Alzheimer's Society
Leading the fight against dementia

Dementia and the brain

Dementia occurs when the brain is damaged by disease. Knowing more about the brain may help someone caring for a person with dementia to understand the condition and support them better. There has been a lot of research into how the brain works. However, not all the details are clear and more research is needed. This factsheet explains which areas of the brain are thought to be responsible for which skills and abilities. It explains how changes in the brain of someone with dementia relate to the changes that they – and those around them – may notice as the condition progresses. It will be helpful for anyone who wants to find out more about how the brain is affected in dementia.

The brain is incredibly complex and this factsheet contains a lot of information about how the brain is thought to function. For more about how the brain works and the effects of dementia, see the film at alzheimers.org.uk/braintour

Parts of the brain

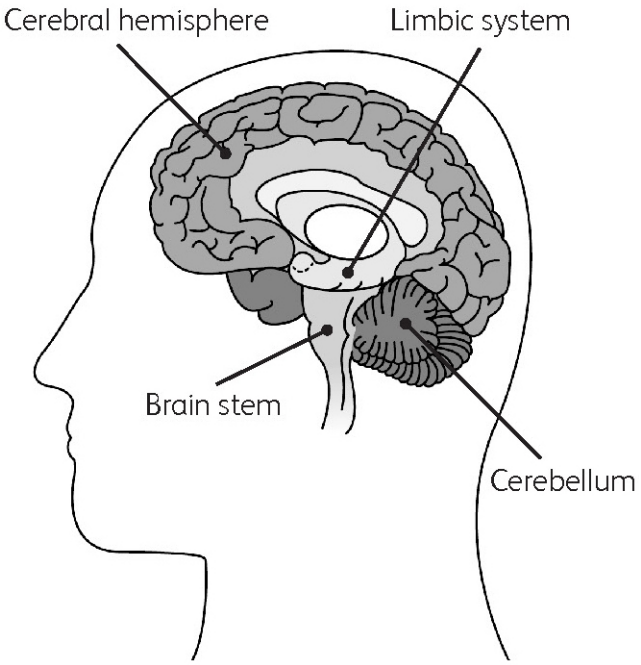
The brain can be divided into different parts: the brain stem and cerebellum, the limbic system, and the cerebral hemispheres (see Figure 1 on page 2). Each part has different functions.

Brain stem and cerebellum

The brain stem is at the base of the brain. It controls basic bodily functions such as heartbeat and breathing. The nearby cerebellum

controls balance and posture. Breathing and staying upright are things that we normally do automatically.

Figure 1: Parts of the brain



The limbic system

The limbic system is deep inside the brain. It links the brain stem and the cerebral hemispheres. The limbic system includes structures with key roles in memory (the hippocampus) and emotions (the amygdala).

Cerebral hemispheres

The tissue that makes up three-quarters of the brain is called the cerebrum. It is responsible for consciousness, memory, reasoning, language and social skills. A deep groove that runs from the front to the back of the cerebrum divides it into left and right halves: the two cerebral hemispheres.

The left and right cerebral hemispheres have different functions. For example, language is usually dealt with mainly by the left hemisphere. In contrast, awareness of where things are around us is usually dealt with mainly by the right hemisphere.

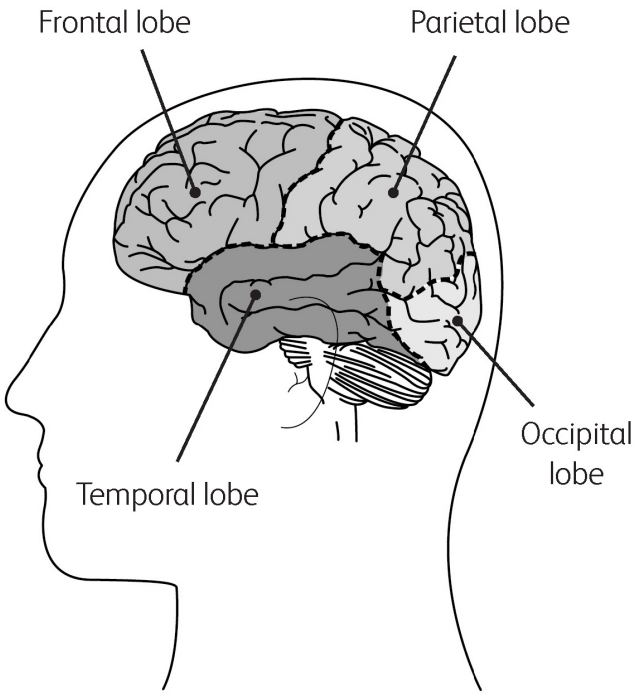
The surface of the cerebral hemispheres is covered by a thin layer known as the cerebral cortex, sometimes just called the cortex. It contains billions of brain cells called grey matter.

Underneath the cortex are bundles of nerve fibres known as white matter. These transport nerve signals between parts of the cortex and from the cortex to other parts of the brain.

The cortex of each cerebral hemisphere is divided into lobes. There are four lobes in each hemisphere.

The lobes

Figure 2: Lobes of the brain



The four lobes are: occipital, temporal, parietal and frontal (see Figure 2). Each lobe does different things, though they also work closely together.

Occipital lobes

The occipital lobes at the back of the brain deal with visual information. When we look at something, light entering the eye is converted into electrical signals to the brain. These signals are analysed first by the visual cortex in the occipital lobes. Damage here can cause blindness. For more information see 'Vision' below.

Parietal lobes

The parietal lobes are in the upper-rear part of the brain. They mainly handle information from our senses about space, perception and size.

The left parietal lobe allows us to tell our left from our right side and where a limb is in front of us. For example, it helps us to bring a fork up to our mouth when we eat. Damage to this lobe is common in Alzheimer's disease and can lead to clumsiness (apraxia), for example when putting on clothes.

The left parietal lobe also plays an important role in reading, writing and processing numbers.

The right parietal lobe helps us recognise objects as three-dimensional. It also helps us to work out where objects – including moving objects –

are in relation to each other, and to ourselves. These abilities are used when we pick an object up. Damage to the parietal lobes can cause someone problems with finding their way around places.

Temporal lobes

The temporal lobes are on either side of the brain, near the temples. They deal with memory (including recognition of faces and objects) and language.

Our day-to-day memory of personal experiences (known as episodic memory) is very closely linked to the hippocampus, which is inside the temporal lobe on each side of the brain. The importance of the hippocampus in episodic memory and dementia is explained in the 'Memory' section below.

The outer part of each temporal lobe is where we store general knowledge, which is a different type of memory (known as semantic memory). The left temporal lobe usually deals with facts, the meanings of words and the names of objects. This lobe is central to understanding speech and talking. The right temporal lobe usually deals with visual material. This lobe is central to recognising familiar objects and faces.

Frontal lobes

The frontal lobes are large and complex. They have a wide range of functions. Overall, the frontal lobes are a kind of 'management centre'. They deal with solving problems, setting goals and making decisions, as well as with starting, carrying out and finishing tasks.

This management role is called 'executive function'. We use it when we follow a set of steps, such as making a cup of tea. To do such tasks we have to maintain attention. We also have to briefly hold information (eg how many sugars we have added to a cup of tea) in our working memory. The frontal lobes play an important role in attention and working memory.

Executive function has different aspects and these are dealt with by different parts of the frontal lobes.

The upper parts of the outer surfaces of the frontal lobes are where we organise and plan actions and learn new tasks (see 'Procedural memory'). For example, when learning to drive, these brain areas (together with areas that control movement) help us put together a complex set of actions so they become automatic. These areas also help us switch between tasks or do more than one thing at once. Without them we would get stuck on a task or not be able to concentrate on anything for long.

The upper parts of the middle surfaces of the frontal lobes are important for our interest and motivation. Damage here can cause someone to become apathetic, lethargic and reluctant to do things. It is important to realise that they are not 'just being lazy'.

The area on the underside of the front of the brain controls our social behaviour. For example, it normally prevents us from saying something inappropriate or acting on impulse. There is more about how the frontal lobes control our behaviour in the section 'Emotion and behaviour'.

At the back of the frontal lobes is the motor cortex. This area deals with the planning of movements and the control of certain muscles, such as when we decide to clap our hands, smile or speak.

Functions of the brain

Many of the complicated things that the brain does – memory, language, vision – need several parts to work together. Signals move along pathways of nerves that connect different lobes.

Vision

Vision involves several steps. Information from the eye is processed first in the occipital lobes. Signals are sent to the parietal lobes, to work out the object's location. They are also sent to the temporal lobes, to match up with memories of previous experiences (for example of someone's face or an object). For someone with dementia, disruption

of these signals causes problems such as not being able to recognise faces or objects (known as visual agnosia).

As part of visual recognition, signals are also passed to the amygdala. This is where we make a quick emotional response to the thing we have seen. Problems here can lead to extreme emotions or a loss of emotional reaction to people.

Language

When we listen to and understand speech, sounds are processed in an area towards the back of the temporal lobes called the auditory cortex. Signals are then passed through the temporal lobes, where the meaning of the words is processed.

When we talk, our vocal cords are controlled by areas in the frontal lobe in the left side of the brain. Talking also involves the temporal lobe (where concepts are converted into words) and the auditory cortex, because we rely on hearing our own voice when we speak.

Memory

Different things we remember – events, faces, facts or skills – are stored and recalled by different types of memory.

Episodic memory is our personal memory of events at a certain time and place. For example: 'I ate eggs for breakfast this morning in my kitchen'. These memories are specific to each of us and can have an emotional aspect.

Semantic memory is our general knowledge about objects, word meanings, facts and people. For example: 'Eggs have a shell and are laid by hens'

Procedural memory is our memory for skills we have learned. Examples include tying shoelaces, brushing our hair or riding a bike.

These different types of memory involve different parts of the brain working together. They can be affected by dementia in different ways.

Episodic memory

Our recollection of an event may have several parts: where we were, what we saw or heard, how we felt, for example. These parts are put together to create the memory.

When we experience something, information from our senses initially goes into the hippocampus. Over time, it is thought that the hippocampus begins to transfer memories into long-term storage in the cerebral cortex.

The memory is stored in the cortex as a network of nerve cells. Recent memories, which have just entered long-term storage, still need the hippocampus to retrieve them.

But memories from further back (such as a wedding day) that have been thought about more often, become more firmly established in the cortex. Recall of these memories from longer ago seems to need the hippocampus less. Retrieval of an episode may be triggered by just one part of the memory, such as a particular smell or piece of music.

Emotions have a large influence on what we remember. An experience that is highly emotional is more likely to be stored in long-term memory. We are also more likely to recall the emotional aspects of an experience. The amygdala is the centre for emotional memories.

Other forms of memory

The hippocampus is also involved in forming semantic memories. These are then stored as long-term memories in the cerebral cortex.

With procedural memory, we use the frontal lobes to concentrate, allowing us to first learn a skill. But once the skill has been learned it is stored in the basal ganglia (a group of structures between the cerebrum and brain stem), as well as in the motor cortex and cerebellum.

Emotion and behaviour

How we respond to the world around us – how we feel and how we behave – depends on signals passed between the limbic system (dealing with emotions) and the frontal lobes (dealing with rational thoughts).

Emotions are generated in the limbic system in response to sensory information. For example, our amygdala responds to danger by generating signals for fear.

Emotions are analysed in the frontal lobes. For example, the frontal lobes allow us to check that something really is a threat – perhaps we misread the situation – and so may stop us from reacting aggressively.

In dementia, different forms of damage to these two emotional centres in the brain can cause someone to become either over-emotional or lacking in feelings.

Dementia symptoms and areas of the brain

Knowing how different types of dementia affect the brain helps explain why someone with dementia might behave in a certain way. Until recently, seeing changes in the brain relied on studying the brain after the person had died. But modern brain scans may show areas of reduced activity or loss of brain tissue while the person is alive. Doctors can study these brain scans while also looking at the symptoms that the person is experiencing.

The most common types of dementia each start with shrinkage of brain tissue that may be restricted to certain parts of the brain. This means that each type of dementia tends to have particular early symptoms, depending on which part of the brain is affected. Later on, as damage spreads to more areas of the brain, the symptoms across different types of dementia tend to become more similar.

Alzheimer's disease

In Alzheimer's disease, among the areas often damaged first are the hippocampus and its connected structures. This makes it much harder for someone to form new memories or learn new information. A person with Alzheimer's may struggle to remember what they did earlier that day, or what they have just said, meaning they may repeat themselves in conversation.

The hippocampus is needed for retrieval of memories, but retrieving those from longer ago may depend on it less. This is why someone in the earlier stages of Alzheimer's (with a damaged hippocampus but an intact cortex) may remember a childhood holiday but struggle to remember what they ate for breakfast that morning.

In Alzheimer's disease the amygdala is generally affected later than the hippocampus. So a person with Alzheimer's will often recall emotional aspects of something even if they don't recall the factual content. They may therefore respond more according to how they feel about a place or person than in a more logical way.

As Alzheimer's disease damage spreads through the brain, additional areas and lobes become affected. The cortex overall becomes thinner (so memories from longer ago are lost) and the brain gradually shrinks.

Damage to the left hemisphere is linked to problems with semantic memory and language, so someone may struggle to find the right word for something.

Damage to the visual system in the temporal lobes makes recognising familiar faces and objects harder. The person may seem to forget who a familiar person is. However, because the pathways for vision and hearing are separate, they may still know who that person is once they hear them speak. The person with Alzheimer's disease may also respond to someone at an emotional level even if they seem not to recognise them.

If there is damage to the right parietal lobe then the person might have problems with judging distances in three dimensions. Navigating stairs is a common difficulty.

As the damage spreads to the frontal lobes, someone with Alzheimer's may struggle with decision-making, planning or organising (eg family finances). A more complex task with a sequence of steps, such as following a new recipe, might also become much harder.

In contrast to these losses, many abilities are retained, particularly those acquired long ago. Learned skills such as dancing or playing the piano rely on procedural memories, and so are mostly stored deep within the brain. In Alzheimer's disease, these skills are often retained the longest.

'Atypical' Alzheimer's disease

There are rarer forms of Alzheimer's in which the first parts of the brain affected may not be in or near the hippocampus. This means that memory problems are often not the earliest symptoms.

In one form of atypical Alzheimer's – posterior cortical atrophy (PCA) – the early damage is mainly to the occipital lobes and parts of the parietal lobes, which help to process visual information and deal with spatial awareness. The early symptoms of PCA are often problems identifying objects or reading, even if the eyes are healthy. Someone may also struggle to judge distances going down stairs or parking the car. Or they may seem uncoordinated, for example when dressing. For more about atypical Alzheimer's see factsheet 401, What is Alzheimer's disease?

Vascular dementia

Vascular dementia has a wider and more variable range of symptoms than the other types of dementia. It is caused by a range of different diseases of the blood supply to the brain.

Sometimes vascular dementia follows a major stroke, in which a large area of tissue on one side of the brain dies because the blood supply is suddenly cut off. Symptoms are often seen in problems with planning, concentrating and thinking or memory. In addition, the person may be left with weakness down one side of the body or problems with vision or speech. With rehabilitation, some degree of recovery may be possible.

Vascular dementia can also follow several mini-strokes over time. Each mini-stroke creates a small patch of dead brain tissue, called an infarct, in the cortex. Early symptoms can be very specific to where the tissue is lost. For example, problems with episodic memory can be caused by an infarct in the hippocampus, and problems with executive function can be caused by an infarct in the frontal lobe.

A different kind of vascular dementia, called subcortical vascular dementia, follows disease of the small blood vessels deep in the brain. This disease often causes widespread damage to white matter beneath the cortex. These nerve fibres carry signals between different parts of the cortex, including the frontal lobes. A person with subcortical vascular dementia will therefore often have slowed thinking and problems with executive function.

For more information see factsheet 402, What is vascular dementia?

Frontotemporal dementia

In all forms of frontotemporal dementia (FTD), the frontal and/or temporal lobes shrink. The different sub-types of FTD – which affect the person's behaviour and language – reflect different patterns of damage. For more information about these sub-types see factsheet 404, What is frontotemporal dementia?

In behavioural variant FTD, the areas of the brain affected early on are in the frontal lobes. For example, damage to the upper middle surfaces of the frontal cortex is linked to becoming withdrawn and losing motivation. Damage to the front under-surface is linked to losing inhibitions, meaning the person might make inappropriate

comments, for example. Damage to the frontal lobes may also mean the person repeats the same word, phrase or action over and over again. It is important to appreciate that none of these things are done by choice.

In semantic dementia, the front of the left temporal lobe, dealing with verbal semantic memory, is damaged first. So the person may have fluent speech but struggle to find the right word for something, or they may ask what a familiar word (eg 'knife') means. Damage to the right temporal lobe leads to problems recognising faces and objects.

Dementia with Lewy bodies

The brain of a person with dementia with Lewy bodies (DLB) often shows less overall shrinkage than the brain of someone with Alzheimer's or FTD. Instead, tiny deposits of protein (Lewy bodies) are seen in the cerebral cortex, limbic system and brain stem.

In DLB, early damage is seen in the visual pathways and – in some studies – also in the frontal lobes. This may explain why problems with vision and attention are common early symptoms of DLB. Similarly, Lewy bodies in the brain stem may be linked to the problems with movement, as also seen in Parkinson's disease.

Remembering the person

Researchers have discovered so much about how the brain works that it can be tempting to think of the person just in terms of their brain, and that changes in a person's behaviour are caused wholly by damage to their brain. This is a mistake. Our behaviour does reflect changes in our brain. But it also depends on our attitude, life experiences and environment as well as how others relate to us – whether we have dementia or not. It is important to focus on what a person with dementia can still do or feel, not just on what they might have lost. This will help support them to live well with the condition.

Factsheet 456LP

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This factsheet has also been reviewed by people affected by dementia. A list of sources is available on request.

Alzheimer's Society National Dementia Helpline

England, Wales and Northern Ireland:
0300 222 11 22

9am–8pm Monday–Wednesday
9am–5pm Thursday–Friday
10am–4pm Saturday–Sunday

alzheimers.org.uk

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