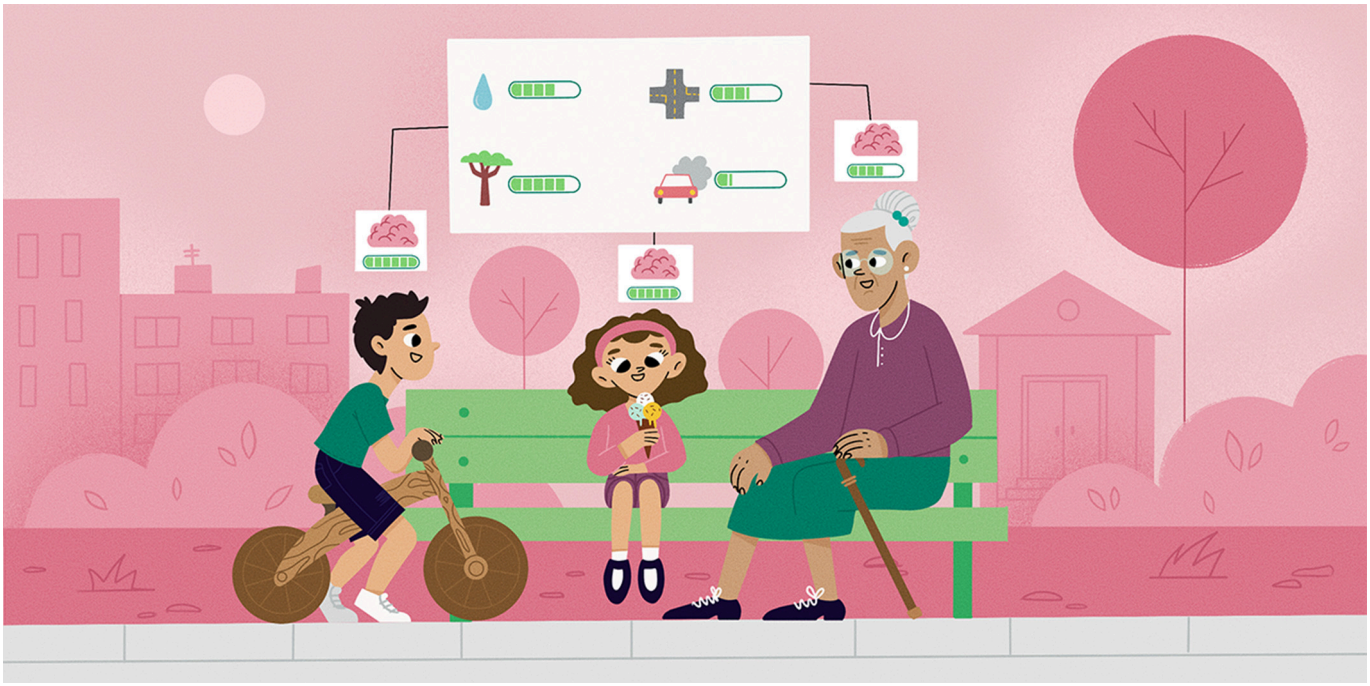

HOW IS BRAIN AGING INFLUENCED BY WHERE WE LIVE?

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YOUNG REVIEWERS:

ALESSANDRO
AGE: 11

ARASI
AGE: 9

When our brains are healthy, we can memorize, pay attention, reason, move, communicate, make decisions, and complete complex tasks. As some people get older, they can no longer do those things—they suffer from cognitive disorders that could indicate the start of dementia. Many factors might play a role in the development of dementia and some of those factors, like age and education level, have been identified. We know that there are additional, unidentified factors that play a role in the development of dementia, and scientists are discovering that where we live also matters. Our living environments include buildings and other structures, green spaces, and the level of air pollution. In this article, we explain the impact of the living environment on brain health decline during aging.

OUR LIVING ENVIRONMENTS ARE MORE THAN OUR HOMES

When we think about our homes, we are usually not aware of all the environmental characteristics surrounding them. These environmental characteristics include physical characteristics like the built environment (buildings, natural areas, parks, roads), exposure to toxic agents (air pollution, pesticides), and environmental hazards (noise, temperature). The environment also includes social characteristics, like neighborhood poverty level; access to gathering places, cultural activities, and social life; access to resources and work; and any feelings of insecurity and discrimination that we might experience in those environments. Every neighborhood is unique in terms of all these environmental characteristics, so some neighborhoods are healthier than others. For instance, some people have easy access to parks, while others do not. Park access can lead to increased physical activity, which is good for health. Differences in environmental characteristics of neighborhoods can help to explain health differences between individuals—our living environments can be major determinants of our health.

WHAT IS BRAIN AGING?

BRAIN AGING

Changes in brain health as we grow older.

COGNITIVE FUNCTIONS

Brain capacities that allow us to communicate, perceive our environments, concentrate, remember an event, or accumulate knowledge.

COGNITIVE DECLINE

Decrease in cognitive functions over time.

DEMENTIA

Disease characterized by a cognitive decline serious enough to affect our daily habits.

In this article, we will focus on one important aspect of health: how brain health changes as we grow older, which is called **brain aging**.

We do many things with our minds—we see, remember, move, talk, and solve problems. These mental abilities are called **cognitive functions**. Cognitive functions are the capacities of the brain that allow us to communicate, to perceive our environments, to concentrate, to remember events, or to accumulate knowledge. There are several cognitive functions (Figure 1): perception (the ability to detect objects and the location of our bodies in space), attention (the ability to concentrate for a certain amount of time), memory (the ability to store and retrieve information in the short and long term), motricity (the ability to perform movements), language (the ability to communicate in oral or written form), and executive functions (the ability to reason and to coordinate other cognitive functions). Cognitive functions can be assessed by various tests and questionnaires. When doctors observe a progressive decrease in cognitive functions over time, they call that **cognitive decline**. Some cognitive decline is expected during normal aging, but when cognitive decline is excessive and associated with behavioral disorders and a loss of the ability to do things for ourselves, patients are said to suffer from **dementia**. Alzheimer's disease is the most common form of dementia. To study brain aging, doctors look at both cognitive decline and the occurrence of dementia.

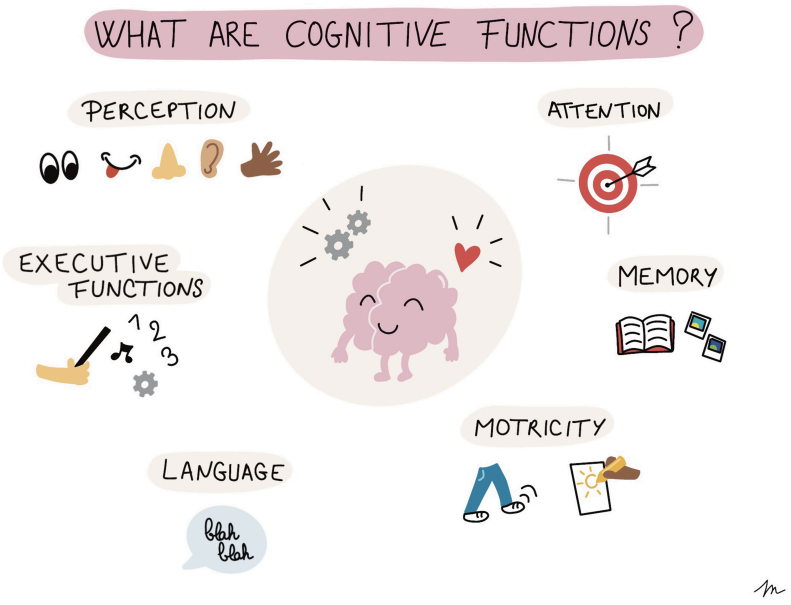

Figure 1

Cognitive functions include perception, attention, memory, motricity (movement), language, and executive functions (the coordination of the other functions). When our brains are healthy, we have good cognitive functions (image credit: Margaux Letellier).

WHICH ENVIRONMENTAL CHARACTERISTICS CAN IMPACT BRAIN AGING?

Many factors have been linked to brain aging[1], and especially to dementia. Individual socio-economic characteristics (sex, age, level of education, income), lifestyle (smoking, physical activity, social isolation) or medical characteristics (diabetes, depression) are well-known to influence the risk of developing dementia. Yet, even when these individual factors are taken into consideration, there are still differences in the risk of developing cognitive decline or dementia. Environmental characteristics may explain some of the remaining differences.

As we mentioned previously, our living environments can also impact our health, including brain aging. The impact of living environment on brain aging is partly dependent on where we live and how long we live there (Figure 2). It is difficult to determine exactly which environmental characteristics affect the brain and how, because there are many environmental characteristics and they vary over time and interact with each other. Thanks to **epidemiology**, the science that studies how often diseases occur in specific groups of people, scientists can identify some of the environmental risk factors of cognitive decline or dementia. A **risk factor** is something that increases the risk of developing a disease. When you identify the enemy, it is easier to fight it—this is particularly important for dementia because we do not know how to treat it.

We will now discuss three environmental characteristics that scientists have linked to brain aging: air pollution, green space, and neighborhood deprivation.

[1] For more information on brain health, see https://ipbis.org/MyBrainRobbie.html.

EPIDEMIOLOGY

Science that studies the frequency of diseases in specific groups of people and the reasons for their occurrence.

RISK FACTOR

Something that increases the risk of developing a disease.

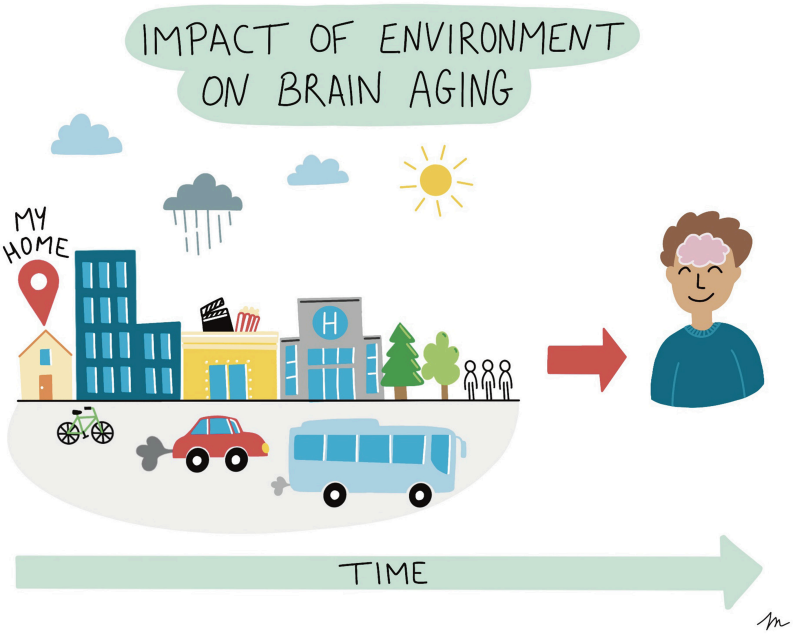

Figure 2

Figure 2

Various aspects of our living environments may impact brain aging over time, including resources (such as sports equipment, museums, libraries, cinemas, healthy food stores, public transport, or health services), social environment (feelings of community, social clubs), built environment (presence of green spaces, cycle paths), exposure to toxic agents (air pollution, pesticides), and environmental hazards (noise, temperature) (image credit: Margaux Letellier).

AIR POLLUTION AND BRAIN AGING

Although we cannot see them, there are many compounds in the air we breathe. Unfortunately, some of them can be harmful for our health or for the planet. If harmful compounds are present in high amounts, the air is considered to be polluted. Air pollutants can arise from natural phenomena (such as volcanic eruptions or wildfires) and from human activities (agricultural dust, emissions from cars or manufacturing plants, or chemical products). Depending on where people live (closer to or further from highways, for example) they can experience varying amounts of air pollution. In many countries, some air pollutants are monitored and regularly measured with sensors at various locations. Thanks to these measurements, scientists can estimate the concentrations of air pollutants people are exposed to. This allows them to study whether higher air pollution levels are associated with harmful health effects.

Scientists have found that exposure to air pollutants can affect brain health. One air pollutant has drawn particular attention: particulate matter. **Particulate matter** is a mix of tiny particles and liquid droplets in air. Depending on the size of the particles, particulate matter can sometimes penetrate deeply into our bodies. Fine particulate matter could even reach the brain. Epidemiological studies have shown that people exposed to higher levels of particulate matter have lower **cognitive performance** compared to people who are less exposed, and they have faster cognitive decline [1]. Exposure to higher levels of particulate matter also increases the risk of developing dementia. In one study in France, in which 7,066 participants were followed for 12

PARTICULATE MATTER

Mix of tiny particles and liquid droplets in air.

COGNITIVE PERFORMANCE

Measurement of cognitive function at a given time.

years, researchers found that a higher level of fine particulate matter in the air was associated with Alzheimer's disease [2].

GREEN SPACES AND BRAIN AGING

Green spaces are natural areas like parks, woods, playgrounds, riverbanks, beaches, zoos, and urban gardens. Scientists hypothesize that the presence of green spaces in individuals' living environments could be beneficial for their general health and for their brain health. For instance, green spaces could help with relaxation and stress reduction, promote physical activity, and promote social interaction[2] . All these positive aspects of green spaces could in turn improve cognitive functions or delay cognitive decline. Green spaces can also be physical barriers that reduce our exposure to air pollutants, noise, or excessive heat. Scientists are studying whether green spaces are truly associated with healthy brain aging. Some epidemiological studies suggest a positive association between greater exposure to green spaces and better cognitive performances [3], but more studies focusing on cognitive decline and dementia are needed.

[2] Urban green spaces and health. Copenhagen: WHO Regional Office for Europe, 2016.

NEIGHBORHOOD DEPRIVATION AND BRAIN AGING

On the material level, deprivation refers to a lack of resources, services, or equipment. On the social level, it refers to isolation, exclusion, and fragility of one's social network. A deprived neighborhood is characterized by higher levels of poverty, unemployment, and exclusion, and a lack of services and equipment.

A neighborhood's deprivation level can influence people's cognitive functions [4]. Epidemiological studies have shown that living in a deprived neighborhood is associated with poorer cognitive functions and can increase the risk of cognitive decline, mostly in people over 65 years old. These results were shown in older Mexican Americans living in California, in older adults living in Chicago, and in adults living in England. Recently, epidemiologists also found that living in deprived neighborhoods may be associated with a higher risk of developing dementia and Alzheimer's disease. A neighborhood's deprivation level is associated with differences in resources (such as sports equipment/recreation centers, museums, libraries, bookstores, cinemas, healthy food stores, public transport, and health services), difference in the social environment (feelings of community, social clubs), and differences in the built environment (presence of parks/green spaces). Lower availability of these resources could affect cognitive function by resulting in a less active/healthy lifestyle (for example, less physical activity), lower social activity, or higher levels of anxiety and depression. All these factors may increase cognitive decline or risk of dementia.

CONCLUSION

Now you know that it is important for us to take care of our brains, to keep them healthy as long as possible while we age. There are some things we can do to keep our brains healthy (exercising more, staying curious and learning new things every day, having many social interactions) but, as we have seen in this article, our living environments also play a key role! We know that improving our living environments can help promote healthy aging. We can work to keep our neighborhoods healthy by taking steps to decrease air pollution and to develop more accessible green spaces, especially in neighborhoods with high poverty levels.

There is still more research needed to fully understand the role our living environments play in brain aging. While we only talked about our living environments, we often visit various places each day. Some scientists take this mobility into account and are investigating the environments of places we visit, like school or work. In addition, research on *other* factors that might influence brain aging will help to give us the full picture. For example, scientists are studying things like the impact of weather and climate change on brain health. Lastly, while we focused on brain *aging* in this article, the environment can also impact brain development from our earliest age and even before birth! So, it is never too early to inform people about brain health and how to protect it!

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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YOUNG REVIEWERS

ALESSANDRO, AGE: 11
Hello! I am Alessandro and I am 11 years old. My favorite sport is Rugby, which is the sport I play. I love Rock music. I play Electric guitar and I like to play the PlayStation with my friends. I would like to be a doctor when I grow up, because it is very important for me to help people.

ARASI, AGE: 9
Hola Amigo! I am Arasi. I am in 3rd grade. I love to dance, play the piano, and draw! In my free time, I read books, my favorite series are diary of a wimpy kid, and dork diaries. My favorite colors are pastel pink and purple, and mint green. When I grow up, I want to be a lawyer. I just want to say, for a better world, kindness is the way to go!

AUTHORS

JEANNE DUCHESNE
I am a Ph.D., student in epidemiology at the Institute for Neurosciences of Montpellier in France. After earning a bachelor's degree in environmental health and a master's degree in public health and epidemiology, I started my Ph.D., work on the effects of air pollution on cognitive aging. When I discovered environmental factors and the impact they can have on our health, I developed a great interest in this topic. I believe it is essential to understand the role environmental factors can play in health

because we are all exposed to various environmental factors, and knowledge can help us to prevent their harmful effects or promote their beneficial effects.

MARION MORTAMAIS

I am an epidemiologist with an interest in environmental risk factors, cognition, and neuroimaging. After earning a doctorate in veterinary medicine and an M.S. in biostatistics and epidemiology, I did my Ph.D., thesis at the French National Institute of Health and Medical Research (Inserm), on the relationship between brain imaging and the risk of dementia in the elderly. Then, I studied the impact of air pollutants on brain structures in children at the Barcelona Institute for Global Health (Barcelona, Spain). Currently, I am researching how air pollution may impact brain aging in France.

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I am an associate professor in epidemiology with a joint appointment at the University of California San Diego's Scripps Institution of Oceanography and the Herbert Wertheim School of Public Health. I finished my Ph.D., in epidemiology jointly from the University of Montreal and Paris Sud, and completed a post-doctoral position at McGill University with the Institute for Health and Social Policy. My work is combining epidemiological methods with environmental and econometric models with a specific focus on health policies and environmental justice.

NOÉMIE LETELLIER

I am a post-doctoral researcher in epidemiology at the University of California San Diego. I did my university education in France, where I was born. I have a bachelor's degree in geography, a master's degree in public health and a Ph.D., in epidemiology. I am studying the effects of living environment on aging, with a focus on health inequalities. One of my motivations for doing research is to raise awareness about the importance of the environment and protecting it, as well as the importance of addressing socio-economic, racial/ethnic, or gender health inequalities. I believe that we need more popularization of science to disseminate scientific findings among researchers from different disciplines and especially outside of the academic network. *nletellier@ucsd.edu