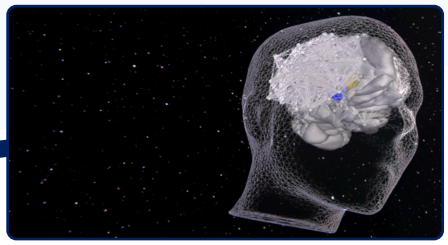
VirtualBrainCloud

Personalized Recommendations for Neurodegenerative Disease



www.VirtualBrainCloud-2020.eu

Public deliverable report

D9.6: Health & lifestyle recommendation system implemented

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1. Introduction

The burden of dementia represents a growing challenge for the elderly population, as well as for society and healthcare systems at large. While neurobiological research continues to unravel its underlying mechanisms, treatment options still remain limited. Therefore, the ideal approach lies in the prevention of dementia altogether. However, it is essential to acknowledge that not all contributing factors, such as genetic risk factors, can be avoided entirely.

Nevertheless, by implementing a combination of avoidable interventions, the risk of dementia can be significantly reduced by approximately a third (Norton, Matthews et al. 2014). Among the well-established lifestyle factors contributing to this risk reduction are physical exercise, healthy nutrition, cognitive training, strict management of concomitant diseases, and various other factors.

However, the translation of these general lifestyle recommendations into clinics is challenging. First, it is well-known that lifestyle changes are often associated with low adherence. The heterogeneous and very particular patient group makes the implementation even more complicated: We have to differentiate between dementia patients, who need recommendations suitable for their disease stage, and people at risk, who often show high motivation to implement changes in their lives to prevent a progression into dementia. Therefore, the content needs to be stratified for the particular user, and the form must simultaneously be precise and intuitive.

Here, we can make use of recent advantages in science communication. People deserve and desire the latest cutting-edge results from neuroscience, but as they are mostly no neuroscientists, the knowledge must be provided in a correct but easily understandable form. For this, modern technologies such as mobile apps and high-end 3D visualizations can contribute to success.

Consequently, we have developed an extensive and comprehensive brain atlas that not only facilitates the exploration of neuroscience knowledge but also offers valuable recommendations for preventive lifestyle interventions. The atlas is a powerful tool enabling users to access individualized selections of information and suggestions tailored to improve their unique risk profiles. With its expanded functionalities, the atlas provides visual representations and detailed insights into various aspects of the brain, including its anatomy, functions, receptors, and more. By encompassing such a broad range of neuroscientific data, this sophisticated atlas empowers users to gain a deeper understanding of the intricacies of the brain. It offers personalized guidance to enhance their cognitive health and well-being.

2. Partners involved

CHARITE

3. Description of work performed

The core part of this deliverable is a brain atlas enhanced with lifestyle recommendations for preventing dementia. For this, we integrated results from several fields together.
The anatomic atlas of the brain has been enhanced with helpful lifestyle information, allowing us to learn neuroanatomy together with clinical recommendations.
Further, we implemented current research results into this visualization tool: The atlas can uniquely visualize complex simulations of The Virtual Brain (TVB (Ritter, Schirner et al. 2013,

Sanz Leon, Knock et al. 2013)) by showing the electric information flow along the fiber tracts. Even the virtual stimulation of the brain with deep brain stimulation in a use case of Parkinson's' Disease (Meier, Perdikis et al. 2022) can be visualized, bringing the stimulating electrodes and their effects on brain activity into one frame. The atlas can also visualize state-of-the-art empirical data about the brain, as it can be shown exemplarily with receptor densities from autoradiography. Finally, our novel software, The Virtual Brain Adapter of semantics (TVBase, (Stefanovski, Bülau et al. 2021)), can produce new data modalities from the analysis of the scientific literature, which can be used to visualize biochemical pathways and brain functions. We show this exemplarily with the visualization of emotions.

As a second part, the atlas offers a graphical user interface that provides individually suited knowledge about the clinic of dementia. The structure is oriented on clinical needs, focusing on the user groups of patients, people at risk, relatives of patients, and interested laypersons. For frequent clinical situations, a unique selection of texts and suitable visualizations from the atlas are provided.

4. Results

4.1. Multimodal atlas

The atlas offers an overview of a plethora of entities. In the following, we will briefly describe each of the functionalities:

- Brain anatomy
- Alzheimer pathways
- Braak stages
- Receptor densities
- Cytological characteristics
- Brain activity

4.1.1. Brain anatomy

The areas of the well-known Desikan-Killiany (Desikan, Ségonne et al. 2006) and Destrieux (Destrieux, Fischl et al. 2010) atlases are extensively described and can be interactively explored. The descriptions are available in 6 languages (English, German, Spanish, Polish, Arabic, and Hebrew).

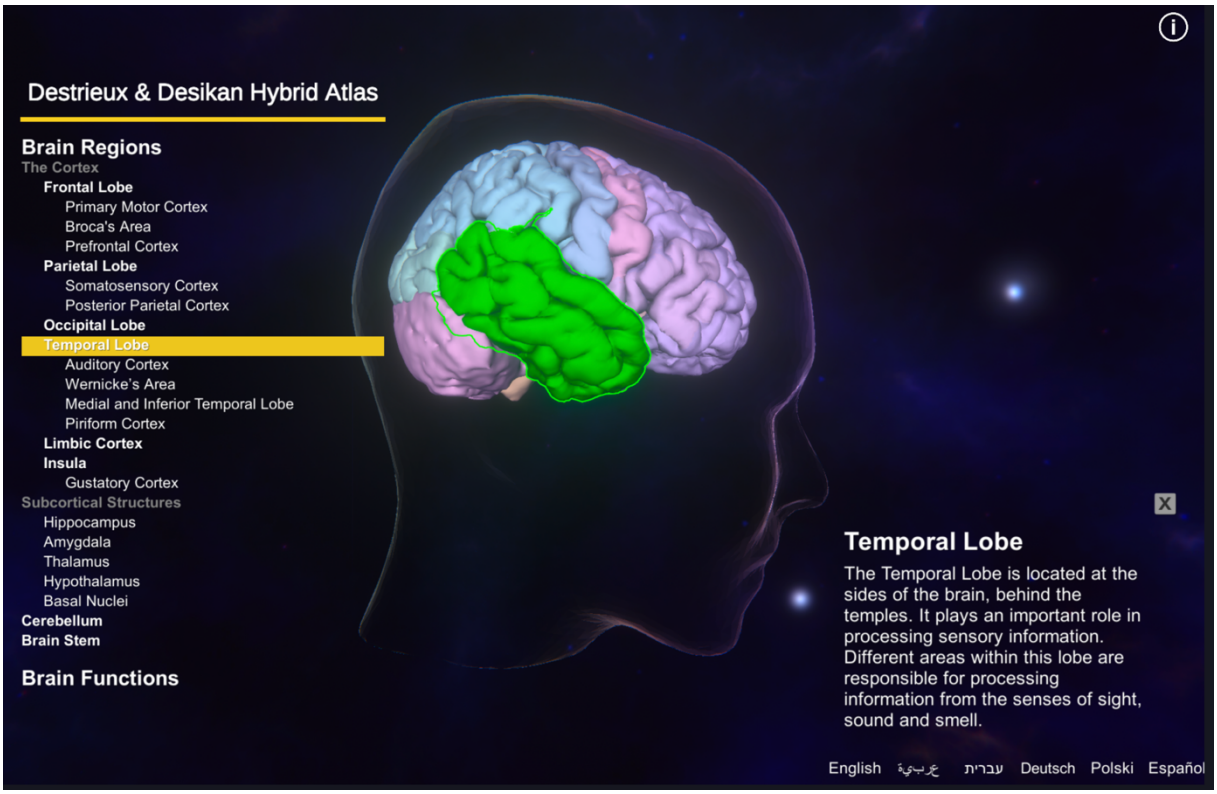

Figure 1: Anatomic atlas. The description of the temporal lobe can be seen.

As it is often more practical to segregate the brain into its functions and not its structural parts, the atlas also contains the most relevant brain functions, including descriptions:

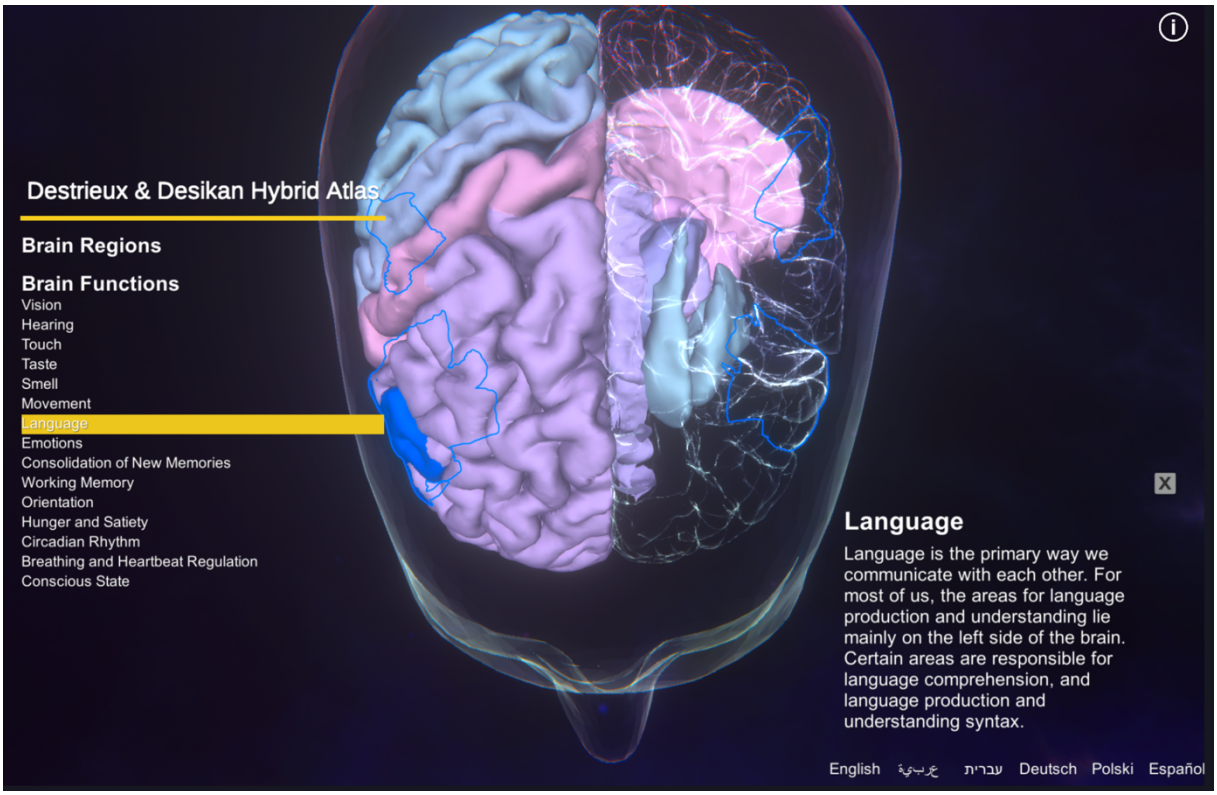

Figure 2: Brain Functions in the Anatomic Atlas.

4.1.2. Alzheimer pathways

The atlas uses the novel software TVBase (Stefanovski, Bülau et al. 2021), a semantic mapping tool that allows for extracting knowledge from the scientific literature and plotting it onto a 3D brain. Here, we mapped a selection of concepts that play a role in Alzheimer's Disease, taken from the knowledge graph NeuroMMsig (Domingo-Fernández, Kodamullil et al. 2017).

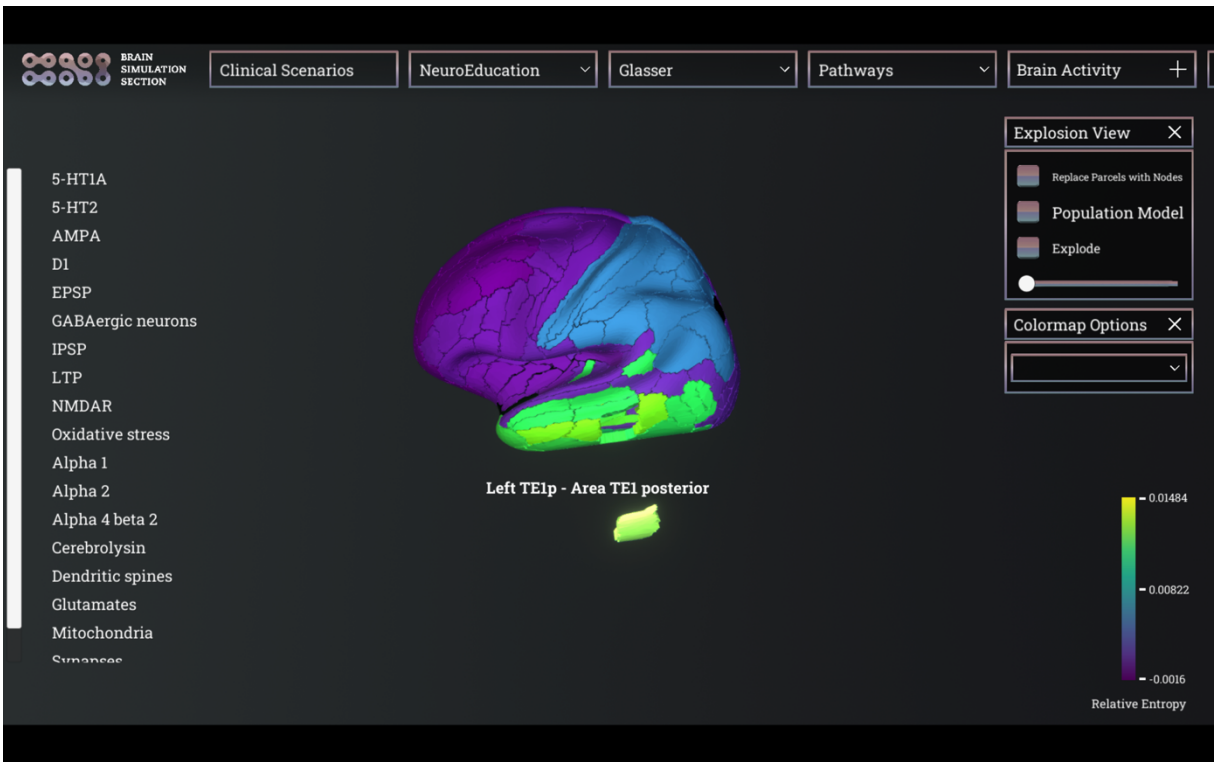

Figure 3: Important pathways in Alzheimer's Disease, derived from NeuroMMsig. Shown is the association of oxidative stress with several brain areas. The single areas can be identified by clicking on them.

4.1.3. Braak stages

The atlas further visualizes the distribution of the two hallmark proteins in Alzheimer's disease: Amyloid-beta and Tau. They have been described by Braak and Braak (Braak and Braak 1991, Braak and Braak 1997), while the Tau distribution is usually referred to as "the" Braak stages.

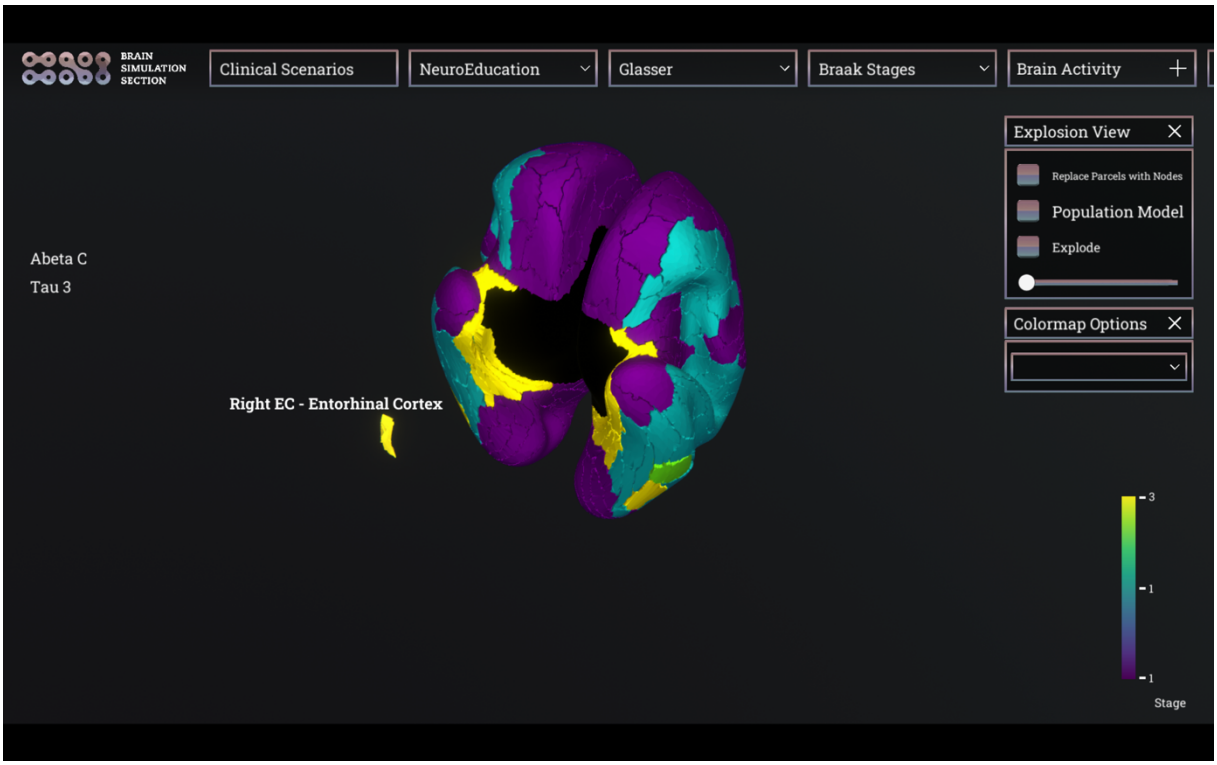

Figure 4: Tau distribution in different Braak stages. It can be seen that the highest-burden is in the medial temporal lobe, surrounding the hippocampus.

4.1.4. Receptor densities

We implemented the empirically measured receptor densities from the data platform EBRAINS (Palomero-Gallagher and Zilles 2018). Therefore, the atlas provides information about 16 different receptor types measured in particular brain areas with autoradiography.

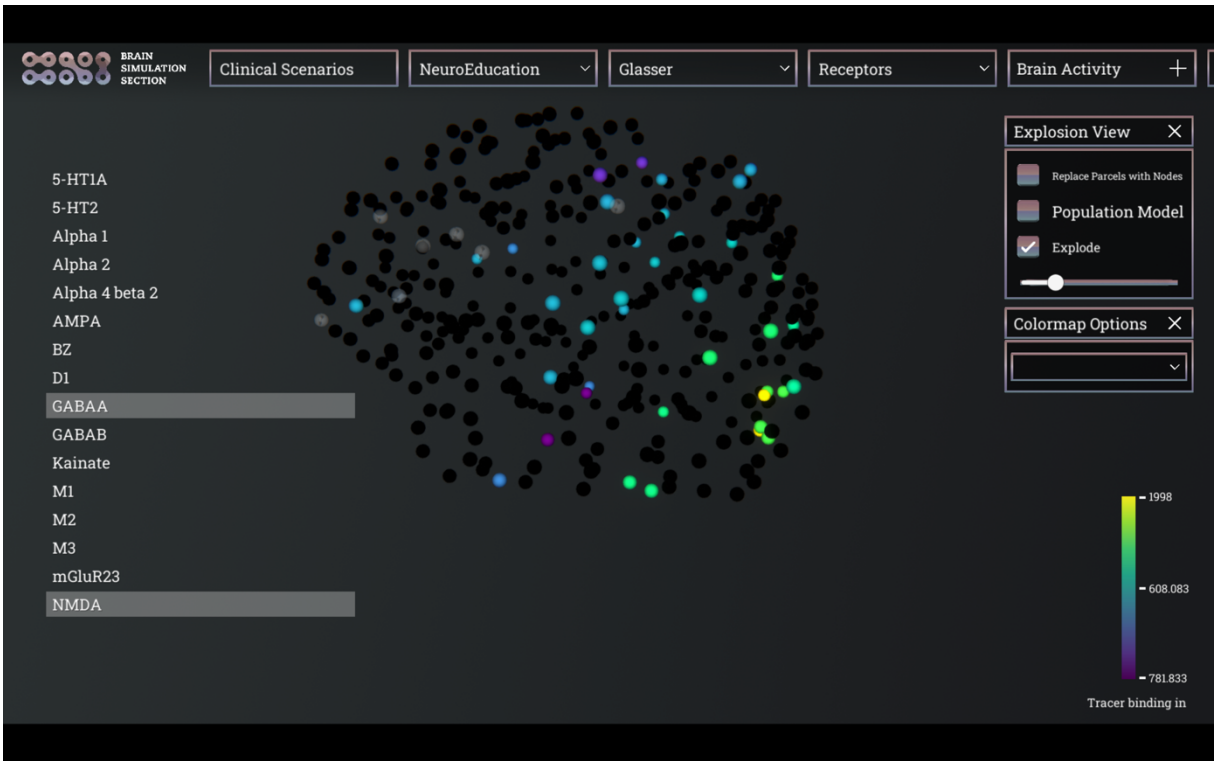

Figure 5: Receptor densities. Shown is the density of $GABA_A$ receptors in the measured brain regions.

4.1.5. Cytologic characteristics

Similar to the receptors, we visualize cytological characteristics, e.g., the cell content per region.

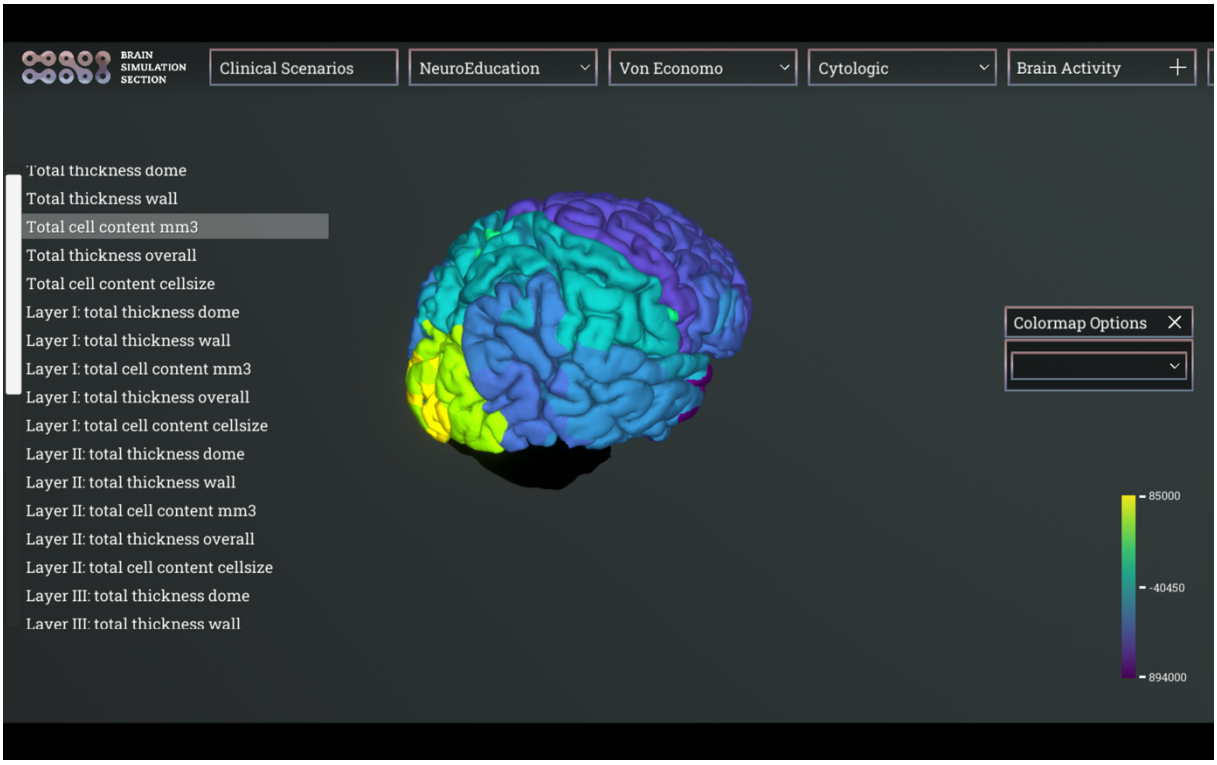

Figure 6: Cytological characteristics of the brain. Shown is the cell content per volume.

4.1.6. Brain activity

Brain activity can be visualized in various ways in the atlas. From firing rates to live-visualized functional MRI and 3D-volumetric views, the software offers many tools to visualize experimental and simulated data.

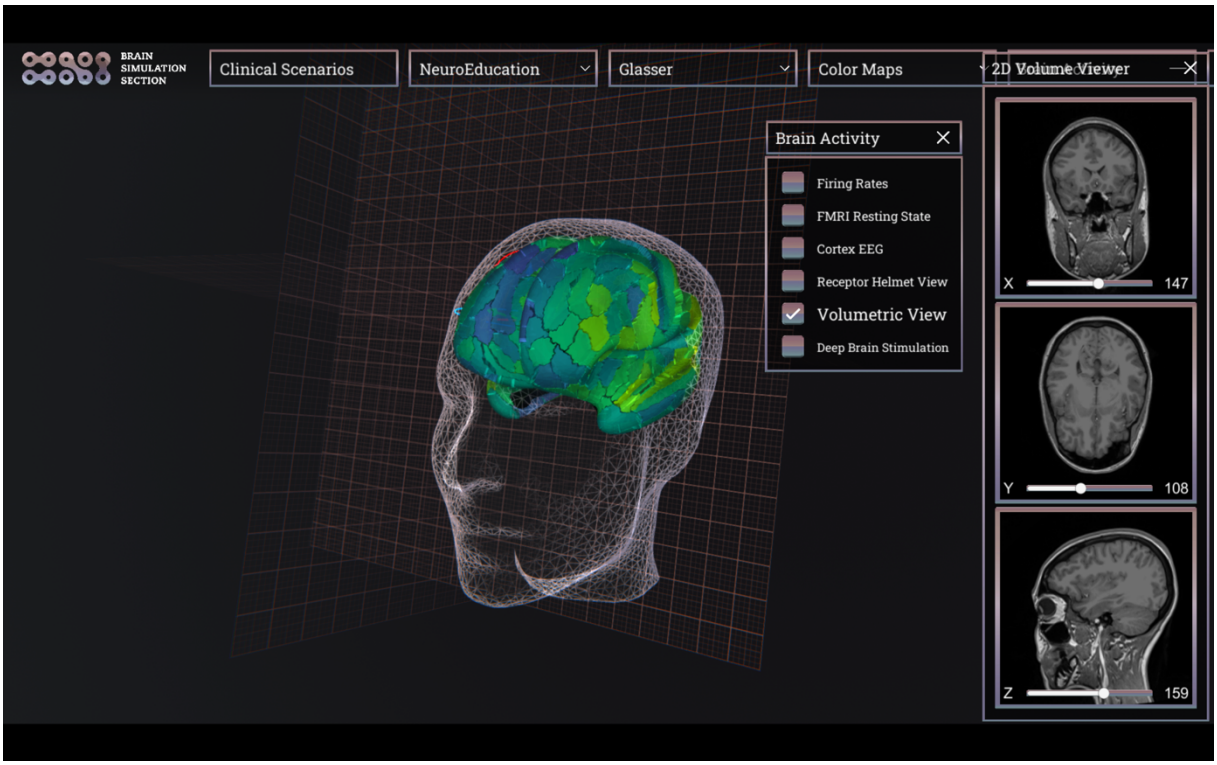

Figure 7: Brain activity visualizer. Shown is the simulated resting-state functional MRI activity, while the volumetric interface can navigate the brain slices.

4.2. Lifestyle recommendation App

Directly implemented with the educative atlas tools, the user can find an interface to explore a variety of evident lifestyle recommendations and helpful knowledge about dementia. The information is sorted in two ways: First, one can explore the whole library of recommendations in three categories:
Coping, i.e., information helpful to handle the diagnosis of neurodegenerative disease, including knowledge about treatments and how they work.
Prevention, i.e., the strongest-evident recommendations on how to prevent getting dementia or not to convert from mild cognitive impairment to dementia.
Knowledge, i.e., explanatory content about different dementias, their mechanisms, treatment, and prognosis.

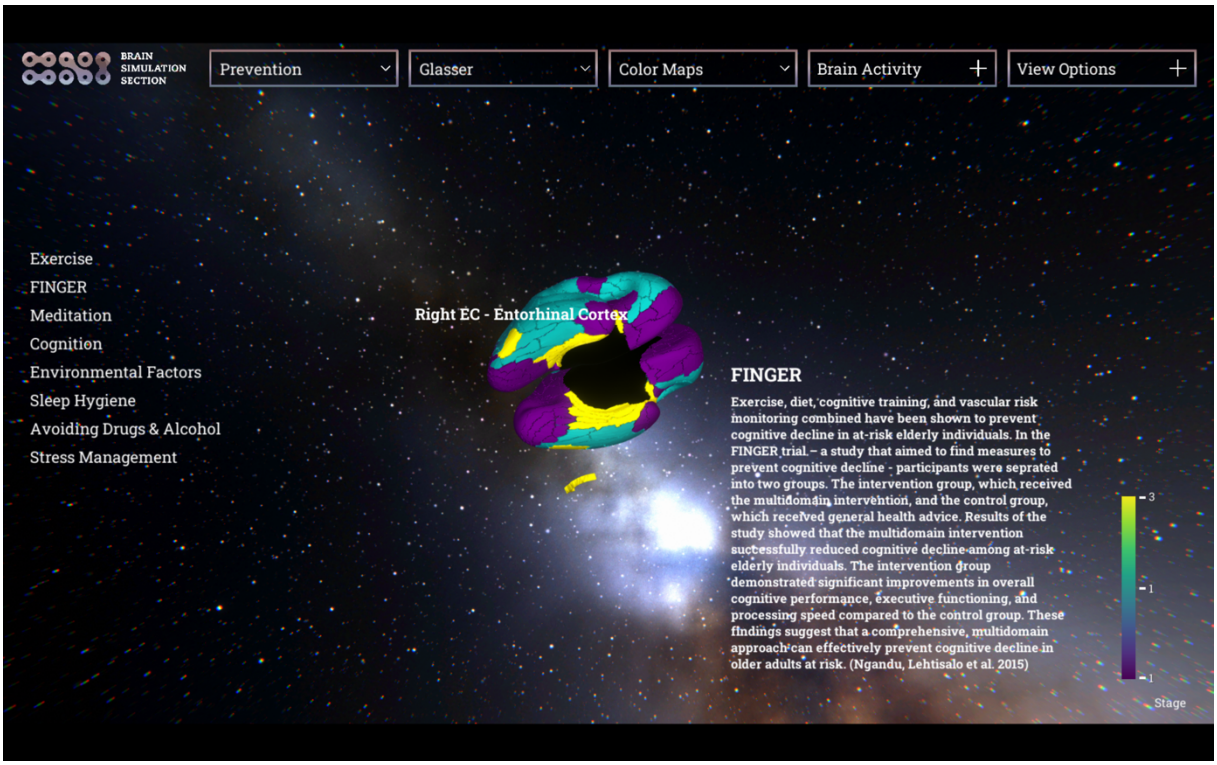

Figure 8: Prevention information in the neuroeducative atlas. Here, the FINGER intervention is explained, while the brain visualization shows the Braak stages for Tau distribution.

It is well-proven in psychiatry that psychoeducation (Zhao, Sampson et al. 2015), i.e., mainly providing information about the diseases a patient is suffering from, significantly affects these patients. This concept is relatively new in neurology, but dementia is a neuropsychiatric condition between neurology and psychiatry. Therefore, it can be seen as transferrable to "neuroeducation" (Jolles and Jolles 2021).

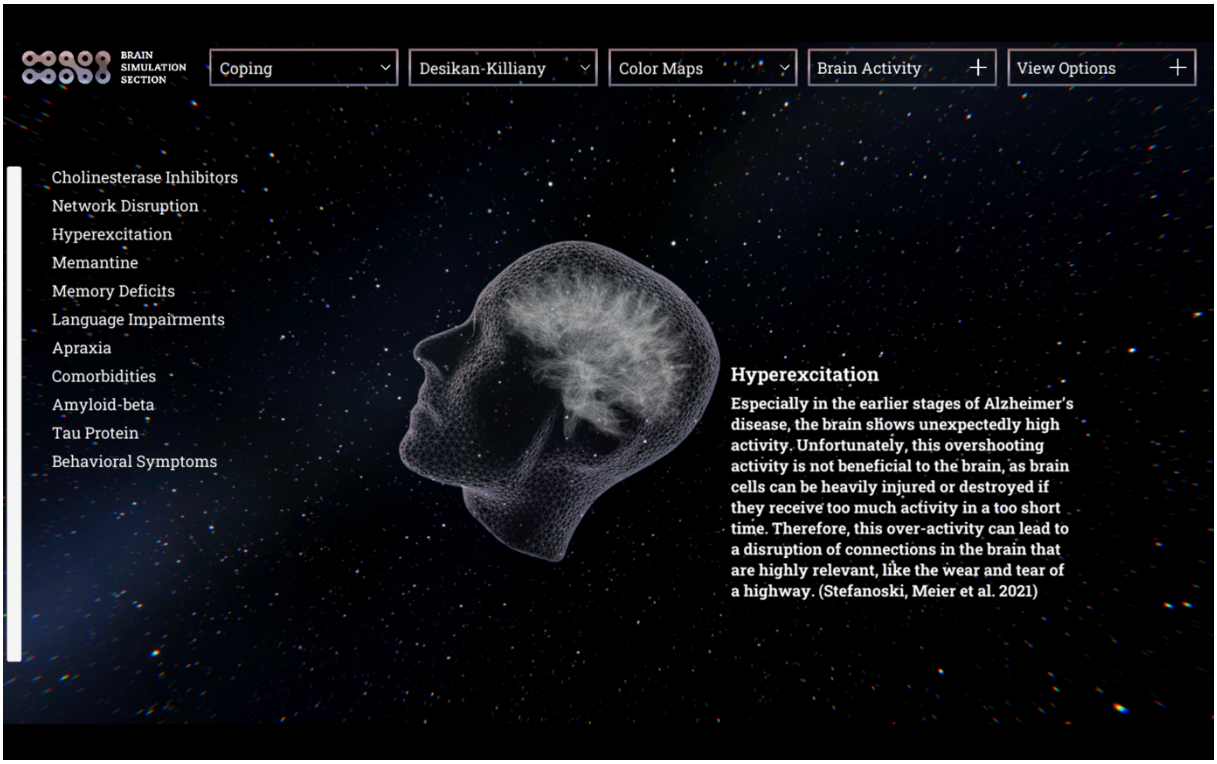

Figure 9: Coping information in the neuroeducative atlas. Besides basic information on how to treat the disease and symptoms, the atlas also provides information about underlying mechanisms, such as the concept of hyperexcitation.

Finally, as much evidence about dementia is focused on Alzheimer's Disease – and so are most recommendations – the atlas also contains a part about the potential causes of dementia. Alzheimer's disease is the most common cause, but many patients suffer from other entities.

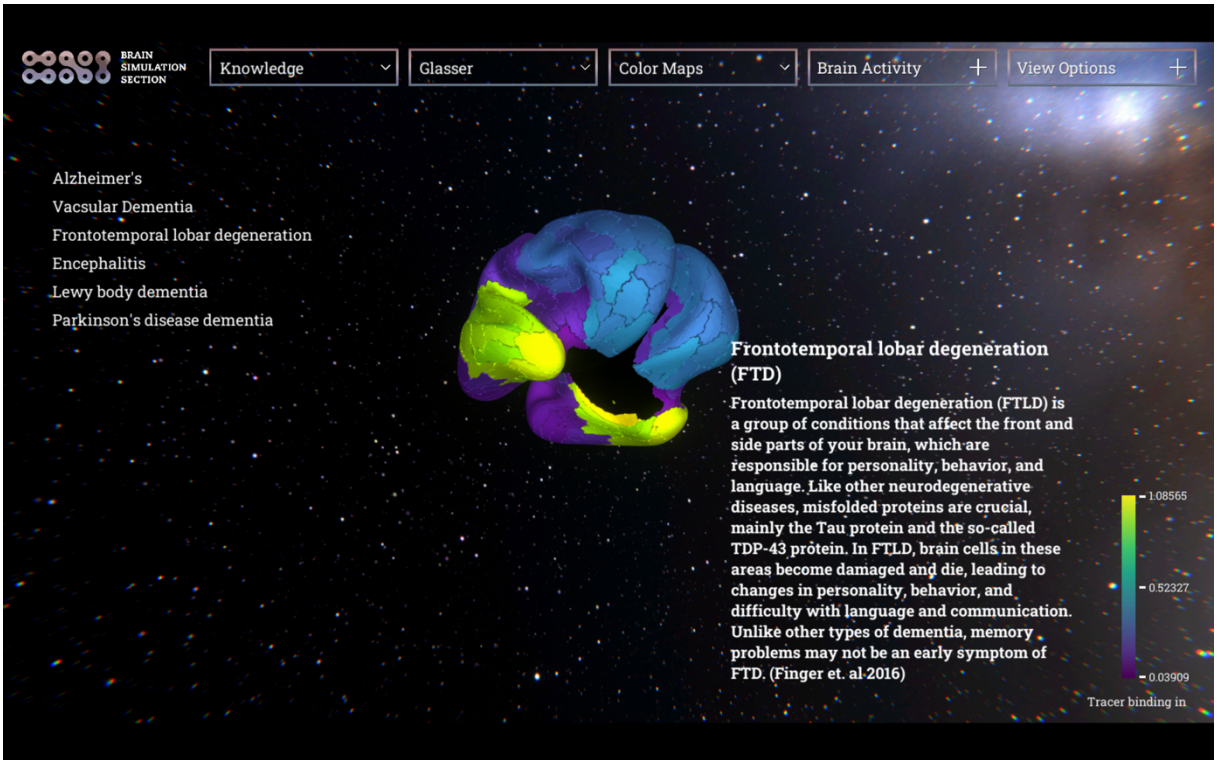

Figure 10: Knowledge part of the neuroeducative atlas. Here, several disease entities are explained, such as frontotemporal dementia in this example.

However, selecting the correct information pieces can still be challenging for some users. Therefore, we provide a possibility to individualize the knowledge from the atlas according to particular clinical needs. The following situations are typical for a memory clinic, wherein systematic and modern communication, aimed by the atlas app, can improve patient-to-professional communication.

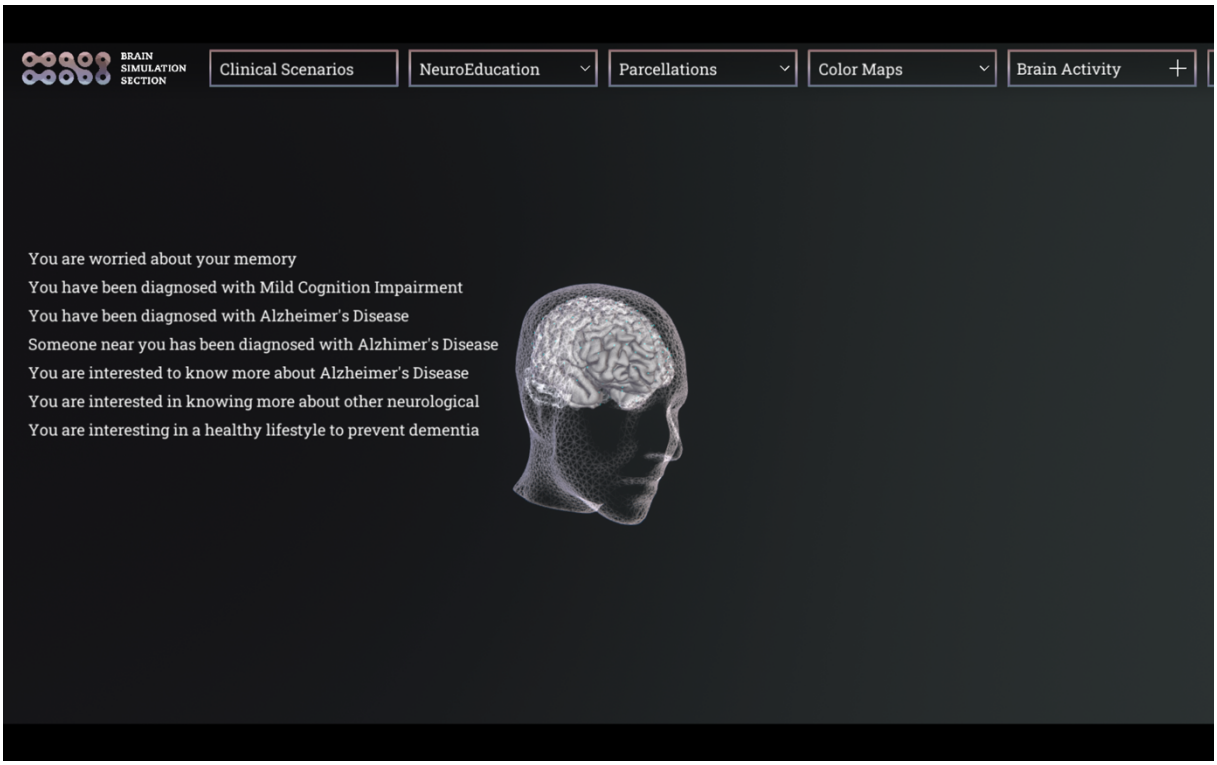

Figure 11: Possibility to individualize the information from the atlas for typical clinical situations.

In the following, we provide the complete list of recommendations, including their corresponding evidence.

Table 1: Complete list of lifestyle recommendations and corresponding evidence.

Story	Text	Evidence	Visualization
COPING	Information regarding treatment and disease processes to increase adherence, mainly for patients		-
Cholinesterase inhibitors	The largest drug group used to treat dementia consists of so-called cholinesterase inhibitors. These drugs increase a critical signaling molecule, acetylcholine, to improve memory function. They sometimes lead to dizziness, headaches, or sleep problems, and often an electrocardiogram (ECG) measuring the heart condition is necessary before starting the treatment. The map shows where in the brain these drugs work on cholinergic receptors.	(Blennow, de Leon et al. 2006)	M1 and M2 maps
Memantine	The drug memantine is used in middle or later-stage Alzheimer's disease to improve cognitive function. It reduces the activity of one important glutamate receptor of the brain: The NMDA receptor. The underlying idea is to prevent an overshoot in neural firing, which is one remarkable factor in Alzheimer's Disease. Besides, you can see how widespread NMDA receptors are distributed across the brain.	(Blennow, de Leon et al. 2006)	NMDA map
Memory deficits	Memory problems in Alzheimer's typically affect the so-called short-term memory. While old memories, e.g., about childhood, are often unaffected, the patients have problems learning new things. This has to do with the harmful effect of the disease on the hippocampus. This brain structure is responsible for acquiring new memories.	(Blennow, de Leon et al. 2006)	Hippocampus
Language impairment	Besides memory issues, patients with dementia often suffer from language problems, e.g., difficulties in word finding. One of the reasons for this is the affection of the brain's temporal lobe. It surrounds the memory-responsible hippocampus, where language is typically located on the left side of the brain.	(Blennow, de Leon et al. 2006)	Temporal lobe near the hippocampus
Apraxia	People with dementia often acquire problems with complex actions during the disease course, e.g., repairing a coffee machine or driving a	(Blennow, de Leon et al. 2006)	Parietal lobe

	car. This symptom – called Apraxia – concerns an affection of the parietal lobe in a later disease stage.		
Behavioral Symptoms	Many neurodegenerative diseases can damage the frontal areas of the brain, wherein personality and social skills are represented. This can lead to symptoms, including slight personality changes and sometimes aggressive behavior.	(Blennow, de Leon et al. 2006)	Frontal lobe
Network disruption	One crucial aspect of how Alzheimer's Disease affects the brain is that it destroys more and more connections between brain regions, called disconnection. Most of the human mind's complex functions do not occur in single brain areas but in networks between many brain parts. Such network disruption can severely disturb the brain's function, potentially worsening the disease's progression.	(Stefanovski, Meier et al. 2021)	Network visualization
Hyperexcitation	Especially in the earlier stages of Alzheimer's Disease, the brain shows unexpectedly high activity. Unfortunately, this overshooting activity is not beneficial to the brain, as brain cells can be heavily injured or destroyed if they receive too much activity in a too short time. Therefore, this over-activity can lead to a disruption of connections in the brain that are highly relevant, like the wear and tear of a highway.	(Stefanovski, Meier et al. 2021)	Firing brain
Comorbidities	Most dementias are not caused by a single disease, as often many factors are at least contributing to the progression. Therefore, it is vital to avoid cardiovascular risk factors are hypertension or high blood lipids. But also mental disorders can have a harmful effect – depression can, e.g., worsen the cognitive decline in Alzheimer's and lead to cognitive impairment. This relationship is currently under extensive research, as many potential interactions may arise here – see, besides the serotonin receptors in the brain, that play a crucial role in depression.	(Stefanovski, Meier et al. 2021)	TVBase maps for “Mental disorders” and “Alzheimer’s disease” next to each other
Amyloid-beta	Amyloid beta is a protein that is an essential factor in the course of Alzheimer's Disease. It is a misfolded version of a healthy protein of the brain, and many adverse effects of it have been described. Although the exact contribution to the disease development is still debated, it is the most critical marker to diagnose Alzheimer's Disease and follows a particular distribution pattern.	(Blennow, de Leon et al. 2006)	Braak stages for Abeta
Tau protein	Tau is a protein involved in many neurodegenerative diseases and is vital to Alzheimer's Disease. It has been shown to have the ability to harm the brain in a self-sustainable way once it is accumulated. It follows a particular spatial pattern of distribution.	(Blennow, de Leon et al. 2006)	Braak stages for Tau
PREVENTION	Information regarding primary and secondary prevention, mainly for the general public or people at risk like MCI or SCD		-
Sports	The effects of exercise are not limited to growing muscles and decreased heart rate. The practice has also shown significant effects on cognition and memory. Only 150 minutes of moderate-intensity exercise per week, such as sportive walking, or 75 minutes of vigorous-intensity physical activity, such as jogging, are a good start. This is a 20-minute walk a day! Such exercise can be, of course, complemented by muscle-strengthening activities.	(Larson, Wang et al. 2006)	5-HT maps
WHO lifestyle	The World Health Organization provides extensive suggestions for a healthy lifestyle. The main recommendations for maintaining well-being and preventing various diseases are a well-balanced diet, regular physical activity, an optimal body weight, avoidance of tobacco and alcohol, stress management, adequate sleep, and regular check-ups. More details can be found online at www.who.int/health-topics	https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle---who-recommendations	-
FINGER	Exercise, diet, cognitive training, and vascular risk monitoring combined have been shown to prevent cognitive decline in at-risk elderly individuals. In the FINGER trial – a study that aimed to find measures to prevent cognitive decline - participants were separated into two groups. The intervention group, which received the multidomain intervention, and the control group, which received general health advice. Results of the study showed that the multidomain intervention successfully reduced cognitive decline among at-risk elderly individuals. The intervention group demonstrated significant improvements in overall cognitive performance, executive functioning, and processing speed compared to the control group. These findings suggest that a comprehensive, multidomain approach can effectively prevent cognitive decline in older adults at risk.	(Ngandu, Lehtisalo et al. 2015)	Show Braak stages that should be prevented
Meditation	Negative stress is not only uncomfortable but also harmful to one's mental abilities. Pressure can be reduced by exercising and activities such as meditation. There are many techniques and opinions on how to meditate. Probably the most straightforward approach is to sit down for ten minutes daily in an upright position and watch one's breath. Since	(Goyal, Singh et al. 2014)	TVBase map for “meditation”

	this can be difficult in some situations – primarily when one is stressed – many excellent sources on the internet provide help here.		
Cognition	Cognitive training has been shown to reduce dementia risk. Engaging in activities such as learning a new language or dancing can be cognitive tasks that support mental health and can be fun.	(Teixeira-Machado, Arida et al. 2019)	Hippocampus visualizations
Nutrition	A balanced diet supports many aspects of health, including mental well-being. While the overall amount of fat can be reduced, one should increase the intake of unsaturated fatty acids, as in linen oil, fat sea fish, rapeseed, or olive oil. To differentiate between saturated and unsaturated fats, one can check what they look like at room temperature. While saturated fatty acids usually are solid at room temperature, unsaturated fats are liquid.	(Fadó, Molins et al. 2022)	-
Environmental factors	Unless the scientific community has conducted extensive research on the risk of developing dementia, many factors remain unclear. Besides a genetic risk, which often plays only a minor role, and lifestyle factors, there are other contributing conditions as the reaction to environmental toxins or the inflammatory response to a virus. Besides, you can see which brain regions are associated with inflammation, the general term for the immune system acting against an external factor.	(Stefanovski, Meier et al. 2021)	TVBase map "Inflammation"?
Healthcare	If you are worried about cognitive deficits, there are many possibilities to get help from healthcare professionals. A first contact can be your general practitioner, who, if necessary, recommends a followed-up consultation with a neurology or psychiatry specialist. Do not hesitate to contact a professional if you feel something is wrong with your memory or another brain function.	(Damian, Rouaud et al. 2018)	-
Sleep hygiene	Sleep allows the mind and body to recover and process memories and experiences one made during the day. Sleep quality can be improved by following the simple rules of sleep hygiene. Ideally, one goes to bed simultaneously throughout the week (even on weekends). Since that can be difficult for many people due to their natural rhythm and family and work obligations, it can help make one's sleep schedule as regular as possible. Avoiding blue light (mainly from the screens of technical devices) ahead of going to bed and having a cool bedroom support high sleep quality too.	(Chaput, Willumsen et al. 2020)	Hypothalamus with nucleus suprachiasmaticus
Avoidance of drugs	Alcohol and other drugs severely impact your body, like the liver and kidneys. But also, your mental health can be strongly affected. The advice here is simple: Use as little alcohol and drugs as possible to support your brain.	(Anderson, Berdzuli et al. 2023)	Nucleus Accumbens
Stress management	One can have, in fact, many different kinds of "stress". There are even theories about suitable, inspiring forms of stress. On the other hand, uncomfortable, involuntary pressure can harm one's health. It can be addressed, for example, by exercising or stress-reducing techniques. There are many techniques and opinions on how to meditate. Probably the most straightforward approach is to sit down for ten minutes daily in an upright position and watch one's breath. Since this can be difficult in some situations – especially when one is stressed – many online instructions provide help.	(Gotink, Meijboom et al. 2016)	Dorsolateral Prefrontal Cortex
KNOWLEDGE	Providing knowledge about the clinical neurology of NDDs, mainly for relatives or interested people to understand the diseases better		-
Alzheimer's Disease	Alzheimer's disease is the most common cause of dementia, affecting memory, language, and behavior. While the causes of Alzheimer's are not yet understood, it usually starts with mild forgetfulness and confusion. Still, it slowly worsens over time, making it difficult to perform daily tasks and live independently. Current biomarkers often allow for establishing the suspected diagnosis early in the disease.	(Blennow, de Leon et al. 2006)	Braak stages
Vascular dementia	Vascular dementia is caused by multiple tiny strokes, I.e., damage induced by blood flow restriction to your brain. This typically happens due to degenerative problems of blood vessels or due to heart diseases. The most common risk factors for stroke are elevated blood pressure, high blood lipids, obesity, diabetes, smoking, and positive family history. When your brain doesn't receive enough blood, even for a few minutes, brain cells don't get the oxygen they need, leading to irreversible damage. This can cause problems with thinking, memory, and decision-making. Vascular dementia is typically characterized by subcortical dementia, wherein a slowing in all cognitive functions is the predominant feature.	(Graff-Radford 2019)	Subcortical structures

Frontotemporal dementia	Frontotemporal lobar degeneration (FTLD) is a group of conditions that affect the front and side parts of your brain, which are responsible for personality, behavior, and language. Like other neurodegenerative diseases, misfolded proteins are crucial, mainly the Tau protein and the so-called TDP-43 protein. In FTLD, brain cells in these areas become damaged and die, leading to changes in personality, behavior and difficulty with language and communication. Unlike other types of dementia, memory problems may not be an early symptom of FTD.	(Finger 2016)	Frontal lobe
Encephalitis	Encephalitis is when the brain becomes inflamed, usually due to an infection or an autoimmune reaction. This inflammation can cause the brain to swell, leading to various symptoms such as headaches, fever, confusion, and seizures. In some cases, encephalitis can be severe and may result in long-term damage to the brain. The most common infectious form, caused by Herpes viruses, and the most common autoimmune form, limbic encephalitis, mainly affect the inner parts of the temporal lobe, wherein the memory is typically consolidated. When encephalitis causes damage to the brain, it can lead to problems with memory, thinking, and behavior, which are characteristics of dementia. The damage caused by encephalitis may not be reversible. The extent of the issues depends on the severity of the inflammation and which parts of the brain are affected.	(Herken and Prüss 2017)	Limbic system
Lewy body dementia	Lewy body disease is a cause of dementia induced by abnormal protein deposits, so-called Lewy inclusion bodies, in your brain. They consist of the protein alpha-synuclein, which is also involved in Parkinson's Disease. These deposits disrupt the normal functioning of brain cells and can lead to problems with visual processing, memory, and movement. People with Lewy body dementia may also experience visual hallucinations, fluctuating levels of alertness or attention, and Parkinsonism.	(Gomperts 2016)	TVBase map
Parkinson's disease dementia	Parkinson's disease is primarily known for causing movement problems, but some people with Parkinson's may also develop dementia. Parkinson's disease dementia can lead to memory, decision-making, and attention difficulties. This happens because the disease affects brain cells responsible for movement and thinking.	(Gomperts 2016)	Deep brain stimulation
Mixed dementia	Mixed dementia is a defined term for the common condition when a person has both Alzheimer's Disease and vascular dementia. This can happen because different brain changes are taking place at the same time. Mixed dementia can cause a combination of symptoms from each type, making it difficult to predict how the condition will progress.	(Graff-Radford 2019)	TVBase map
Huntington's disease dementia	Huntington's disease is a hereditary condition that causes the progressive destruction of nerve cells in the brain. As the disease concedes, it can lead to dementia, affecting memory, thinking, and behavior. Symptoms of Huntington's disease dementia may include impulsive behavior, difficulty making decisions, and personality changes.	(Roos 2010)	TVBase map
Creutzfeldt-Jakob disease	Creutzfeldt-Jakob disease (CJD) is an extremely rare and rapidly progressing brain disorder caused by abnormal and infectious proteins called prions. These proteins cause damage to brain cells, leading to quickly worsening symptoms such as memory loss, confusion, and difficulty with movement. Unfortunately, CJD is a severe and incurable condition at present.	(Geschwind 2015)	TVBase map
Wernicke-Korsakoff syndrome	Wernicke-Korsakoff syndrome is a disorder caused by a severe lack of vitamin B1 (thiamine), often due to long-term alcohol abuse or poor nutrition. The syndrome has two related conditions: Wernicke's encephalopathy and Korsakoff's psychosis. Symptoms include memory problems, confusion, and difficulties with balance and coordination. The early supply of high amounts of thiamine in a hospital is essential for the treatment and to prevent irreversible damage.	(Butters 1981)	TVBase map
Mild cognitive impairment (MCI)	Mild cognitive impairment is when a person has minor problems with memory, thinking, or other mental functions. Still, these issues are not severe enough to affect them in activities of daily living. An impairment that does affect these daily routines is called dementia, irrespective of its cause. People with MCI might have a higher risk of developing dementia later on. Still, not everyone with MCI will progress to	(Lopez 2013)	TVBase map

	dementia. Monitoring and discussing any cognitive changes with a healthcare professional is essential.		
Subjective Cognitive Decline	Subjective Cognitive Decline is when a person has minor problems with memory, thinking, or other mental functions. Still, these issues are neither severe enough to affect them in activities of daily living nor are further objectifiable in formal neuropsychological testing. The causes for this condition can be very diverse, though. Still, it has turned out that patients with subjective memory complaints have a higher risk of developing Mild Cognitive Impairment or dementia at a later stage.	(Lopez 2013)	TVBase map
Dementia	The term dementia refers to any severe cognitive impairment that affects the patients in their daily living and is present for extended periods. If a neurodegenerative disease leads to slight cognitive impairments without affecting everyday life, it is called mild cognitive impairment. There are many causes for dementia, e.g., Alzheimer's Disease or multiple strokes.	(McKhann, Drachman et al. 1984)	TVBase map
Pseudodementia	The term pseudodementia refers to a particular symptom of major depressive disorder, wherein patients suffer from severe cognitive deficits similar to dementia. It is typically characterized by severe concentration problems and unexpectedly low values in formal cognitive tests. Meanwhile, the patients often maintain most of their daily life competencies. In contrast to other cognitive disorders, depressive pseudodementia can be reversible by treating the underlying depression, e.g., with psychotherapy and antidepressants.	(Kiloh 1961)	TVBase map
Posterior Cortical Atrophy	Posterior Cortical Atrophy is a rare variant of Alzheimer's Disease. Instead of affecting memory, the disease predominantly affects the brain's rear parts, which build the visual system. Therefore, people with this condition often have problems recognizing and understanding visual information, which can progress into functional blindness.	(Schott and Crutch 2019)	TVBase map
Primary Progressive Aphasia	Primary Progressive Aphasias are a group of dementias characterized by severe language impairment. While language problems are a common symptom in most dementias, in Primary Progressive Aphasia, they are typically the first symptom in addition to memory problems. This disease has different variants, and the causes vary between an atypical form of Alzheimer's Disease, Frontotemporal Dementia, and other neurodegenerative conditions.	(Botha and Josephs 2019)	TVBase map
Progressive Supranuclear Palsy	Progressive Supranuclear Palsy is a rare, atypical form of Parkinson's Disease, typically characterized by symmetric slowing of movements, problems with arbitrary eye movements, and an early onset of subcortical dementia. The disease is associated with the Tau protein and shows weaker response to dopaminergic drugs than Parkinson's Disease.	(McFarland 2016)	TVBase map
Corticobasal Degeneration	Corticobasal Degeneration is a rare, atypical form of Parkinson's Disease, typically characterized by strictly one-sided slowing of movements, problems with complex motion programs, and the so-called Alien-limb phenomenon, wherein the patient does not consider one limb to be still a part of the own body. If affecting the dominant side, it can also affect language production and is associated with an early onset of dementia. The disease is related to the Tau protein and shows weaker response to dopaminergic drugs than Parkinson's Disease.	(McFarland 2016)	TVBase map

5. Conclusion, next steps

In this deliverable, we present a ready-to-use application that combines the functionalities of a didactic atlas of the brain with the concept of neuroeducation. We developed a framework that allows the users to explore knowledge about the brain and directly receive the consecutive practical recommendations for their lifestyle. For this, we have combined expertise from clinical settings, state-of-the-art neuroscience research, and high-end visualizations. Taking this all together, the interactive atlas is a hybrid between a scientific visualizer, a didactive platform, a lifestyle app, and an

art project. We believe that its use in patient communication can improve the information flow and, by this, increase both the adherence and the resilience of patients, people at risk of dementia, and their relatives.

The atlas is continuously adapted and extended, and future versions could also provide the possibility to visualize and analyze own data. More importantly, we plan a small clinical study exploring the potential benefits of this atlas in real-life settings. It will be examined whether using the patient-individual knowledge visualization can foster communication and increase the knowledge gained on the patient side. This will be assessed in a randomized and controlled setting. Meanwhile, objective (e.g., the declarative knowledge about the communicated information) and subjective criteria (e.g., the patient's experience in the setting) will be considered for the evaluation.

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