Knowledge & Expertise

Visio

CVI in the picture

When the brain is the cause of visual impairment in children

Sander Zuidhoek

Royal Dutch Visio is an important resource centre for people with a visual impairment. Royal Dutch Visio also helps people who, apart from a visual impairment, are also mentally, physically or otherwise sensory impaired. Royal Dutch Visio tries to provide the best possible answer to needs ranging from aids, education, housing, work or leisure activities. All over the country Royal Dutch Visio staff have formed professional partnerships with clients, residents, students and the people in their environment. At Royal Dutch Visio, expertise, innovation, enthusiasm and cooperation are key.

CVI in the picture

When the brain is the cause of visual impairment in children

Sander Zuidhoek

Colophon
The utmost care has been taken during this publication. The author and publisher accept no responsibility or liability for any information that may be incomplete or incorrect.

Photography
Screenshots from the movie "CVI in the picture"

Lay out
Makes Sense Design

Table of contents

Preface

In order to see, our eyes are not enough. In recent years we have increasingly come to the realisation that it is often the brain that causes children to experience visual problems. These children have a disorder, called Cerebral Visual Impairment (CVI). They are visually impaired because their brain does not process visual information properly.
They experience limitations and restrictions in daily life that are difficult to understand, both for themselves and for the people around them. CVI is complex and each child with CVI is unique. This makes effective intervention and guidance of these children difficult. To be able to help them, it is necessary to understand CVI thoroughly.
This book is part of a project called "CVI in the picture". The project's overall intention is to increase the knowledge of those who need it the most: the parents/caregivers of children who have CVI, the professionals who work with them and, last but not least, the adolescents and adults who have CVI. In addition to this book, the project includes a film and an interactive experience workshop which allows different aspects of CVI to be experienced.

Figure 1. You have CVI when you're visually impaired due to your brain not processing visual information properly.

The film "CVI in the picture" gives an impression of CVI. It lets you meet several children and adolescents with different types of CVI and provides insight into the practical and socio-emotional effects that this disorder often has. The workshop "CVI in the Picture" introduces various exercises to experience the most common forms of CVI. Professionals from Royal Dutch Visio use these practical exercises to help family members and other professionals improve their understanding of CVI.
This book is the foundation of the project. It provides parents, caregivers, teachers and professionals with the knowledge and tools needed to understand children and adults with CVI. It clarifies what CVI is and what it is not. It explains what goes wrong in the different forms of CVI and discusses what other factors may play a role in the lives of children and adults with CVI. It emphasizes that every person with CVI is unique: each has his/her own restrictions and limitations, ways of compensating the impairment, strengths and weaknesses, surroundings, ambitions and interests. A complete picture is essential for

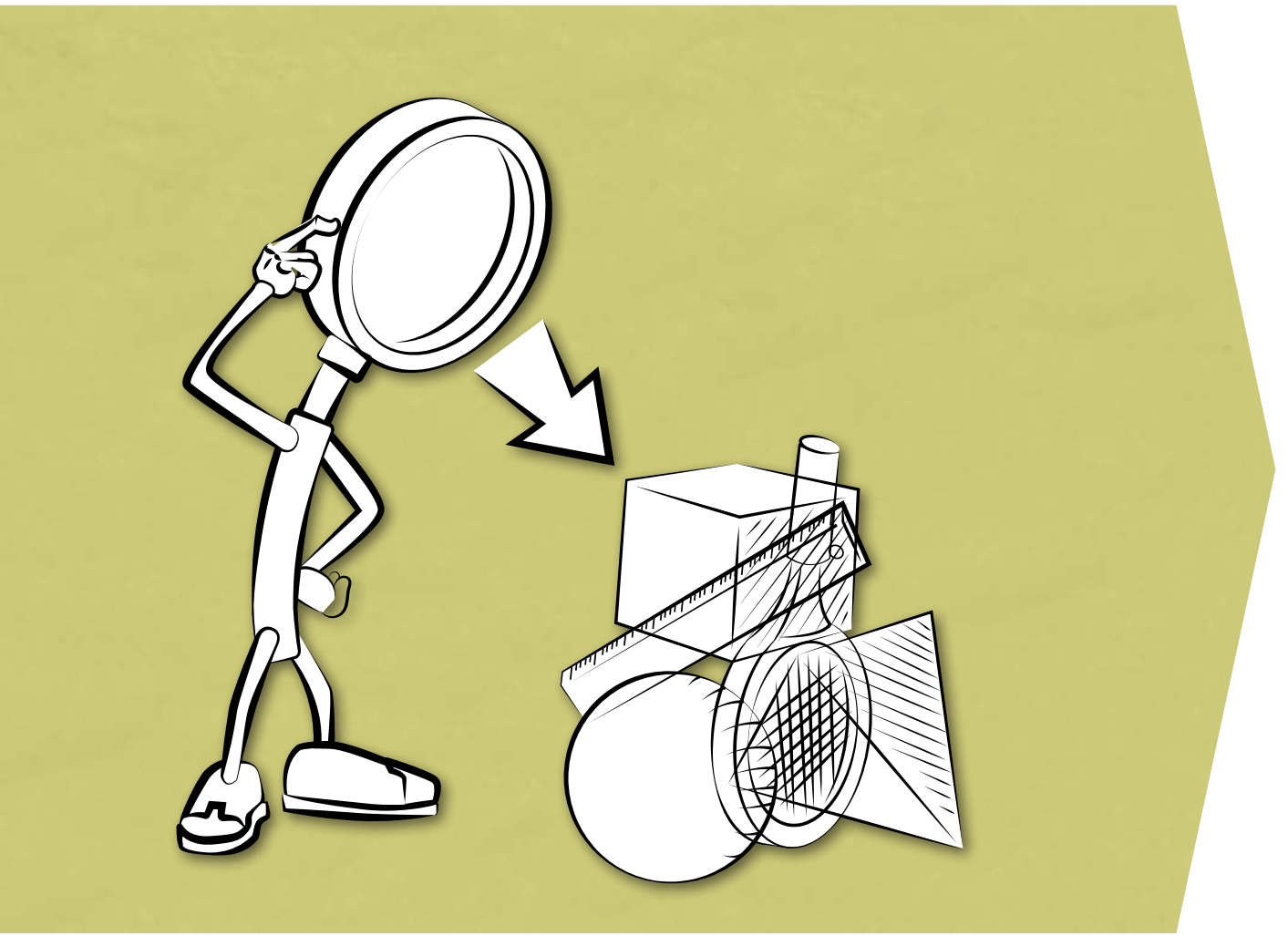
successful individual intervention and guidance. Chapter 13 may be of particular interest to the Dutch readers, since it describes the way the care for people with CVI is organised within Royal Dutch Visio in The Netherlands.
The book also provides a framework that allows a parent, teacher and healthcare professional to develop a personal guideline together with the person who has CVI. Royal Dutch Visio has recently introduced a CVI passport and a corresponding key card which offers individuals with CVI and those in their immediate surroundings, a practical and useful overview of the key characteristics of that individual's CVI. The pictures that are used in these tools to illustrate the various visual functions are included at the end of the related chapters and in the summary at the end of the book.
The theoretical framework underlying "CVI in the picture", the CVI passport and the key card was first published within Royal Dutch Visio in 2013 by Sander Zuidhoek and the members of the CVI Expertise Group. Its neuropsychological foundation was published in two chapters written by Sander in the book "Vision and the Brain: Understanding Cerebral Visual Impairment in Children" (edited by Gordon N. Dutton and Amanda Hall Lueck, 2015).

The three products of "CVI in the Picture" (the book, film and workshop) were enabled by a grant provided by the Novum Foundation. "CVI in the Picture" is a collaborative effort of Sander Zuidhoek (neuropsychologist, initiator, content project leader and author of the book), Henk Benjamins (itinerant teacher), Femke van der Veer (occupational therapist), Ria Waelen (development support worker and overall project manager), Lianne Noteboom (knowledge broker) and Eline Kreuze (remedial educationalist).

Before you start reading this book

CVI is fairly complicated. This book does not shy away from this complexity. It is recommended to watch the film "CVI in the picture" (found on https://www.youtube.com/watch?v=9wvGZiTDwa8) before you start reading this book. The summary may also be helpful whilst reading. Moreover, the book contains a list of definitions and key words. The appendix "Vision and the Brain" is not necessary to be able to understand the rest of the book. It is meant for readers who wish to know more about how the brain processes visual information.

1 What is seeing?



This book is all about Cerebral Visual Impairment, abbreviated as CVI. Before we start discussing what this disorder exactly entails, it is important to first understand about how we see. We look all day, every day. But how does this actually work? We hardly ever stop to think about this. A brief summary of the most important elements of vision will help you to understand the rest of this book better.

Attention

Seeing involves both the eyes and the brain. An important prerequisite for seeing is **attention**. Without attending to what there is to see, you don't see anything at all. You can stare without actually seeing anything, because your attention is focused on something else. For example, you might be thinking or listening intently.

Being rested and motivated

To be able to use your attention, you need to be awake. The more rested and alert you are, the more attentional resources you have.

Furthermore, you need to be motivated to see. When your mind is elsewhere, something else is apparently more important to give your attention to. Or you are simply unable to focus on whatever there is to see.

So, to be able to see, you need to be:

1. sufficiently rested and alert
2. motivated to see
3. able to attend to what there is to see

When these conditions are met, you see. Obviously, the quality of your eyes and the level of attention for what there is to see affect the quality of your visual image.

Directing your eyes, focusing your attention

Imagine that you are in a classroom and your teacher draws something on the blackboard. The drawing is not the only thing to look at in the classroom. How do you manage to see just *what is drawn* and not, for example, the fidgety pupil to your right? What helps is directing your eyes to the drawing and focusing your attention on it. Doing this optimizes the visual image you experience. In order to do this, your brain must select that specific drawing out of all there is to see. This is harder than it may seem.

What you see depends on:

4. the quality of your eyes and the visual image you experience
5. how well your brain can direct your eyes
6. how well your brain is able to focus your attention on something specific

Understanding what you see

OK, suppose all this works properly and you actually see what is drawn. The fact that you *see* the drawing doesn't mean that you *understand* it. Imagine that your teacher draws the symbol "¥" on the blackboard. If you have never seen this symbol before, your brain will try to understand it, for example as a Y with two small horizontal

lines crossing the vertical one. Your brain will try to store the image, so that you can recognise it should your teacher draw it on the blackboard again tomorrow. After school you can still see the symbol in your mind's eye and think about what you saw.

In short, how well you *understand* what you see depends on:

7. how well your brain understands visual information
8. how well your brain can store what you have seen
9. how well you can think in visual images

Seeing involves 9 steps, plus 1 more

Excellent, in just nine steps you see what you want to see, you understand what you see and you can also think about it. Do you need anything else? Yes, seeing is hardly ever a goal in itself. Most of the time, we want to *do* something with what we see and preferably quickly and accurately. Suppose I unexpectedly throw a ball in your direction and you catch it. How does your brain manage to process something you see so quickly and accurately that you can catch it? That type of action is performed by a specific part of the brain.

How well you *can act on* what you see depends on:

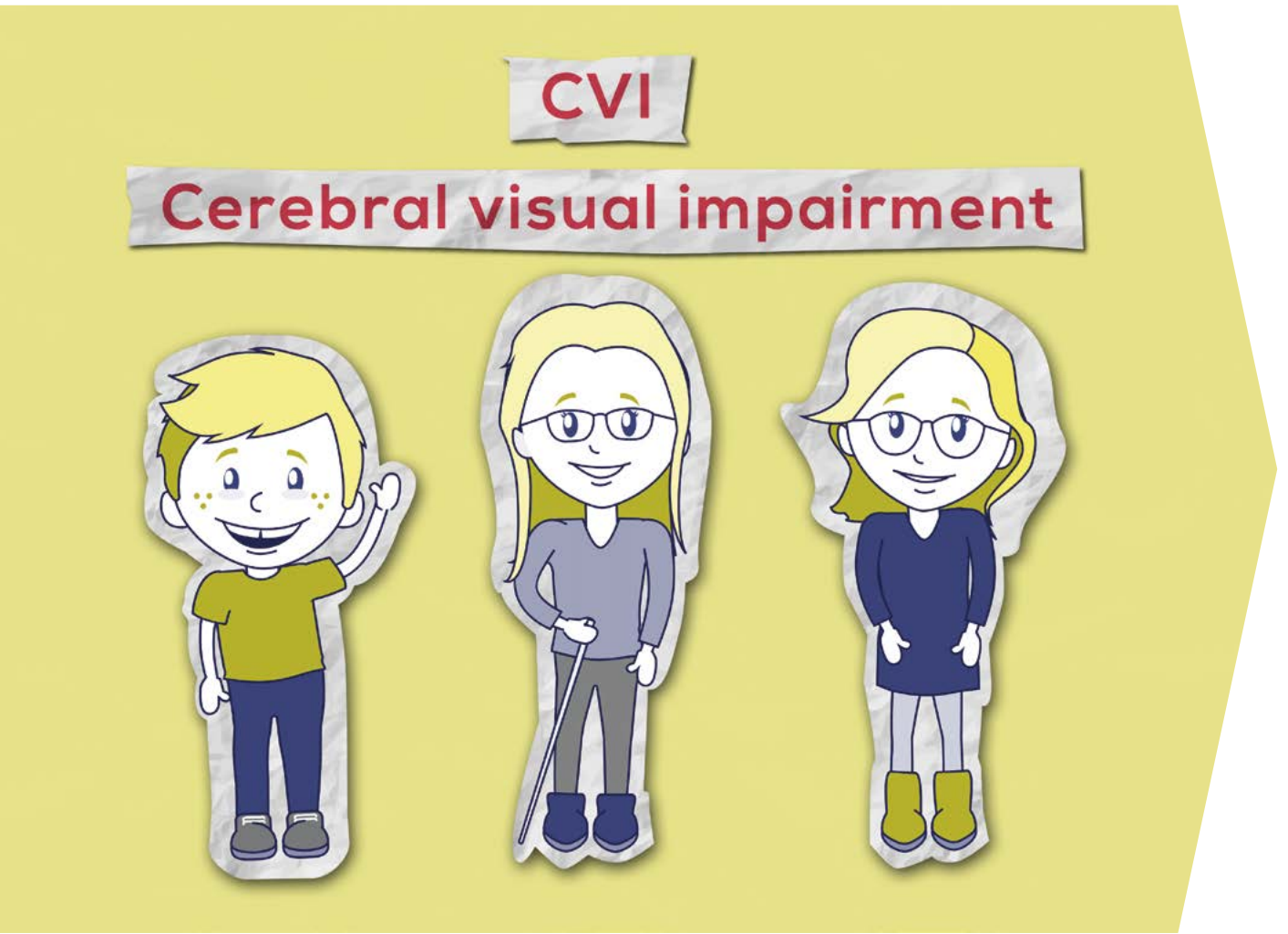
10. how well your brain can convert what you see into a fast and accurate action

These ten steps are the building blocks of how we see and how we perform visual tasks. When you have CVI, something goes wrong in one or more of these steps, leading to poor visual functioning. The ten steps form the pillars of this book. The following chapters explain how your brain performs these steps and what goes wrong in specific types of CVI.

What have I read in this chapter?

- CVI is a visual disorder.
- To understand CVI, you need to know how seeing works.
- Seeing involves both your eyes and your brain.
- *Whether* you see depends on several conditions: being rested and alert, being motivated and being able to attend to visual information.
- *What* you see depends on how well you can direct your eyes and your attention to what you want to see.
- How well you *understand* what you see depends on the quality of your visual image, how well your brain understands the visual information, how well it stores that information, and how well you can think in visual images.
- Seeing happens preferably at a fast speed.
- An additional element of seeing is that you can act fast on what you see.
- In the case of CVI, something goes wrong in one or more of these building blocks of seeing.

2 What is CVI?



Imagine that you are visually impaired. Not because something is the matter with your eyes, but because your brain does not process the visual information properly. Is that possible? Yes, that is what we call CVI. But what exactly does the brain fail to do, or fail to do properly, in CVI? And what do you see when you have CVI? Most people, when thinking about what it must be like to be visually impaired, cannot imagine anything other than blurred vision. But quite often that is not the case with CVI.

CVI

When your brain and eyes work together properly you are able to see. Your eyes provide visual information which is processed by the brain. Without this cerebral processing you don't see anything. CVI stands for **Cerebral Visual Impairment**. It occurs when your brain does not process the visual information properly.

Royal Dutch Visio defines CVI as follows:

CVI is diagnosed when a person experiences limitations or restrictions in everyday activities, resulting from dysfunctions and/or multiple weaknesses in visual functions, caused by damage to or abnormal development of one or more parts of the brain, irrespective of neurological demonstrability.

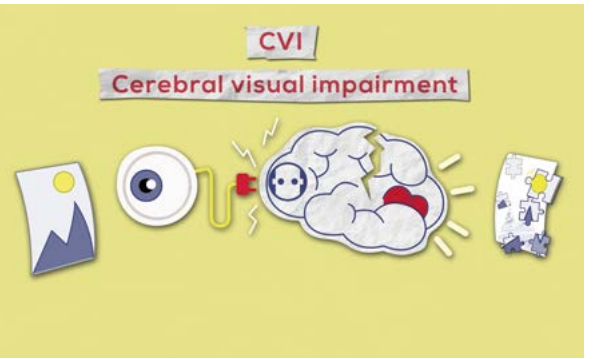


Figure 2. In order to see, your brain must process the visual information.

Seeing involves various steps

The brain handles the processing of visual information systematically in a total of ten steps. The first three are requirements for seeing. To see you must be:

1. sufficiently rested and alert
2. motivated to look
3. able to attend to what there is to see

Steps 1-3 are general, in the sense that they are needed not just for vision. The following seven steps relate specifically to vision:

4. The brain ensures, by means of attention, that an image is created in the back of your head using the visual information delivered by the eyes.
5. The brain then selects, out of all the things that can be seen, something specific to look at by directing the eyes and
6. attending to what you are looking at; what the brain selects is what you see.

7. The brain tries to understand what you see.
8. The images you see are stored in your memory. The brain uses these stored images to recognise the things it sees.
9. The stored images are also used to create mental visual images. For example, you can imagine the face of your mother even though she is not physically present. Or you can make a mental picture of the route you need to take from your home to the train station.
10. The brain enables you to act very fast on the visual information that it has selected, for example picking up or catching something.

The brain performs a number of **functions** that allow each step to be performed correctly. If a function works poorly or not at all, we speak of a **disorder** in that function. When you have CVI something goes wrong in one or more functions, causing you to experience restrictions and limitations in everyday life.

CVI is a generic term

CVI is a generic term used for different types of visual impairment, each of which has a specific effect on the ability to see. Each type of CVI is unique. The consequences of something going wrong during one of the processing steps differs, depending on which step is involved. And just as important, each person with CVI is unique. You could be a football player, while someone else a guitar player. Some people are quickly inclined to ask for help, while others want to do everything on their own. The problems encountered in daily life are different for each person with CVI.

CVI is not yet very well-known

Until recently there was very little consideration given to the fact that visual impairment may result from errors in the processing of visual information by the brain. Even now, the possibility of visual impairment tends to be quickly ruled out when it turns out that the eyes are of sufficient quality.

What causes CVI?

A disorder in the processing of visual information may result from brain damage or other abnormalities in the development of the brain. Sometimes the cause is unknown. To date, no hereditary factors (*1) are known to cause CVI. For many people who have CVI, the exact cause of their disorder remains unclear.

When does CVI occur?

CVI usually results from small errors in brain development or from brain damage around the time of birth. When a child suffers brain damage at a later age resulting in visual problems, we also speak of CVI. In most cases, CVI is not immediately diagnosed after birth. Often more noticeable impairments, such as short attention span or poor motor skills, are interpreted to be the cause of the restrictions and limitations. It is usually not until a child enters elementary school that it becomes clear that he/she has problems of a visual nature.

(*1) Recent studies suggest that some genes may play a role in causing CVI, but more research is needed.

CVI is a visual disorder

Damage to the brain is usually not confined to the areas that process visual information. More often other brain areas are also affected. As a consequence, children with CVI may well have other disorders, such as **poor motor skills** or difficulty focusing on tasks. The term "CVI", however, is only used to describe problems of a visual nature. Some people with CVI are diagnosed with other disorders in addition to CVI.

Is CVI a childhood condition?

When we talk about "someone with CVI", we generally tend to mean a child. The term "CVI" is often used to imply that the visual restrictions and limitations first occurred during the development from childhood to adulthood. When children with CVI grow up they become adults with CVI. CVI is therefore not only a childhood condition and it does not simply go away. On the other hand, as a child grows older, he/she generally gets better at compensating the visual impairment. After all, how well you see and how well you carry out visual tasks does not just depend on the quality of your eyes and on how well your brain processes visual information.

The consequences of CVI for general development

Visual impairment, and therefore CVI, directly impacts the general development of a child. Seeing stimulates active exploration, which strongly promotes learning. Visual impairment therefore negatively impacts the development of motor skills and the rate at which knowledge is acquired. Due to the important role vision has during childhood development, all developmental areas should be monitored closely in children with CVI.

Visual tasks require more than just good vision

In order to help a person with CVI it is essential to know what type(s) of CVI is/are involved. However, to help with specific problems resulting from CVI is not enough. After all, both the quality of seeing and the performance of visual tasks depend on more than just visual factors. They are strongly influenced by your motivation to carry out a specific task or on how you feel. On whether you had a good night's sleep and how much energy you have. On how well you can come up with a plan to carry out the task. On how well you can keep your mind on the task, on how skilled you are with your hands and body and on how fast you are. But it also depends on the people you can call on for help. Thus, to be able to help a person in the best possible way, we need to know everything about that person. This requires a thorough assessment.

The intervention specialists

The interventions for, and treatment of people with CVI are performed by professionals (from Royal Dutch Visio). Interventions are focused on increasing the person's insight, having him/her

learn compensation strategies and on informing and advising those around them. This last aspect is crucial in order to ensure continuity in the support and intervention methods. Obviously, people who have CVI will also want to understand the cause of their problems. Understanding their CVI helps them to compensate their limitations and restrictions as much as possible.

What does having CVI involve?

To understand what CVI is and what having it means, it is important to understand the role that seeing plays in the lives of people. The next chapter will focus on this.

What have I read in this chapter?

- CVI is the abbreviation for different visual impairments all caused by the brain's failing to process visual information properly.
- CVI is caused by damage to or abnormal development of parts of the brain.
- The steps that the brain performs in processing visual information consist of both general and visual functions.
- Many people with CVI also have other disorders in general and/or in functions of a different kind.
- CVI develops in the early years of life, but it is not a childhood disorder.
- To be able to support a person with CVI properly, it is necessary to know practically everything about that person.

Figure 3. In order for daily support to be successful, it is crucial that parents, caregivers and teachers have knowledge about CVI.

3 The prerequisites for seeing

It is early in the morning. Your alarm clock goes off and it startles you out of your sleep. Your hands search for the alarm clock to turn it off. You feel tired. You open your eyes in an effort to wake up. The daylight is already creeping through the curtains. While staring at the ceiling you ponder on all the things you need to get done today. How is it possible that sometimes with your eyes open, like when staring at the ceiling, you don't really see anything? In this chapter we will explore the prerequisites for seeing.

People have many goals

To achieve what we want we set goals for ourselves. In setting these goals, and achieving them, we use different sources of information. Some of these sources are in our head. Information about what we want, about our **needs** and **emotions**, is important for setting goals. In addition, our brain stores knowledge about the world in our various types of **memory**. This information we can use to achieve our goals.

We also use information *from the outside world* to help achieve goals. Our **senses** inform us about the world around us. Our **visual sense**, the system that allows us to see, provides us with detailed information about the world, from both close by and far away. This is why we use our visual sense a lot and almost always to achieve a certain goal. We look in order to absorb information, to read or to follow a story on television. We look in order to do something, to go somewhere, or to get hold of something so we can make use of it.

The senses and other sources of information are merely tools

No matter how important, our visual sense is just one of the many sources of information that are there for us to use. These sources contain a lot more information than we need at any given moment. The trick is to select only those pieces of information that are needed at that specific moment. For example, when is it necessary to know that Athens is the capital city of Greece? And do you really want to hear the constant whirring of the refrigerator? If all of the information inside and outside your head entered your thoughts all at the same time, you would be totally overloaded with information. To prevent this, you select only small pieces of all the available information.

Selecting information by means of attention

Choosing from the many sources of information is called **selection**. You select by means of **attention.** When you pay attention to something, that particular piece of information enters your thoughts so that you are conscious of it. A well-known home furnishing store uses the slogan: "Attention makes everything more beautiful". It would, however, be better to say: "Attention makes everything (possible)". After all, without attention you would not experience anything. Only by giving attention to something that is visible, do you actually see it. If you have your attention focused on something other than your visual sense, you do not see consciously: you are

just staring into space.
Other information sources, both inside and outside your head, work the same way. You hear the whirring of the refrigerator only when you pay attention to it. Only when you pay attention to information in your memory about the capital city of Greece can you come up with Athens. Only information that you pay attention to enters your thoughts.

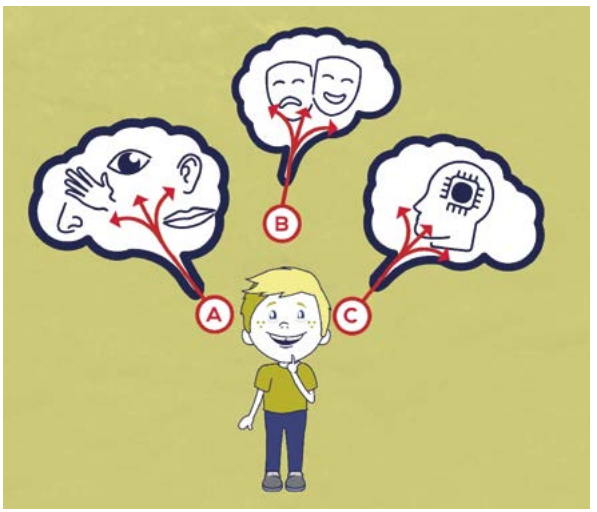


Figure 4. To use a specific source of information, we must select it. By means of attention we select from our various senses (A), our emotions and needs (B), and from various types of memory (C).

Seeing is paying attention to visual information

Giving attention to the information that your eyes deliver to the brain, is a prerequisite for seeing. Our attentional resources are limited and even the smallest thing can distract us from visual information. When this happens, you will not see or you will be less conscious of what you see. The visual information is there, but it does not enter your thoughts, or it only partially does.
A prerequisite for many visual tasks is that you consciously see, allowing you to think about what you see. Paying attention to visual information is easier for some people than for others.

Directing attention to visual information

Directing your attention to visual (or other) information is done in two ways. Ideally you direct your attention from within yourself, based on what you want. We call this endogenous attention. If you want to direct your attention to what you feel with your right hand, then you do exactly that. But what if there is a lot of noise and commotion around you? In that case it is harder to direct your attention the way you want. Your attention is drawn by the sounds and movements that force themselves into your thoughts, outside of your personal control. We call such stimuli exogenous. They direct your attention exogenously.

Endogenous attention based on emotions and needs

Whether you direct your attention to *visual* information from within yourself – endogenously – depends in the first place on the goal you have set for yourself. Establishing a goal starts with finding out what you want. How do you determine this? By directing your attention to your **emotions**

and needs, you become conscious of them. They then enter your thoughts, and by using this information you can determine what you want at that particular moment. For example, maybe you decide that you would really like an ice cream. Your goal will become getting yourself an ice cream. In other words, your emotions and needs result in your **motivation** to get the ice cream. Next, you use your knowledge about the world to come up with a plan to get the ice cream.

To carry out that plan you need your visual sense. You use this by engaging it at the right moments, by selecting it with your **attention**. The plans we make are flexible. Suppose there is no ice cream in your freezer and then on your way to the front door you come across a bottle of cola. You then realise that you don't really feel like going all the way to the store anymore. Your actions and plans, and thus how you direct your attention, all depend on your needs and emotions.

Exogenous attention

Some exogenous stimuli are so strong and/or unexpected that they prevent you from achieving your goal. They break into your thoughts, just like that. That can be annoying, such as a noisy scooter that rides by. However, this kind of stimuli can also be very helpful, for instance when you accidentally place your hand on a hot stove. Less obvious signals can also unexpectedly attract your attention. Such as a bird that flies by, a white envelope on an otherwise dark empty table, or a big black horsefly on a white wall.

Figure 5. A big horsefly on a white wall attracts your attention exogenously.

Associations

Other types of information can enter your mind quite suddenly without you choosing them. At school, while calculating the ice cream sales in August, your thoughts may automatically wander to warmer weather, a swimming pool, the beach or a summer holiday. We call this association. In most cases, **associations** help you to easily obtain the information that you are likely to need at that very moment.

Control over your attention: executive functions

They are quite convenient, all these associations and alarm bells. But to make proper use of them you must not let them take over. You need to decide, by checking your emotions and needs

by means of attention, how relevant or urgent the information is and then decide what you will do with it. What will you do about your scalded hand? And it sure is fun to think about the summer, but weren't you in fact working on a math assignment?

Control over your attention is crucial in order to achieve a goal. If you would allow yourself to be distracted by every possible stimulus, you will be at the mercy of your surroundings. The functions that allow us to control our attention are called **executive functions**. By controlling attention, they can suppress and restrain distracting information coming in to your thoughts (such as associations about the summer). We call this **inhibition**.

Even though emotions, needs and physical pain form the basis for our final decisions, they must also be suppressed to a certain extent.
If you constantly allow yourself to be led by your feelings, needs or discomforts and have no attention for anything else, you would not get anything done.

Executive functions

To be able to deal properly with everything that happens and be flexible at the same time, you must have control over your attention.
By controlling your attention, you control your thoughts and actions. This constitutes the basis for all the other important work that the executive functions do. By controlling attention, they have access to every source of information at all times. By being able to access our emotions and needs, the executive functions are the starting point of our motivations, ideas and goals. Their access to the various types of memory and all of our senses enables them to create plans and to execute these in an optimal way. Through their control over our attention, the executive functions determine the content of our thoughts.

The executive functions continue to develop at least until the age of 25. People who have disorders in executive functions as well as (young) children, have considerable difficulty in controlling their attention and thus their thoughts and actions.

Important attentional functions

Through their control over our attention, the executive functions have a great impact on the quality of our **attentional functions**. Important attentional functions include **keeping your attention** on a single task or a single type of information and dividing your attention over different tasks or types of information. Through this controlling ability, they also determine when we attend to visual information.

Automated skills

Acquiring new knowledge and skills demands our attention. But practice makes perfect. Things you practice over and over, whether simple or complicated, become automatic. They do not require your attention anymore. Such skills are

automated. Reading, for example, is a skill that requires lots of attention and repetition to master. But once you can read, it goes automatically.

Executive and attentional functions, energy, fatigue and alertness

Attending to something, or instead suppressing one's attention to distracting stimuli, does not come automatically. It requires energy and anything using up your energy, wears you out. If you feel energetic, you will be alert. If you are tired, you will be less sharp, making it more difficult to control your attention. This has a direct impact on how well you are able to keep control over your actions. You will be more easily distracted by exogenous stimuli and it will take more time to collect the information you need. Fatigue will also cause a person to give in more quickly to small aches and pains or to negative feelings.

Loss of sleep will obviously cause fatigue. For someone with CVI, looking, learning and simply doing things requires more attention and energy than for someone with normal vision. A person with CVI will tire more quickly and will thus lose control over his or her behaviour more easily, while he or she actually needs this control even more than those without CVI.

Hierarchy of the brain functions

The above shows that human behaviour, everything that we do, is the outcome of general functions that the brain performs according to an apparent hierarchy or order:

1. **Alertness:** the more alert we are, the more we can employ our attention and the more we are conscious.
2. **Motivations:** what we want is determined by our emotions and needs.
3. **Executive functions:** these functions determine our goals, thoughts and actions since they have access to all information sources in our head (emotions, needs, memory) and in the outside world (the senses), through control of the attentional functions.
4. **Attentional functions:** by paying attention we can consciously use the information from information sources to achieve our goals.
5. **Information sources:** the sources in our head and in the outside world that we use to achieve our goals. These consist of:
   a) various types of memory.
   b) emotions, needs and motivations
   c) our senses (sight, hearing, touch, smell and taste).

These functions all impact each other. In the order presented above, but also in other ways. For example, if you suddenly hear a loud blast that attracts your attention via your hearing sense (exogenously), you will immediately be alert and consider whether you need to do something with this information, after which you might adjust your goals.

The importance of these prerequisite functions and factors for CVI

The hierarchy will reappear in this book, and it will be expanded with the visual functions. You can find it on *page 144* of this book. Why so much emphasis on this hierarchy? In nearly all of the children with CVI, all functions and factors that are prerequisites to be able to see are of lesser quality, which has major consequences for their ability to see and their execution of visual tasks. People with CVI tire more quickly and therefore have less control over their attention. They fail in visual tasks and are subsequently often scared of failing, which eats away at their motivation to perform visual tasks.

CVI, fatigue, attention and executive functions

As explained, optimal vision and proper execution of visual tasks starts with being rested and alert. People with CVI – but also people with other disorders – tire more quickly because they lose energy and attention on things, that others do automatically or with less effort, while they need their attention even more than others. Unfortunately, a relatively high number of people with CVI also have, in addition to their visual disorder, weak executive, attentional and/or motor functions, making visual tasks even more difficult for them.

Mental disability and attention for vision

Some people find it difficult to focus their attention on visual information. This is quite common in people with a mental disability. Even when one really tries their best to draw their attention to visual stimuli, they fail. As a result, they often do not use their vision, making it difficult to predict when they are consciously seeing or not. Since they do not use their vision as much as everyone else, their visual functions also develop slower. Therefore, we need to get these people to look by stimulating them visually. That starts with drawing their attention to visual information. This is described in greater detail in Chapter 5.

The importance of minimizing environmental stimuli

Because of the important role of attention in seeing, it is essential to make the setting in which the visual tasks take place as tranquil as possible. Stimuli that could be distracting must be kept to a minimum. This is even more important for people with CVI.

Motivation in people with CVI

Unfortunately, the motivation to put in the necessary effort to perform visual tasks is often diminished or even gone in many people who have CVI. This is due to various reasons:

- They do not perform well in some or all visual tasks.
- They know that they do not perform well in visual tasks.
- They feel insecure and inferior when performing visual tasks and sometimes also in other tasks.
- They themselves and the people around them do

not fully understand why they are not good at visual tasks.
- Due to a lack of understanding, they are often expected to be able to see things as well and as quickly as others.
- Others often blame their poor performance on a lack of commitment and/or on their personality.

CVI, fear of failure and the performance of visual tasks

As a result, a relatively large number of people with CVI suffer from a **fear of failure**. At an early age they have already discovered that they are not as good as others in many tasks, and that hurts. To avoid this pain, most children will initially do all they can to keep up with the rest. But when even their best efforts fail, their motivation will often diminish quickly. This may ultimately lead to a reluctance to try anything new. Since parents/caregivers, teachers and classmates often do not understand why they perform badly or lack motivation, they tend to get blamed for having a poor attitude. They are told to "try harder", even though they are already doing their very best. For many children this ultimately leads them to stop doing their best. Or to say that they have not done their best. That, after all, is less painful than admitting that they have done their best but have nonetheless failed.

Fear of failure and difficult behaviour

Of all the possible consequences of CVI, the most damaging and extensive are fear of failure and insecurity. Aside from the fact that they impact a child's happiness in life, they lead to behaviour of which it is not directly clear that it arises from fear of failure. Some children may invent excuses, others may become angry or act like a clown. Another possibility is that a child withdraws altogether and tries to become invisible.
How the social status of a child with CVI will develop in the classroom, depends significantly on how the teacher responds to the behaviour of the child and of his or her classmates. The needs and emotional development of a child are determined by the interplay of **personal factors** (such as personality, abilities and interests) and **environmental factors**. Knowledge about CVI on the part of intervention specialists, teachers, parents and/or caregivers is of utmost importance to ensure positive social and emotional development.

What have I read in this chapter?

- The ability to see depends on general factors and functions that together form the "visual hierarchy" (*see page 137*).
- To achieve our goals, we use various sources of information.
- Giving your attention to a source of information makes you conscious of that information.
- Our visual sense is one of these sources of information.
- Whether we see depends on whether we pay attention to the visual information.

- We direct our attention as much as possible on the basis of our personal needs (endogenously).
- However, some information is so intense and unexpected that it inevitably draws our attention to it (exogenously).
- Our executive functions allow us to control our attention and therefore to access all information sources, in order to achieve our goals.
- People with CVI often have disorders in executive and/or attentional functions.
- The extent to which you can use your attention depends directly on your level of alertness.
- For a person with CVI, seeing takes lots of energy. Consequently, people with CVI tire more quickly, causing their alertness to diminish.
- People with CVI are often afraid to fail, making them less motivated to exert themselves for visual tasks.

Recommendations to optimise the prerequisites for seeing

Below we present practical recommendations. To personalize these recommendations for a particular individual, requires proper knowledge of and experience in working with this individual.

Recommendations aimed at prevention and diminishing of fear of failure

- Be very sensitive to what the child is capable of in every particular task. Do not ask too much of the child.
- Emphasize that it is not the performance but the effort that counts.
- Reward task-directed behaviour, even more so with tasks that the child finds difficult.
- Do not give negative feedback in response to a serious effort.
- Reward a serious attempt that failed just as much as a successful response.
- Emphasize that the child is not facing his or her difficulties alone, but that cooperation and shared responsibility is key.
- Keep assignments playful and do not dwell on disappointing task performance.
- In case of an incorrect response, do not keep repeating the question or assignment, hoping that the child will eventually do it correctly. Restate the request one more time and keep it at that.

- Give the child fewer practice items than his or her classmates once in a while (for example, exercises 1, 3, 5, 7 and 9 instead of 1 to 10), so that the child can experience how it feels to finish first.

Recommendations aimed at disorders in general cognitive functions (executive, attentional and automation disorders)

- Assign clear, single tasks.
- Split complicated assignments up into single tasks.
- Prepare written instructions with individual steps for tasks that recur.
- Offer repetition (of small steps).

Recommendations aimed at enhancing self esteem

- Allow the child to experience his or her personal strengths and talents by assigning tasks that appeal to his or her strengths and talents.
- Regarding tasks that are difficult, explicitly point out the progress the child has made compared to previous attempts.
- Plan a fixed moment during the day (for example, at the end of a school day or at dinner time) where everyone has the opportunity to share their proudest moment of the day.
- Provide a positive and constructive atmosphere that encourages mutual compliments and discourages competition.

4 Low visual functions: the visual field and eye movements

When you open your eyes in the morning, you look around and see. You direct your eyes towards an object, and you have a large full colour three-dimensional picture which is sharp in the centre. If it is not sharp enough, you put on your glasses and everything is alright. Right? Yes, but this does not apply for everyone. What if you continue to see hazy images even when you wear the best possible glasses? Or if your visual image is very small? Or if you find it hard to direct your eyes? If any of this is the case, then you probably have a disorder in one or more of the low visual functions. Contrary to what people often think, not just the eyes determine the quality of your visual image and the directing of your eyes. The brain is involved too. Disorders in the low visual functions can result from errors in the visual processing by the brain. If that is the case, we speak of CVI.

Visual functions

The eyes and the brain cooperate to perform functions that enable us to see. There are two types of visual functions: the **low and the high visual functions**. There are two types of low visual functions:

- **Sensory functions**, which determine the quality of your visual image.
- **Oculomotor functions**, which determine the quality of your eye movements.

The low visual functions are the functions that are addressed by **ophthalmologists**, **orthoptists** and **optometrists**. The high visual functions further process the image that the low visual functions produce. The high visual functions are the territory of **behavioural scientists**, in particular **neuropsychologists** and **remedial educationalists** with knowledge of neuropsychology.

CVI

The term CVI usually refers to disorders in the high visual functions. However, disorders resulting from defects in or damage to the brain can also occur in the low visual functions. In CVI combinations of disorders in the low and high visual functions are not uncommon. The low visual functions are described in detail in other books.We will therefore only discuss these briefly here. We will, however, discuss the high functions in detail.

The low visual functions and the brain

When you direct attention to visual information, you have a conscious visual picture of the outside world. This is referred to as the **visual field**.
The visual field is located in the back of the head (**V1**, also referred to as the primary visual cortex) as shown in Figure 6. This entails that the visual information is sent from the eyes to the back of the head. By means of the **thalamus** (T) – halfway between the eyes and the back of the head – we can direct our attention to the visual information. Without this attention, the visual information hardly reaches the back of the head, with the result that you do not see consciously. The quality of your visual field – the sensory functions –

depends not only on the quality of your eyes but also on V1 and the regions of the brain between your eyes and V1. If you wish to learn more about how the brain enables you to see, then read the appendix "Vision and the brain".

Our visual field offers so much information, usually too much. The visual image is sharpest where the eyes are focused. It is therefore extremely important that you are able to direct your eyes quite accurately. This is also done by your brain. Hence, the quality of all low visual functions are results from the cooperation between the eyes and the brain.

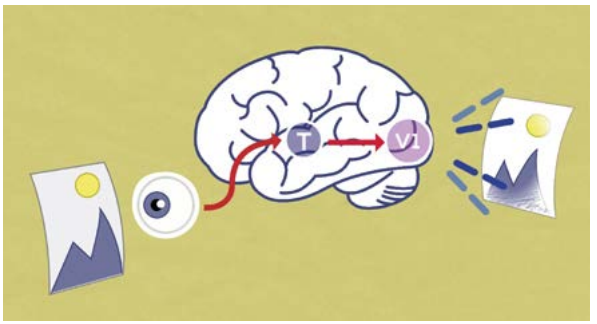


Figure 6. Attention to visual information, allowed by the thalamus (T), produces a visual representation of the outside world in the back of our head: the visual field.

In case of disorders in low visual functions, the eyes and eye muscles are examined first

The eyes are the source of all visual information and are relatively easy to examine. Disorders in the sensory functions, therefore in the quality of the visual image, usually result from eye defects. That is why the eyes are generally examined first in case of visual limitations. Only when the quality of the eyes does not fully explain the visual problems, CVI comes into consideration. In case of disorders in oculomotor functions, in the eye movements, the quality of the eye muscles will also be examined. However, which sensory and oculomotor functions are there to be examined?

The quality of the visual field: the sensory functions

First, we will briefly discuss the sensory functions and related disorders. The sensory functions are those that most people think of first when speaking of "visual impairment".

Visual field and visual field loss

One type of visual impairment is having a narrower field of vision than most other people, or that parts of your visual field do not function. We refer to this as **visual field loss**. This can pose serious problems, for example in busy traffic or when reading. The loss of visual field loss is not experienced as total darkness. The part that is missing is simply not experienced. In the same way as you do not experience the information outside your field of vision as darkness.
The cause of visual field loss can lie in the eyes but also within the brain: in V1 and all along the pathway from the eyes to the back of the head. Visual field loss can vary in type and size and can occur in all parts of the visual field.

Visual acuity

The area in the visual field where the image is sharpest is referred to as the **central visual field**. That is generally the spot that you direct your eyes to. The sharpness of your visual image at that spot, when wearing the best possible pair of glasses, is your **visual acuity**. This is generally expressed in a value between 0 and 1, with 1 being regarded as normal visual acuity. A common type of visual impairment is **low visual acuity**. In this case your vision is impaired to such an extent, compared to that of other people, that it restricts you in daily life. Low visual acuity is usually caused by a defect in or damage to the eyes, but damage to V1 and/or the connecting pathways between the eyes and V1 is a possible cause as well.

Contrast

Both the eyes and the brain can cause low **contrast sensitivity**. Contrasts are differences in the quantity of light. In the central visual field, good contrast sensitivity contributes to the experience of a sharp image. At the edge of the visual field, contrast sensitivity enables the registration of light changes. Significant, fast and unexpected changes in light draw attention exogenously and thus have a signalling function.

Colour

We see best in the central visual field because the density of the colour-sensitive cells in the eyes ("cones") is highest there. Towards the edge of the visual field our ability to distinguish different colours is reduced. **Colour blindness** comes in different forms. Often it involves difficulty in distinguishing between two colours, such as red and green. Although this can pose difficulties, people who have such a type of colour blindness are usually not that profoundly hindered in their daily tasks. Therefore, we do not speak of visual impairment. The cause of this type of colour blindness is found in the eyes. However, there is a form of visual impairment where you only see black, white and shades of grey. This is called **achromatopsia** and this may occur from defected cones but can be also be due to damage to the brain. In either case, achromatopsia is usually such a nuisance in daily life that it is regarded as a visual impairment.

Adaptive functions

The quality of a visual image also depends on how easily your eyes adjust to different light conditions. For example, it is quite problematic if it takes long for your eyes to adjust to the dark (**light-dark adaptation**). The same applies if you always need to put on sunglasses when going outside because the bright light otherwise hurts your eyes (**light sensitivity**). These situations usually result from developmental defects in the eyes, but again the brain may also play a role.

Binocular depth perception

Another important feature of the visual field is that it contains the information of both the eyes. This results in **binocular depth perception**. Binocular depth perception gives you that little

bit of extra information about the exact location of an object in relation to yourself.
This information is extremely useful for picking up things or catching them, climbing stairs, stepping onto a curb, moving over bumps in the road, and so on. It arises because the images that the two eyes forward differ just a bit from each other. The closer you get to what you are looking at, the bigger the difference between the images in both eyes. Your brain combines these images into a single image, the visual field, where the differences between the images of the two eyes are maintained. If your binocular depth perception is not optimal, then all of the actions above are more difficult. Also, you cannot experience the 3D in a 3D film. This is inconvenient, but the problems in everyday life are generally not so serious that one would use the term visual impairment. Inability to see depth can occur when the visual acuity of one eye is much lower than the other. It can also be caused by improper functioning eye muscles where the eyes do not move in unison with one another. However, the cause may also be in the brain.

The quality of the movements and interaction of the eyes: the oculomotor functions

In some children their visual image is of high quality, but they can still not use it fully because of disorders in the oculomotor functions. The most common disorders are:

- disorders in **saccades**, the fast and goal-directed movements of the eyes
- disorders in **smooth pursuit eye movements**
- **nystagmus**, involuntary eye movements
- disorders in moving the eyes towards one another (convergence) or moving them away from one another (divergence)
- disorders in the adaptation of the lens (accommodation)
- disorders in (the adjustment of the size) of the iris, resulting in too much or not enough light entering the eye

Saccades and smooth pursuit eye movements

There are two types of movements that the eyes perform together towards specific locations in the visual field: very fast and abrupt eye movements that you use to look from one spot to another (saccades), and the smooth movements that your eyes make to track a moving object. In order to obtain the sharpest possible image of what you want to see, it is essential that you direct your eyes to the right spot and keep them there, even when the object moves. If you look to the side of it, your image will be less sharp, or you may not see it at all.

When problems in saccades or smooth pursuit eye movements occur, this may be caused by a dysfunction of one or more eye muscles. The eye muscles are controlled by various processes in the brain. For example, the accuracy of saccades depends on specific attentional processes. We will discuss these in greater detail in Chapter 5.

Nystagmus

Some people experience that their eyes move back and forth involuntarily, either slow or fast. This is called **nystagmus**. You would think that these people experience the world as if it is moving, but that is usually not the case. However, the movement of the eyes blurs the image. Some people with nystagmus manage to reduce the involuntary movement of their eyes by turning their head in such a way that they can fixate their eyes in a corner of the socket. This reduces the problems that they experience.
The cause of nystagmus always lies in the brain. Therefor everyone with nystagmus has CVI. But in practice no one talks about CVI when nystagmus is involved. Nystagmus is a common phenomenon for which we do not need an additional – in this case confusing – label such as CVI.

Convergence and divergence

The eyes must cooperate properly, for example to ensure binocular depth perception. They must turn towards each other, when the object that you are looking at comes closer. We call this convergence. The opposite – the eyes moving away from each other – is called divergence. The cause of a convergence or divergence disorder may lie in the eye muscles, but also in the brain. Disorders in convergence or divergence sometimes cause blurred vision or double vision. When the eyes have not worked together effectively since birth this usually results in the brain ignoring the image of one eye and thus in the loss of binocular depth information.

Movements within the eye

Movements also occur *within* the eye. These functions are likewise regulated by different parts of the eye and the brain. The eye lens, for example, changes shape to enable us to focus on objects both nearby and distant. This adjustment is called accommodation: the lens becomes rounder when looking nearby and flatter when looking farther away. In the case of a disorder in accommodation, the alternations of looking nearby and further away can lead to the image being less sharp. Or, if the lens does not easily become round or flat, this leads to lack of acuity when looking respectively at nearby and distant objects. This last problem can usually be solved with glasses.

The size of the pupil also adjusts. When changes occur in light intensity, the pupil size is adjusted by the muscles that together form the iris, the coloured area surrounding the pupil. The pupil becomes larger when there is little light and smaller with more light. A disorder can lead to too little or too much light entering the eye. When the pupils remain too large, allowing too much light to enter, this is experienced as glare. If the pupils remain too small, with not enough light, the surroundings may be experienced as being too dark.

The low functions depend on each other

The various low visual functions can be assessed separately, but they are clearly interdependent. For example, your visual acuity depends on

how accurately you can direct your eyes. But conversely, the quality and development of the oculomotor functions depend on the sensory functions. Because how, for example, would you direct your eyes to a smaller detail if your visual field is blurry? This constant cooperation and interaction between the various elements and functions of vision does not make it any easier to understand how we see, nor does it simplify figuring out the cause of a visual restriction.

What have I read in this chapter?

- There are two types of visual functions: low functions and high functions.
- There are two types of low visual functions: sensory and oculomotor.
- The sensory functions determine the quality of the visual field.
- The oculomotor functions determine the quality of the movements of the eyes.
- Whether you experience a visual image consciously depends on whether you pay attention to the visual information.
- The high visual functions get to work with the visual image that the low visual functions produce.
- The brain is involved in both the low and the high visual functions.
- When speaking of CVI, we usually refer to the high visual functions.

Recommendations regarding disorders in low visual functions

As mentioned earlier, there is a considerable amount of literature on low visual functions. Even though there is ample advice on how to deal with disorders in the various low visual functions, that is beyond the scope of this book. The general recommendations with respect to disorders in low visual functions are similar to those regarding salience and attention. These can be found at the end of Chapter 6.

5 Visual selective attention and directing of the eyes

When your alarm clock wakes you in the morning, you direct your eyes towards the clock. When you pay attention to the visual information and you have no oculomotor disorders, this all happens automatically. Right? That is what you may expect. But in order to be able to direct your eyes exactly to the right location, you need to direct your attention there first. Your brain does this for you. In some people's brains, however, this doesn't work properly. As a result, they cannot easily find what they are looking for. We then speak of CVI.

Selection within the visual field

Ideally, we have a large visual field that is of good quality. But that is just the start. Your brain still needs to do a lot of work with the image. The visual functions involved in this are called the high visual functions. Usually there is more to see than the brain can handle. Therefore, within the visual field, the brain starts with selection: the first thing the brain does with the visual image is to select something to look at, using attention. The functions responsible for this are called **visual selective attentional functions**. The first step in the selection within the visual field is directing the eyes to a single spot. The quality of the eye movements is part of the low visual functions. However, before you can direct your eyes, your brain must choose where you will direct your eyes to. This process is part of the high visual functions.

Attention from within and from outside

Selection *within* the visual field also comprises of two types of attention: **endogenous** and **exogenous**. Endogenous visual selective attention operates from top to bottom on the hierarchical ladder (*see page 137*). You direct your eyes and your attention to where you want them, based on the goals that you have at that specific moment. Suppose you are looking for your bicycle key because you want to visit a friend by bike. Your goal is to find the key, so you direct your eyes and attention to those places where you expect to find it. Parallel to this endogenous process, exogenous processes are also involved in directing your eyes. After all, while you are searching, stimuli in the outside world compete for your attention. Suppose you want to direct your eyes to the dining room table because you expect to find your key there, when suddenly a bright lamp switches on in the corner of the room. This is so unexpected and potentially threatening, that you involuntarily direct your eyes and attention towards the lamp.

Cooperation between endogenous and exogenous attentional processes when searching

Exogenous attentional processes can thus distract you from what you were intending to do. There are also less conspicuous influences of exogenous attention, which in fact usually *help* to direct your eyes to where you want them. Your endogenous attentional system allows itself to be influenced by, what we may call, visual "exogenous attention magnets" in the outside world. It usually does not make sense to direct your eyes to an empty space. If you

expect to find your bicycle key on the table top, your eyes are unlikely to focus on the empty places. They inadvertently let themselves be drawn exogenously towards objects that are on the table. This is a good thing because you are generally not looking for the table top itself, but for something lying on it.

Impact of disorders in sensory functions on exogenous attention

Using "exogenous attention magnets" is more difficult when your visual acuity is not optimal. Blurred vision makes objects in the outside world less salient, so they are less likely to draw your attention. Similarly, a red poppy in a green field is more likely to remain unnoticed by someone with red-green colour blindness.

Disorders in endogenous and exogenous attention in directing the eyes

Some people have a form of CVI in which their endogenous and/or exogenous visual selective attention does not function well. They have trouble precisely directing their eyes and their attention as they would like to. Or their brain might not register the more subtle exogenous stimuli properly, making it more difficult for them to use the exogenous attention magnets. These people experience difficulty in finding what they need. It is important that they direct their eyes to the right spot, especially when there is so much to look at. It is essential for them that the visual information that is needed to perform a task is as salient (or noticeable) as possible.

Figure 7. Drawing a person's visual attention works best by moving a sharp contrasting object at the periphery of the visual field.

Our exogenous attentional system works best at the periphery of the visual field

Your exogenous attention is mostly drawn by a sharp contrast, movement, light sources turning on and off (changes in contrast), unexpected events, and – to a lesser extent – contrasting colours. Movements and contrast changes are registered best at the periphery of our visual field. This does not apply for colour, since colour is registered less towards the periphery. The most effective way to draw a person's attention visually is to flash and move a light in a dark room, at the edge of their visual field, when he or she does not expect it. Sounds can also help to draw the eyes and attention in the desired direction.

Our endogenous system works best in the central visual field

The central field of vision, the area to which we direct our eyes, is where our endogenous attention operates the best. This way the two

systems complement each other perfectly. Also, in the central field of vision, sharp contrast and deviant colours work perfectly fine to draw attention, but not in abundance. If everything has a lot of contrast and striking colours, everything will draw your attention, resulting in that you would no longer be able to find what you need. You could even become overstimulated by all the attentional triggers. To stimulate someone's attention centrally, we may also use an object that is meaningful to that person. Furthermore, limiting the amount of information may well be the most important way to ensure that the relevant visual information stands out. When all unnecessary information is eliminated, the objects that are left will be more successful at drawing the attention exogenously. The things you would like someone to see must be presented as a clear bite-sized chunk of information for the person's attention to be able to digest it: separated from the rest, with sharp contrast and a striking colour, standing out from the rest. And if possible, also moving or flashing.

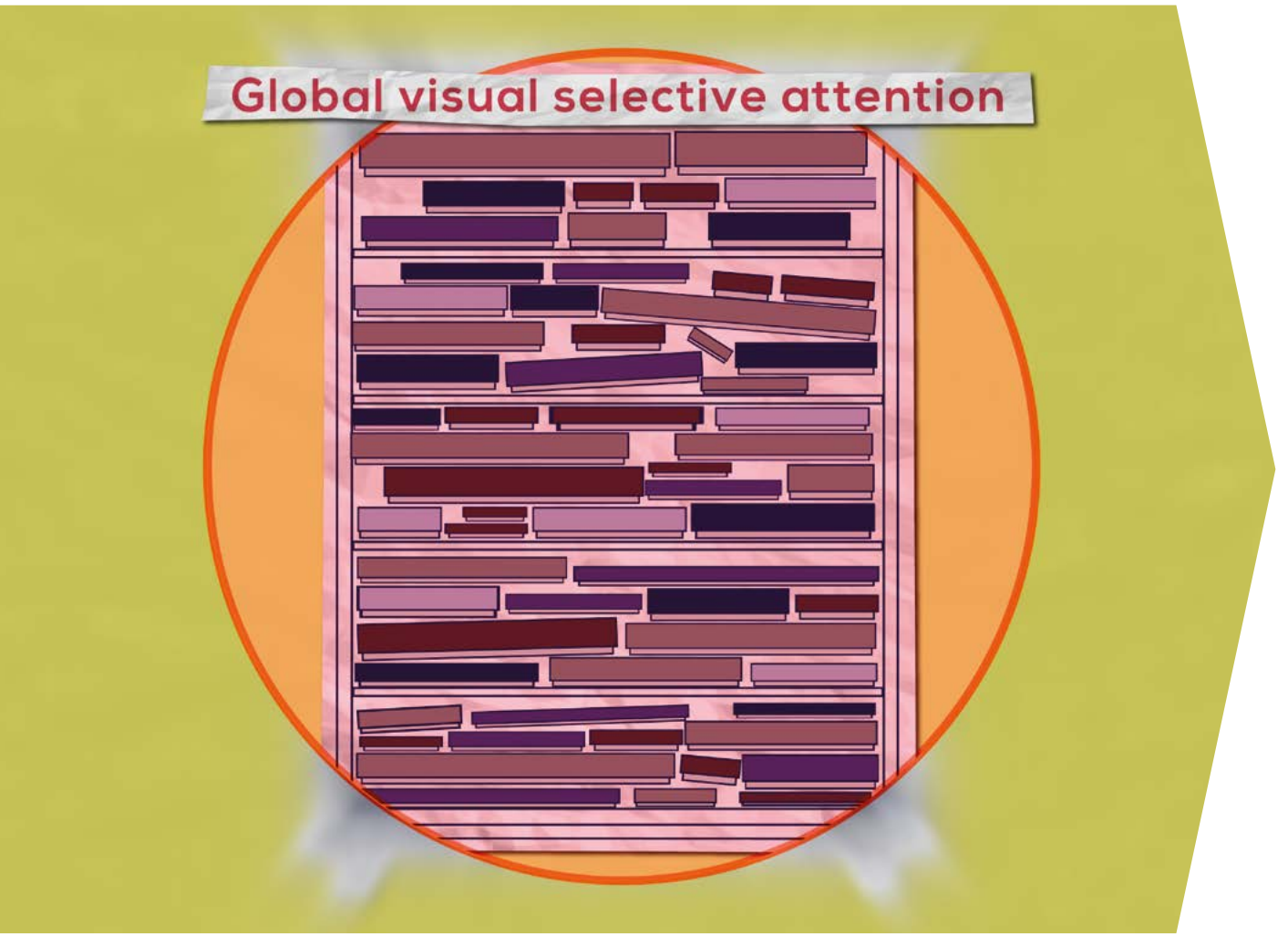
What have I read in this chapter?

- The high visual functions further process elements of the visual image.
- The first thing the brain does with the visual image is to select within it, using attention.
- Therefore, the first category of the high visual functions is that of the visual selective attentional functions.
- The first step in visual selection is directing the eyes.
- Selection and directing the eyes occurs within the visual field also by means of endogenous and exogenous attention.
- The endogenous attentional system directs the eyes via the visual hierarchy and is therefore based on our motivations.
- The exogenous attentional system directs the eyes to objects that are salient (or stand out) in the visual field.
- The exogenous system works best in the periphery of the visual field.
- Your exogenous attention is drawn mostly by sharp contrast, movement, light sources turning on and off (changes in contrast), unexpected events, and – to a lesser extent – contrasting colours.
- Sharp contrast, noticeable and deviant colours and the use of objects that have a special meaning to the individual work best to get their attention centrally.
- In order to draw a person's attention strictly to relevant information, it is important to remove all irrelevant information.
- Some people have a type of CVI where the endogenous and/or exogenous visual selective attention systems do not function well.

Recommendations for disorders in visual selective attention

This chapter allows for various recommendations, of which some are provided in the text above. Since the following chapters dive deeper into the subject of visual selection, specific recommendations on making visual selection easier are found at the end of Chapter 6.

6 Global visual selective attention



Imagine that you are riding your bike in busy traffic and you only see details and not the full picture. You may see a headlight, a bicycle bell or a white line on the tarmac, but you don't see the cars or the other cyclists or the road. Without overview of the street and everyone on it, you don't see where all the cars and cyclists are, let alone where they are going. If you only see details, many situations will be extremely difficult to handle. In busy traffic it would even be very dangerous. A quite common type of CVI, one that results in a lack of overview, is caused by a disorder in global visual selective attention.

Expanding or focusing attention

Directing the eyes (and attention) is only the first step in the selection of information within the visual field. The second step involves what we *do* with our attention *after* directing our eyes. We can *distribute* our attention or instead *focus* it on the location that we direct our eyes to. The size of the area over which you spread out your attention determines what you select with your visual attention. That what you select is what you consciously see and perceive. If everything works properly, you can distribute your attention across the entire visual field and thus have overview, without even moving your eyes. You are also able to focus your attention on that one spot that your eyes are directed at. The choice between these options, and all possibilities in-between, depend on your goal. See Figure 8: direct your eyes to the red dot and keep them there. Do you see that the picture represents a beach? Can you describe the shape of the dot? Can you describe the shape of the cloud that the dot is situated in?

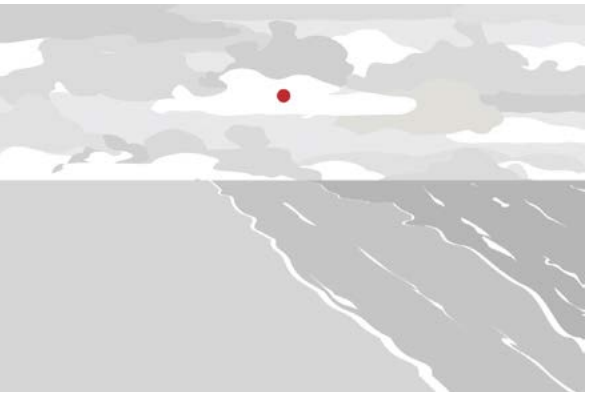


Figure 8. With your eyes focused on the dot, you can: 1) oversee the beach, 2) see the dot, or 3) analyse the shape of the cloud. It all depends on what you select, but you cannot see all three at the same time.

You may be able to do all this, but – if so – not all at the same time. You constantly vary the size of the area that you select. In this case, you expand your attention to see the whole picture first. Then you focus your attention on the dot and spread out your attention further across the cloud.

Selecting on the basis of size: two visual selective attentional functions

Enlarging the selected area, in other words distributing your attention over a broader area of the visual field, is called **global visual selective attention**: by means of attention, you select a large area of the visual field. By spreading your attention, you see what you are looking at as a

whole, without paying attention to the details. The function with which you restrict the area in the visual field that you pay attention to is called **local visual selective attention**: you select using your attention within the visual field, doing this quite locally and in a small area. You use local visual selective attention to analyse a detail. Disorders in these two functions are the most common forms of CVI. Local visual selective attention is discussed in Chapter 7.

The extent to which you spread out your attention depends on your goal

The extent to which you expand your attention around the spot that you direct your eyes to, depends on your goal. Consider the example of the beach in Figure 8. Imagine looking at your alarm clock: you see the dial and the hands of the clock. You select these because that is the only information you need. You do not consciously see the lamp next to it, nor the bedside table that the alarm clock sits on or the photo on the wall, as you don't pay attention to these objects.

Think back to the example at the beginning of this chapter. In traffic there is a lot to see, but nonetheless we do not move our eyes that much. This is because, in most dynamic traffic situations, having overview is the most important factor. Small details are not as important. Using your global visual selective attention, you see the entire car in relation to the road and the cyclist who comes out of the street to your left. You see all this without moving your eyes.

Global visual selective attention

There are many situations that call for overview. For example, in sports we tend to spread out our visual attention. Your eyes may be on the ball, but it is even more important to know where the ball and the other players are going to. That requires overview. When entering a large building or a large room, we also expand our visual attention. You need global visual selective attention to orient yourself. This applies not only to a large scale. Having proper overview is also necessary on small scales. For example, when looking for a specific game in a cabinet or for specific information on a page, it is handy to first have a good impression of the cabinet or page, as a whole.

Global visual selective attention disorder

Relatively many people with CVI have a disorder in global visual selective attention. They are unable to instantly select a larger area at first glance or they find this to be quite difficult. As a result, they never really have overview of the visual information. Since they constantly select only a small part of the visual field, it is as if they are looking through a tunnel. The rest of the visual field is still there, but it doesn't get through to them. This makes finding things somewhat of a disaster. People who have a disorder in global visual selective attention move their eyes around a lot in order to obtain an impression of the overall situation. They never see the total situation all at once, so they need to puzzle the details together in their mind. This takes extra time and energy. Unfortunately, they still do not understand the

whole visual situation as well as someone who does instantly have a total overview.

Someone with a disorder in the global visual selective attention is likely to have difficulty with Figure 9. Without overview, the coherence between the inkblots is not clear as you only see them individually. Take into consideration that this is only a small picture compared to a traffic situation or a school canteen. You can understand that a disorder in a global visual selective attention leads to significant limitations and restrictions in daily life. For children this applies particularly to traffic, at school and searching in general.

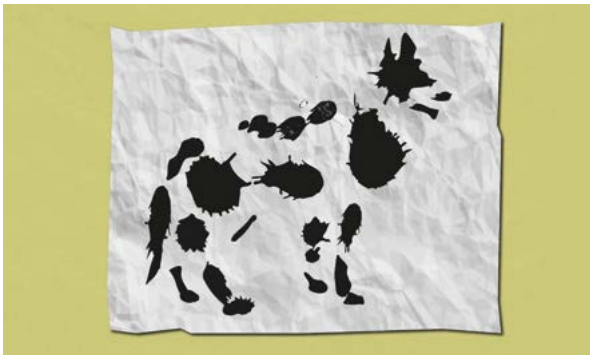


Figure 9. To see what this figure represents, you need to spread your attention out across the entire picture. Only then you can see the coherence between the inkblots.

Different types of global visual selective attention disorders

There are various types of disorders in global visual selective attention, which differ in subtle ways. The severity of the disorder, meaning the size of the area that one can oversee, differs from one person to the next. Some people with a global visual selective attention disorder find it generally difficult to attain overview over details, regardless of the size of the details. Details always attract their attention, so that little or no attention is left for the overall picture. Others find it difficult to attain overview of details, but only when the individual details have meaning to them. They may recognize what is portrayed in Figure 9 because the details are inkblots without individual meaning, but they might not see the "P" in Figure 10 because their attention is drawn to the letters A, as this does have meaning to them.

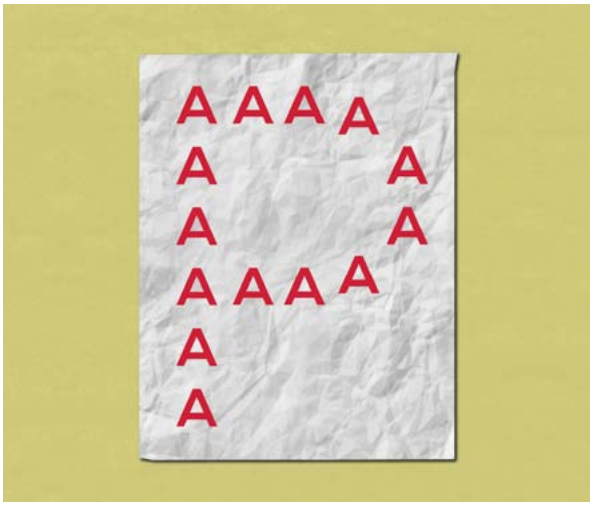


Figure 10. Some people with a disorder in global visual selective attention (only) lose their overview when the details have significance to them. In this example they will only see the letters A.

Furthermore, in some people the ability to select a larger part of the visual field diminishes strongly when they are tired. If your visual selective attentional functions operate the way they are supposed to, you have an overview first before your attention "zooms in" on the details.

Spatial orientation

To find our way in a shopping centre or school building, we use **landmarks**. These are important elements in a spatial lay-out of which we know how they relate to each other. People who have a global visual selective attention disorder do not register all landmarks because they lack overview. They only see individual stores or parts of these, or individual bicycles, traffic signs and trees. The landmarks that they do see they find difficult to relate to each other. The more there is to see, the harder it is for them to obtain an overview. As a result, they can easily get lost. For example, they will see individual trees, but they literally do not see the forest. In a crowded store they find themselves hung up on all the details, making it difficult to find the exit. In a crowded city they have difficulty finding their bearings. It is therefore advisable for people with this disorder to learn fixed routes. How successful this is depends on many factors, such as how crowded the surroundings are. But all of the factors of the visual hierarchy are involved as well (*see page 137*). Thus, success also depends on one's motivation and one's control over his or her attention and on the quality of all other low and high visual functions. And of course, on how well one can remember route descriptions.

Estimating speed

To be able to estimate the speed of a car on the road, of players on the field or of a ball, you need overview. Something always moves in relation to something else. You can only estimate the speed of an object when you select the moving object together with its environment by means of your global visual selective attention. Traffic situations and ball sports tend to be problematic for someone with a global visual selective attention disorder.

Visuospatial figures

To understand geometric forms such as triangles, squares, rectangles and diamonds, you need to have overview of their individual elements. Without overview of the various lines, it is difficult to see how they interrelate. Sometimes it helps to present the forms in a smaller size. People with a disorder in the global visual selective attention generally find it more difficult to learn to recognise and understand visuospatial figures.

Learning to read

Children who have a global visual selective attention disorder experience - aside from problems in understanding visuospatial information - difficulties in learning various educational skills, such as reading and math. To learn to read well, it is necessary to have overview of the letters, words and pages.
Letters are in fact nothing other than complex visuospatial figures that consist of details,

specifically small lines with a detailed spatial interrelation. To learn these spatial relations between the lines, you need to be able to select them together, thus globally. Once you know the letters, you can then proceed from letter recognition to word recognition. In order to be able to read words not just letter by letter, you need to recognise them as a whole, as a picture, the so-called **word image**. It is necessary to be able to select entire words to be able to recognise word images. For someone with a global visual selective attention disorder, learning letters and word images is likely to be more difficult and time-consuming.

To be able to read *quickly*, you need to oversee groups of words at a glance. Understanding the overall context of a text requires an overview of the page. Finding the right information on a page is also difficult without overview. Have a look at Figure 11. Imagine that your teacher says: "Below 2012 you will find the information you need for the next assignment". By the time a person with a global visual selective attention disorder has found "2012", the rest of the class will have moved on.

Delay in reading development: CVI or dyslexia?

When a person experiences a delay in learning to read or in comprehension of texts, **dyslexia** usually comes to mind. If the cause of the delayed ability to read is visual, then not dyslexia but a visual impairment, such as CVI,

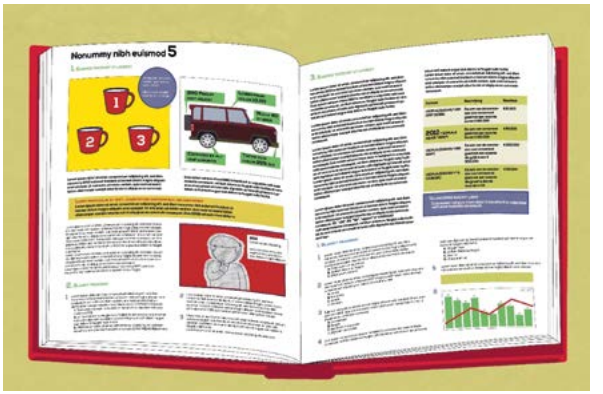


Figure 11. To be able to find inconspicuous information quickly and between lots of distracting data, you first need to have an overview.

is involved. Dyslexia is, after all, a disorder in the processing of sounds and/or in learning the connection between sounds and characters. Thorough and often detailed examination is needed to distinguish CVI from dyslexia. It is also a possibility that someone has both disorders. Disorders in other high visual functions, other than global visual attention, may also cause delayed reading development. More on this topic in the following chapters.

Learning numbers, graphs and topography

Before you learn the meaning of numbers, you need to understand quantities. That is a lot easier when you can oversee the details. By using your global visual selective attention, you see the details in combination, as a whole, so that you quickly have an idea of what "three", "five" or "one hundred" actually entails. A disorder in global

visual selective attention makes this is much more difficult. Furthermore, children who have this disorder cannot oversee number sequences and therefore do not understand the relations between numbers. Their insight into quantities and their ability to estimate distances progresses more slowly and this results in a lag in their mathematical ability. To understand graphs and topographic charts, it is likewise necessary to have an overview of the various elements. People with a global visual selection attention disorder experience more difficulty with this.

Faces and facial expressions

We generally recognise faces through the arrangement of the facial elements and not by the individual elements themselves. In the same way, recognition of facial expressions comes from looking at the entire face. In general, people with a global visual selective attention disorder find this more difficult. They are compelled to recognise faces and facial expressions by paying attention to details. Sometimes this leads to errors. A detail of a mouth or eyebrow is often not enough to recognise a facial expression. This lack of overview may cause the more subtle aspects of social interactions between people to be unnoticed.

Autism?

Because of the possible consequences for social interactions and the focus on visual details, autism is sometimes considered. However, with autism, social problems have a different origin and the focus on details tends to be more general. People with autism often fail to see not just the relationships in pictures, but also the links between other types of information.

Global visual selective attention disorder, a practical example

A disorder in global visual selective attention is often hard to understand. After all, who has ever heard of a visual impairment that causes you to have no overview of visual information? The following story, told by the mother of a boy with a global visual selective attention disorder, illustrates this:

"I was in the swimming pool with Jayden, and all the starting blocks are numbered. He is learning the numbers at school, so while we are just a few feet from one of the starting blocks, I asked him: "Jayden, what number is on that block?" He answered: "A… uh… eight? Or is it three? Or six?" So, I thought: "Well, he simply hasn't learned the numbers yet!" But a few minutes later, while we are walking to the other pool at about fifty feet from the block, he suddenly said: "Oh, now I see it, mama. It is a three!" I don't get it: my son is visually impaired, but he only sees what something is when he is farther away from it? How can that be passible?"

With proper knowledge of global visual selective attention as described in this chapter, we can actually come to understand this.

What have I read in this chapter?

- The second step in visual selection involves the extent to which we distribute or focus our visual attention within the visual field.
- Making the selected area larger, thus spreading out your attention across a larger area of the visual field, is called global visual selective attention.
- By expanding your attention, you see the whole of what you are looking at, without attending to details.
- A relatively high number of people with CVI have a disorder in the global visual selective attention.
- A global visual selective attention disorder leads to difficulty in attaining an overview of visual information.
- This leads to problems with spatial orientation, participation in sporting activities and manoeuvring in traffic, finding objects, possible delays at school in reading, math and topography, and sometimes in recognising faces and facial expressions.

Recommendations regarding disorders in visual selective attentional functions

General recommendations for people who have visual function disorders

- Explain to teachers, classmates/peers, parents, caregivers, siblings, colleagues, coaches, etc. where the person's limitations and restrictions originate from.
- Explain to those who experience restrictions and limitations what causes these.
- Train them to apply their strengths as much as possible, so that they can learn to compensate their restrictions and limitations adequately.

Stated briefly, people with a *visual selective attention disorder* experience problems selecting the right visual information. As a result, they need more time for visual tasks and get tired more quickly. We can make their lives easier by making the information that they need more prominent. Some things attract more attention than others. When something grabs your attention, it stands out, so it is easier to select and perceive. An object will attract attention visually if it:

- contrasts sharply against the background, for example a dark object against a light background, or vice versa.
- has a different colour.
- has a different shape or structure.

- stands apart from the rest.
- moves, or moves more quickly, slowly or differently than the rest (like a ball that suddenly enters your field of vision).
- is meaningful for you, for example something that you need at that very moment, or something you like, or something that is on your mind a lot (for example: when you have a new car, you suddenly see the same car everywhere).

Generally, the following practical tips help in dealing with restrictions and limitations at school that result from visual selective attention disorders:

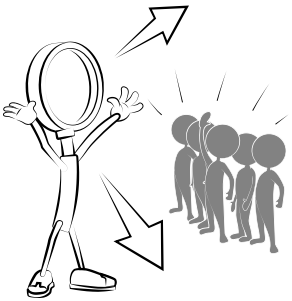
- Show as few things as possible at the same time or use only a single sheet.
- When needed, offer pictures or assignments divided into separate parts (by splitting it up or by using a cover sheet).
- If needed, use pictures/texts that are slightly enlarged. Enlargements that are too big can lead to lack of overview (especially in case of a global visual selective attention disorder).
- Increase the space between words in a sentence, as well as the distance between lines, without increasing the paper size.
- Use colours in a consistent way in order to have important information stand out more, so that it can be found again more easily,

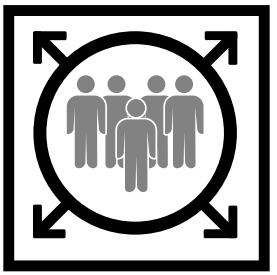
and also to establish links between related pieces of information. Do not use too many colours.

- Only provide materials that are necessary for the task at hand. Put away all other unnecessary items.
- Teach the child to make use of tactile support when performing tasks involving a lot of visual information, such as pointing and following with a finger.
- Teach the child to look and work systematically.
- Ensure that materials can always be found in the same place.
- Avoid visual distractions at home, particularly in the child's own bedroom.
- Allow for moments of relaxation and/or physical exercise at school.
- If possible, give the child fewer assignments in light of the fatigue that a visual disorder can cause.
- Allow more time but be aware that in most cases simply providing more time not always lead to better results because of fatigue.
- Divide a test into two parts and allow a pupil to make it on separate days.
- Limit the amount of screen time.

These are general tips and recommendations. What will and will not work must be decided together with the individual with CVI and the people surrounding him or her.

Illustrations that are used in the CVI passport and on the CVI key card to represent global visual selective attention:





7 Local visual selective attention

Imagine that you are riding your bike in busy traffic and that you have a good overview of all there is to see around you. But still you have difficulty finding significant details such as the traffic signals or flashing lights. Or imagine that you don't see individual Lego blocks within a large box filled with all kinds of Lego toys. You only see a large pile of Lego and therefore you cannot find the specific pieces you need. You go to see an ophthalmologist, and he tells you that there is nothing wrong with your eyes. In that case, you may have a disorder in local visual selective attention. To see a detail clearly and distinctly, you need to be able to focus your visual attention on it. Your brain must zoom in on the detail so to speak, using your attention, to be able to select it. If your brain is not capable of doing this properly, you do not see separate details when in crowded visual situations, but just a jumble of indistinct details. A local visual selective attention disorder is probably the most common form of CVI.

What is local visual selective attention?

By spreading out our visual attention, we gain an overview of details, objects and people. This is sufficient to get a general impression. However, we often use overview in order to find something and subsequently examine it in detail. To be able to see a detail clearly, we need to direct our eyes to it and then select it by focusing our visual attention on it. When you do this on the basis of overview, you then zoom in - as it were - with your attention. This is called local visual selective attention: you select within the visual field by means of your attention by focusing on a small area.

Details matter

Some details are extremely important, in traffic for example. It is no coincidence that many important details try their best to attract your attention exogenously. Think of the flashing lights at a railway crossing, or the brake lights of a car that suddenly light up in front of you. These are hard to miss, you would think. But, what if it is a clear day, the sun is shining directly into your eyes, you are tired and your mind is elsewhere, and on top of all this your favourite music loudly enters your mind via your headphones?
In situations like this, you might not notice all of these details or even miss them all together. Or you suddenly need to do your best to see them clearly. Is the traffic light red? Is that light flashing? Hey, don't I know that cyclist?

Figure 12. If you want to see your teacher's face, you must select it by using your local visual selective attention.

To answer these questions, you must – even in traffic– focus all of your attention on the details, and not distribute your visual attention across the visual field.

Local visual selective attention disorder

In our experience, a local visual selective attention disorder is at least as common as a global visual selective attention disorder. We regularly come across a combination of these two disorders. People with a local visual selective attention disorder are unable to select a small part of the visual field, or at least not sufficiently. They nearly always select too much. As a result, they see far more than just the detail they want to see, and they experience a jumble of indistinct details. They have difficulties in finding and seeing details, especially when these are surrounded by all sorts of other visual details. Take a look at Figure 13.

The flying flea
One day the flea ran into the fly. The last time that they had seen each other was quite some time ago, and they greeted each other enthusiastically. The flea noted that the fly had awfully red eyes, so she asked what had happened. "I'll tell you," the fly replied. "Imagine this. I have a husband. I sting my husband, that's natural for me. And he hits me, that's natural for him. And we have so much fun that Way! But I laughed so hard that my eyes practically rolled out of my head!" And the flea and the fly burst out laughing. "But how about you?" the fly said at last. "Your neck is practically gone. What happened to you?" "You know that I get cold quickly," the flea explained. "So the best spot for me on a human body is where it is warmest. So I creep down between his skin and his clothes. But it is awfully tight there. So tight that I need to push. And I pushed so hard that my entire neck got squeezed in."

Figure 13. If small details are closely packed together, you need to zoom in extremely close with your local visual selective attention to be able to decipher them.

This figure lets you experience what it is like when you find it difficult to zoom in on small details. In this case the words and letters are positioned so close to each other that the word images give you no reference. As a result, you need to decipher the individual letters to be able to read the text. That requires zooming in extremely close with your local visual selective attention.
When you have a local visual selective attention disorder, you may, for example, find it difficult to zoom in on the individual letters in small print or in crowded texts. It is as if you are unable to grab the individual letters with your attention; they are too small as you cannot get the selected area small enough. Thus, we often see that people who have a local visual selective attention disorder reduce their viewing distance. After all, when you get closer to the paper, the details get bigger and become easier to select. Another reaction that we often see in people with this disorder is that they choose not to look at crowded visual information. Their experience is that of an annoying jumble of indistinct and therefore unidentified details.

Different forms

As is the case with global visual selective attention, local visual selective attention disorders come in different forms. The size of the area that can still be selected differs from one person to the next. Some people with a local visual selective attention disorder are not at all able to select small details in crowded visual situations. Others may succeed initially, but as they go on, it gradually becomes more and more difficult as it

costs them lots of energy and wears them out.

General effects of a local visual selective attention disorder

People with a local visual selective attention disorder will experience limitations and restrictions in crowded visual situations like when out on the street, in the supermarket or a shop, on the sports field, in the school building or in a classroom, and when confronted with crowded pages full of small print and pictures with lots of details and colours. They experience chaos where others see details. As a result, finding details is difficult, such as finding a specific game in a cupboard full of games or a specific piece in a pile of Lego. Even to find your own mother in the school yard is difficult (see Figure 14). People with a local visual selective attention disorder especially experience difficulties in traffic situations and at school.

Figure 14. With a local visual selective attention disorder, it is difficult to find your mother amongst all the other parents.

Reading and writing

Probably the most annoying and tiring activity for someone with a local visual selective attention disorder is looking at details for an extended period. Unfortunately, that is what reading involves. The smaller the letters and words, the more difficult it becomes.

When a child learns to read, the letters and words are initially rather big. But as a child advances in school, they gradually get smaller. As a result, some children in second, third or fourth grade suddenly find reading more difficult and very tiring. Reducing the viewing distance – even to merely 5 cm from the paper – is not uncommon among children and adults who have a local visual selective attention disorder. That can result in an aching back, neck or head, painful and weary eyes, frustration and fatigue. It is not surprising that many of these children give up and as a result get behind in their reading and math development. Also, their writing skills are often not what they should be. Since they may not be able to read what they themselves have written, they often write larger. Larger than the lines in their exercise books - and unfortunately, also their teachers - allow. This is very frustrating, since in grades 2 to 5 you are assessed especially on the three Rs: reading, writing, arithmetic. Dyslexia is then often wrongly thought to be the cause. Special fonts have even been developed for students with dyslexia, and people who have been diagnosed with dyslexia are often provided with large-size texts. If such *visual* adaptations facilitate the

reading development, then it is CVI that is involved and not dyslexia.

Local visual selective attention disorder: reading and subjects that involve learning factual information

The impact on the ability to read and write is especially troublesome since these skills are an important foundation for learning subjects that involve factual information, such as history, geography and biology. Another problem is that topographic maps often tend to be overly crowded with data. When virtually all school progress is hampered, the fear of failure and motivational problems are around the corner.

A disorder in switching from global to local visual selection

Some people, even though they do not have a local or global visual selective attention disorder as such, cannot switch quickly between zooming in and zooming out. These people also experience problems and restrictions in daily life. Since we are constantly looking for things and because there is usually a lot to see, we zoom in and out all day long. For example, when looking for your black bicycle key, you start by zooming out to get an overview, and subsequently you reposition your eyes towards what might be your key. Next, when zooming in, you realise that the object is a black pen instead. Therefore, you zoom out again and reposition your eyes to something else that is black and has the right size, and then zoom in again, and so forth. This operates in the same way when your teacher asks you to look for "2012" on a certain page: overview ("there, in the corner of my eye, does it say 2012?"), eye movement and zooming in ("no, it says 2077"), zooming out ("there perhaps, in the corner of my eye?"), eye movement and zooming in ("ah, found it!").

Zooming in and zooming out: an endless process

Be aware that we constantly need to find things, even when not consciously searching for something. Even when you know where the ice cream shop is, you first need to get there. You stand up to leave the house, and you zoom out for overview to find the door to the hallway. You find the door, then zoom in on the door to be able to walk towards it. Next, you look for the doorknob, you direct your eyes on it and zoom in on it. You grasp the doorknob and you open the door. You direct your eyes to where you expect to find the coat rack, you zoom out to find your coat among the rest, you zoom in on one of the coats, probably the one that has the right colour, and you take your coat. You direct your eyes to where you expect the front door. And so on, and so forth. If these processes do not go smoothly, they take a lot of time and energy.

Various concurrent disorders in visual selective attentional functions

Some people with CVI have both global and local visual selective attention disorders. As a result, they view the world through a selected area which is neither very large nor very small and which

can hardly vary in size. These people likewise experience visual chaos: they never really have an overview of the details, and they cannot see the details distinctly either.

Fatigue, uncertainty, frustration, fear of failure

An unpleasant side effect of visual selective attention disorders is that you get tired fast. When you are tired, you lack the attention that is needed for zooming in and out. Not only is looking more difficult when you are tired. Everything takes more effort and you get irritated more easily. It is not realistic to expect a child with CVI to be able to do the same in one day as an average classmate. Children with a visual selective attention disorder are often exhausted after a single hour in school.

They are unlikely to meet expectations and will feel that they are falling short. This results in frustration, lack of self-confidence, low self-esteem and the fear of failure.

Selection on the basis of colour or shape

Using our global and local selective attentional functions, we select on the basis of size. Size, however, is not the only selection criterion. You can also select on the basis of a specific colour or shape, or a combination of the two (such as your black bicycle keys). For example, try looking straight ahead and seeing all things in your field of vision that are red. You should now see red objects. You have selected on "red" so all red objects suddenly jump out in your visual field. You can read more about the processes that play a role in this method of selection in Chapter 10, which discusses our visual working memory.

What have I read in this chapter?

- To be able to view a detail distinctly and clearly, you have to zoom in with your attention in order to select it. You do this by employing local visual selective attention.
- A local visual selective attention disorder may well be the most common form of CVI.
- People with a local visual selective attention disorder experience problems in seeing and finding small details, especially in visually crowded situations.
- They experience a chaotic jumble of indistinct, unidentified details.
- To be able to see a small detail properly, they must reduce their viewing distance.
- A local visual selective attention disorder results in reading, writing and math being tiring and frustrating activities.
- Since reading ability is an important basis for subjects that involve the learning of facts, they get behind in these subjects too.
- Some people have both a global and a local visual selective attention disorder.
- Looking is very tiring for those with a disorder in visual selective attentional functions.

Recommendations regarding disorders in visual selective attentional functions

Although the effects of a local visual selective attention disorder are altogether different from the effects of a global disorder, the recommendations regarding these disorders are similar. What these disorders have in common is that the limitations and restrictions are primarily reflected in the difficulty of finding the correct information. Hence, the methods used to find information more easily are comparable. Please, see the recommendations presented at the end of Chapter 6.

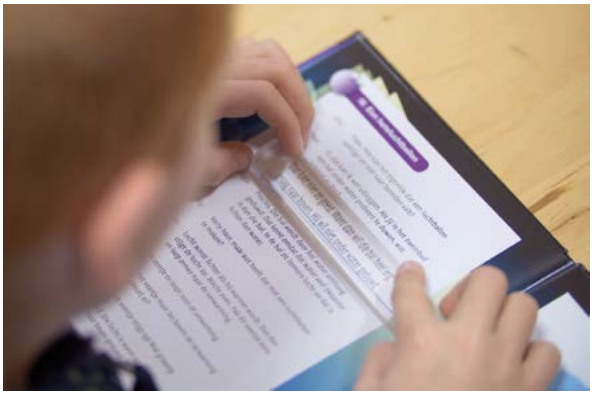
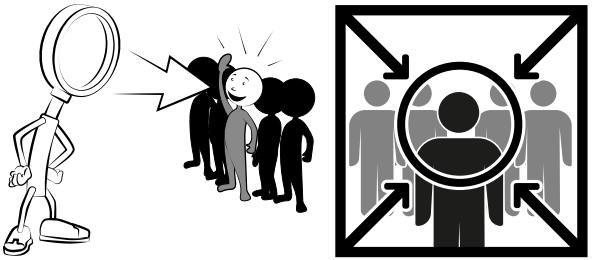
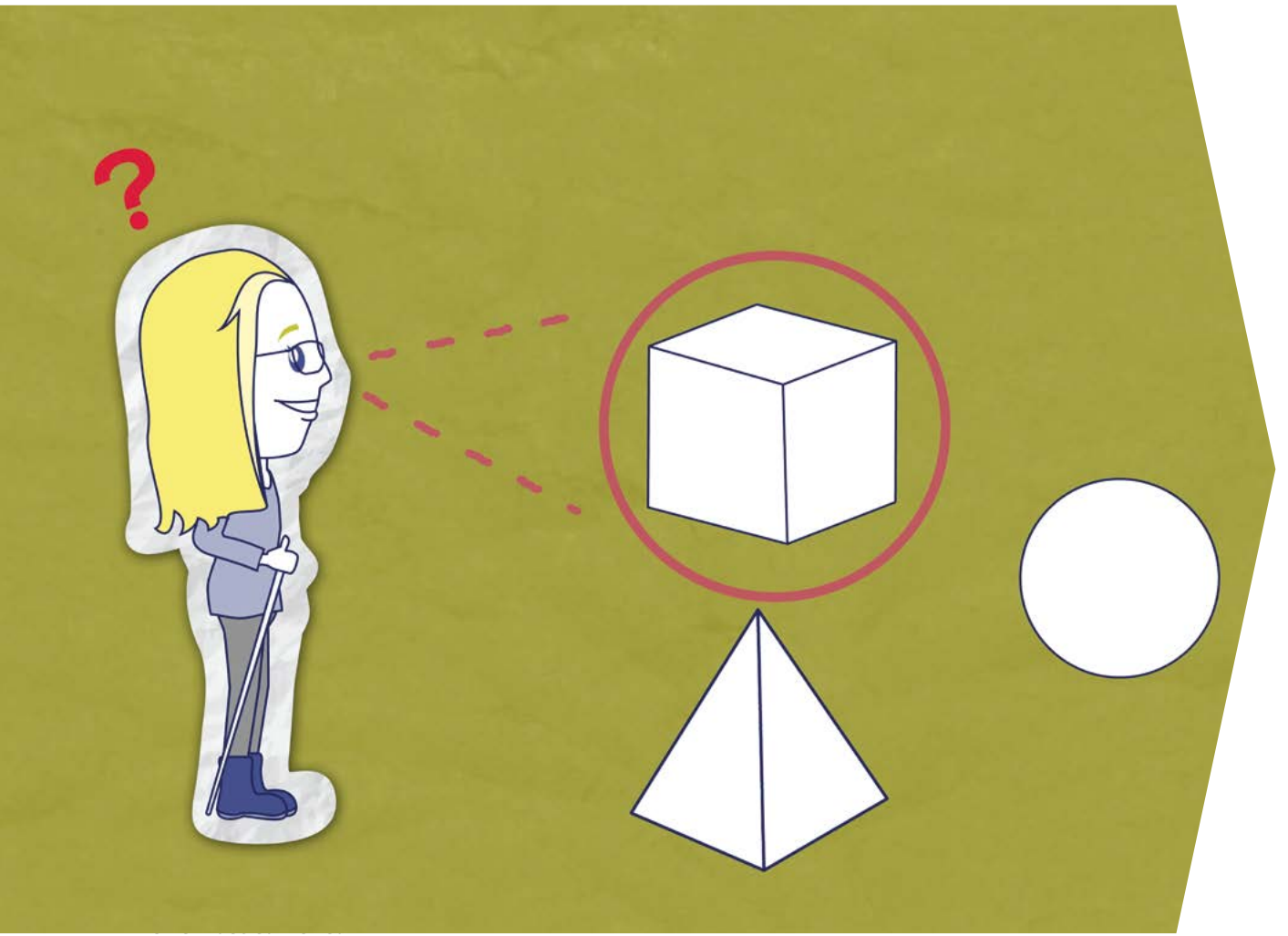


Figure 15. A magnifying ruler helps in selecting a sentence in a crowded text.

Illustrations that are used in the CVI passport and on the CVI key card to represent local visual selective attention:



8 Visual perceptual functions



Imagine that you have a visual field and eye movements of high quality, and that you are capable of selecting adequately within your visual field resulting in good overview and the ability to find and inspect small details. Nonetheless you find it difficult to comprehend shapes, or you do not understand the lay-out of your hometown. Or you find it difficult to estimate the direction and speed of cars and bicycles. This may be caused by a disorder in one or more visual perceptual functions. You need these functions to understand what you see. Most people with CVI do understand what they see, but they often have difficulty understanding visuospatial information. If their global visual selective attention is intact, this problem usually results from one or more disorders in visuospatial perceptual functions.

How do we understand what we see?

You perceive consciously what you have selected by means of visual selective attention. But that does not imply that you also understand this information. To understand what you have selected, you need to process the visual information further. This is done by means of perceptual functions. There are two types of perceptual functions:

- **Visual identification functions**, which help us understand what it is that we see.
- **Visuospatial perceptual functions**, which help us understand the visuospatial properties of what we see.

In CVI, visual identification difficulties are hardly ever caused by disorders in identification functions

Understanding *what* an object is, means recognising what you perceive as something that you have seen previously. To do this, you need to match the new images with images that are stored in your brain (see Chapter 9 on visual memory). Disorders in visual identification functions are rare in CVI. In most cases of CVI, the sections of the brain that perform identification functions are not affected. Nonetheless, someone with CVI may still find it difficult to identify and recognise what is seen. In the vast majority of cases, this results from one of the processing steps that precede the visual identification, such as low visual acuity or a visual selective attention disorder.

Identification difficulty as a result of disorders in selective attention

For someone who has a disorder in the local visual selective attention it is difficult to identify small visual details, in particularly in visually crowded situations. For example, a child who has this disorder may have trouble finding his or her mother and recognising her between all the other parents in the school yard. However, that same child would not have any difficulty recognising his or her mother when she stands directly in front of him/her.

A disorder in the global visual selective attention can likewise lead to identification problems. With this disorder it is difficult to recognise

objects or pictures that require overview due to, for example, there is a lack of defining details. However, single objects or simple realistic pictures would normally not pose as a problem.

Subconscious and conscious processes in identification

The recognition or identification of visual information involves both conscious and subconscious processes. A lot of identification happens automatically, without thinking. For example, you are able to recognise the cars in the street as cars. You do this without having to examine them in detail, without specifically thinking of them and without consciously identifying them as cars. The context and your expectations help you to do this. Sometimes, however, recognition requires detailed analysis of what you see, for instance when your image is blurred, when there is not enough light, when you have no overview of details or when you cannot see small details. Looking in a systematic fashion and focusing first on the things or elements that you do recognise, may help you in that case. It also helps to actively consider the context in which the unknown visual information appears.

What do you expect to see? You can vary the viewing distance or the perspective. Or you can apply other senses like touch, hearing, taste or smell. This is an energy consuming process, where your level of alertness, motivation and control over your attention largely determine the success of your actions.

Disorders in visuospatial perceptual functions

We use visuospatial perceptual functions to understand visuospatial properties. Disorders in these functions are relatively common among people with CVI. Although in the case of problems with understanding visuospatial information, these are not necessarily caused by disorders in visuospatial perceptual functions. If the functions that precede the visuospatial perceptual functions are not optimal, then this impedes the processing of visuospatial information even before the visuospatial perceptual functions have started with their analysis of the information. For the various functions that precede the visual perceptual functions, see the levels of hierarchy (*see page 137*) of this book.

Limitations in visuospatial understanding caused by disorders in visual selection

Visuospatial understanding is all about spatial coherence and therefore depends largely on

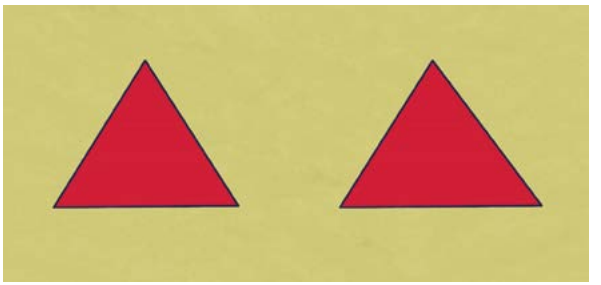


Figure 16. To determine whether these triangles are identical or not, you need both location perception and orientation perception.

overview and thus on global visual selective attention. This applies for the visual space around you, for visuospatial figures and for estimating direction and speed of movement. To fully understand visuospatial information, however, you also need to look carefully at all of the various elements. This means that you also need local visual selective attention. For example, to distinguish between the two triangles in Figure 16, you need to be able to estimate the exact lengths and orientations of the various lines. Therefore, you need to be able to select them independently and separate them from the other information.

A "pure" disorder in one of the visuospatial perceptual functions

In some people with CVI, the development of their visuospatial perceptual functions is delayed or hindered because of disorders in one or several of the preceding processing steps. However, some people encounter difficulties in understanding visuospatial properties even though all preconditional functions are of adequate quality. In these cases, we speak of a "pure" disorder in one or more visuospatial perceptual functions.

Different types of visuospatial perceptual functions

In situations involving non-moving visual information, we use two types of visuospatial perceptual functions:

1. **Location perception**, which enables you to understand where something is in relation to something else. You use this function to estimate location, distance and size.
2. **Orientation perception**, which enables you to understand the orientation or direction of something.

When there is movement, we use three other visuospatial perceptual functions:

1. **Movement perception**, which we use to see whether something is moving or not. In other words, whether its location is changing or not.
2. **Speed perception**, which we use to estimate how fast the location of something is changing.
3. **Direction perception**, which enables you to estimate the direction (or orientation) in which something is moving.

As you can see, all of our visuospatial understanding is based on two key concepts: location and orientation. In short, if you know where something is (location) and which direction it is pointed towards (orientation), whether it moves (change of location) and, if so, how fast (speed of change of location) and where to (orientation), then you know everything there is to know in visuospatial terms.

Location perception

Location perception is understanding, being able to estimate, where something is. It is an important pillar for our visuospatial understanding of the world and thus for our development in general. Healthy children with adequate vision want to take action on whatever

they see, both nearby and far away. Through interaction with their environment and gaining visual experience with objects and things, their knowledge of the world grows, and they quickly come to know where to find what they need.
To be able to learn where the things that we need are located, we must essentially learn to understand where things are in relation to other objects. We do this by using location perception. Once we *understand* where something is, we can then start to *remember* where it is. If you understand where your school is located in relation to other important landmarks, then you can start to remember where it is. Initially in relation to your home, and then if possible, also in relation to the old oak tree, the railway station, the bicycle shed, the intersection. Ideally you will also know the location of all these **landmarks** in relation to each other.

Location perception and the development of educational skills

Also on a smaller scale, visuospatial understanding plays an important role in a person's development. For example, at school when learning various skills. To be able to learn shapes like triangles and squares, letters and digits, you need to be able to distinguish them in spatial terms. That requires understanding them.
Knowing the *locations* of the elements in relation to one another is fundamental.
Consider a triangle, for example. The vertices are the landmarks of the triangle, as it were, since they determine the properties of the triangle. How many relevant vertices are there? Where are they exactly in relation to each other? What is their distance from each other?
In the case of letters, the starting, ending and intersecting points serve as landmarks. Have a look, for example, at the capital letters K and A, and compare them. They both consist of three lines, but they differ from each other. One of the differences is the location of the elements: where are the starting, ending and intersecting points located in relation to each other?

Location perception: size and distance

Location perception answers questions such as where the tips of the line are in relation to each other. Thus, it forms the basis for spatial concepts such as size: large or small, long or short, nearby or distant. Something is large or long if the outer extremities are far from each other. If you find it difficult to assess where the various parts are in relation to each other, then your understanding of these basic spatial concepts will take more time to develop. Consequently, it will probably also take you longer to learn shapes and letters, and to learn the locations of landmarks in your direct surroundings as well.

Small-scale orientation perception

Consider the example of the letters K and A, each involving three small lines that differ as to the location of the key points. They also differ in another aspect. The points are partly linked by lines, and these lines do not only have a certain length but also a certain *orientation*. Understanding

the orientation of the lines is the other important visuospatial perceptual function: orientation perception. Consider the difference between a triangle and a square. Aside from the difference in the number of vertices and their respective locations, the directions of the lines in relation to each other also differ. When viewing the differences between shapes of the same type – such as the triangles in Figure 16 – orientation perception is essential. That particularly applies when the shapes are very similar, as is the case with certain letters. If a child falls behind when learning to read due to disorders in one or more of these functions it is CVI that we speak of, not dyslexia.

Large-scale orientation perception

On a larger scale, in the world that you move around in everyday, a correct assessment of orientations is extremely important. You can connect landmarks in your environment, like your school, the railway station and the old oak tree, by means of lines or roads. That too determines the exact spatial characteristics of the environment. You can see these on a map, possibly also on the mental maps that you have made to get from A to B.

Also take into consideration what the world looks like when you are on the street. All the lines that you see making up the roads, sidewalks and buildings around you. Consider what a school looks like when you walk through the rooms and corridors. Due to your position in the room, the horizontal floors and vertical walls often appear to be slanted. If you do not fully understand the orientation of those lines – or the locations of their starting and ending points – you will not have a correct understanding of space, which can be a problem.

Location and orientation perception: separate functions

You may have noticed that location and orientation are interdependent and impact each other

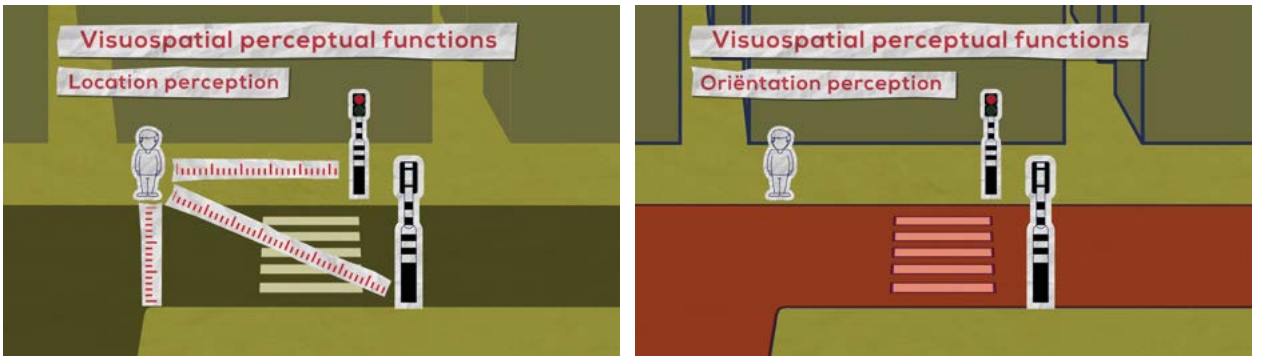


Figure 17. To understand the space around you, you need location and orientation perception.

directly. If you change the location of one of the two landmarks - most of the time - the orientation between the landmarks changes too. Although orientation and location interrelate, the *understanding* of location and of orientation requires two separate visuospatial functions. People who are good at location perception are not necessarily good at orientation perception and vice versa. The connection between these functions is the space in which they are located.

Movement perception

Movement involves change of location. However, to determine whether something moves, we do not use location perception but movement perception. Merely seeing whether something moves is not enough. It is just as important to be able to determine how fast and in what direction something is moving. For that we need speed and direction perception. If you know where something is, how it is oriented, whether it is moving and, if so, how fast and where to, then you know everything you need to be able to function in daily life.

Disorders

Disorders in the various visuospatial functions can occur independently from each other. Disorders in location and orientation perception hinder children the most in general spatial orientation, in traffic situations and at school. In spatial terms, cities, shopping centres and schools are quite complicated. In addition, going to school involves learning shapes, letters and numbers and you need to learn to understand topographical maps, graphs, tables and much more.

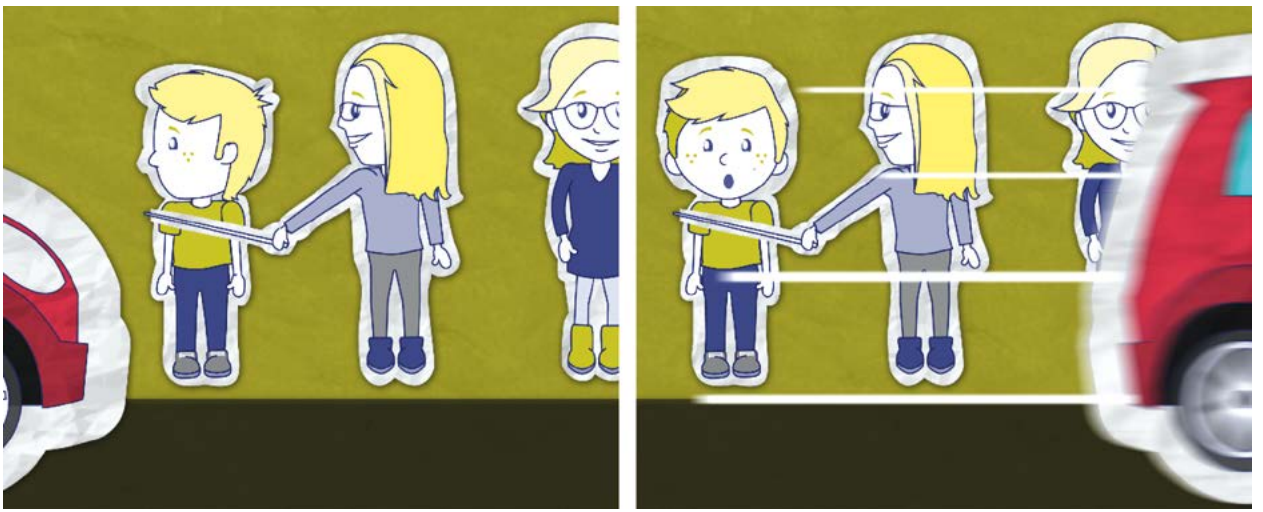


Figure 18. Disorders in the perception of movement are extremely dangerous in traffic situations

Location perception is especially important, for example, when making a jigsaw puzzle: where are the pieces of the puzzle exactly located in relation to each other? The effects of one or more disorders in movement perception are inconvenient in sports and other activities, but in traffic they can be particularly harmful. After all, not being able to determine the speed and direction of other road users is not only inconvenient and tiring; it is extremely dangerous too.

Visuospatial perception and the levels of visual hierarchy

An important factor in understanding visuospatial information is that we sometimes need to analyse the information extensively before we can understand it. This takes time, energy, effort, attention and attentional control and it generally involves a lot more than simply identifying what we see. Understanding visuospatial information is therefore highly dependent on the preconditional functions and factors (points 1 to 4 in the levels of hierarchy). That is why visuospatial perception serves well to clarify the relationships between the various elements of the hierarchy.

Executive functions

Have a look at Figure 19. You can immediately see that coffee cups 1 and 2 are much closer to the edge of the table than coffee cup 3. Are cups 1 and 2 at equal distance from the edge, or do the distances differ? Are the handles of cups 1 and 2 pointing in the same direction? Sometimes it is not possible to see where something is exactly or

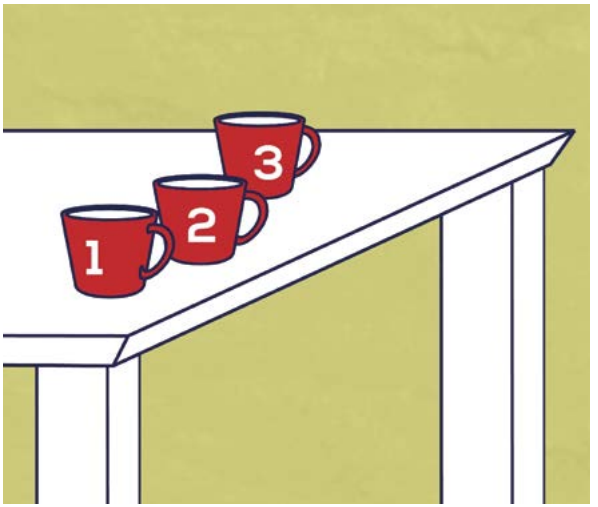


Figure 19. Determining the exact location of an object sometimes involves a lot of conscious effort, using our executive and attentional functions.

how it is situated all at the same time. We then need to look and compare systematically, using our attention. If we still don't succeed, then we may have to come up with strategies to find out how large, small, nearby or far away something is, or what it is directed at. You can come up with and apply all sorts of strategies to try to understand the visuospatial information better. For example, looking back and forth many times, using your fingers as a ruler, using aids like a ruler, changing the angle of vision, or something else altogether. In those cases, visuospatial understanding requires much more than visual functions. It takes time, energy, effort, motivation, attention, flexibility, creativity, systematic thinking and insight into your own performance.

Motivation

As effort and fatigue increase, motivation becomes even more important. How badly do you want to do something right? What are your needs and emotions? Motivation forms the basis of our executive efforts. The amount of effort also largely determines to what extent we develop ourselves in a certain area. Your specific needs and emotional constitution are determined by **personal** but also **environmental factors**. Both have great impact on the development of your visuospatial capacities.

Personal factors

Personal factors play an important role in the development of visuospatial understanding. For example, whether a child is interested in visuospatial games partially depends on the child's personality and talent, but also on the experience of success. If you feel that you can do something well, you will enjoy it and you will want to do it more often. Frequently, we see that children who have little talent for a specific activity lack motivation and do not develop an interest. The lack of experiencing success is part of this. It results in that the child doesn't feel like doing the activity and practices less, while he or she actually needs more practice.

Environmental factors

Social aspects also play an important role in the development of visuospatial understanding. Whether a child experiences his or her performance on a visuospatial task as a success, partly depends on the reaction given by their surroundings. Experiences of success form a foundation for self-confidence in learning new skills and everything else children undertake. So, as a parent or teacher you can play an important role in the development of children, just by letting them experience success.

Visuospatial development also depends on active stimulation by the people in the child's environment. A child that is not stimulated to think about the spatial characteristics of the school building or the village where he or she lives because the parents always lead the way, will develop more slowly. The visuospatial development of children with CVI is often inhibited even further because parents take over, "because it takes so long otherwise". Gender differences can also play a role.

At a certain moment children become aware that they cannot perform specific visuospatial tasks as well as others, who in-turn respond irritated and with lack of consideration. Unfortunately, this often leads to fear of failure and an increased avoidance of visuospatial tasks. All of these factors further delay the development of visuospatial skills.

Verbal support

Factors that are not included in the visual hierarchy also have impact on how well you understand spatial information. An important factor is how well you can describe what you see.

The ability to put things into words – for example visual features – is called verbalisation. If you are capable of describing complicated visuospatial information, you have a tool to understand and remember the information more easily and precisely. This is especially the case when you are able to apply knowledge of measurement units, such as centimetres and degrees. An example: "The long sides of this isosceles triangle are approximately 5 centimetres long, the short side is about 3 centimetres, and the angles are roughly 70 and 40 degrees". When you memorize something, you can use it in turn to recognise or better understand new information ("yes, I've seen a triangle like that before").
Also consider how letters are learned. The letter "b" might be a difficult little figure when you see it for the first time. It can be helpful to describe and understand it as consisting of a "stick" and a "belly". This way, understanding the letter "d" (a small circle at the lower end of a stick) and the "p" (a stick and a small head) becomes easier.
People who have difficulty with visuospatial understanding, but who have strong analytical, executive and verbal skills, may learn to use these skills to help them to get a better understanding visuospatial information. Occupational therapy methods rely on these skills to provide children with tools to improve their understanding of visuospatial information.

What have I read in this chapter?

- The fact that you see something does not necessarily imply that you understand what you see.
- To understand what you see you need visual perceptual functions.
- There are two types of visual perceptual functions: identification and visuospatial perception.
- Disorders in identification functions are rare in CVI.
- When a person with CVI has difficulty identifying, it is usually caused by disorders in functions that precede the perceptual functions.
- Disorders in visuospatial perceptual functions occur relatively often.
- Overview – and therefore global visual selective attention – is important for the development of the visuospatial perceptual functions.
- There are five visuospatial perceptual functions, all based on the spatial concepts of location and orientation: location perception, orientation perception, movement perception, speed perception and direction perception.
- Disorders in location and orientation perception lead to poor spatial orientation, falling behind when learning shapes, letters and numbers, and difficulty in understanding topographical maps, graphs and tables.
- Disorders in movement perception lead in particular to problems in traffic situations and in sport activities.

- Visuospatial understanding or insight often calls for further analysis, involving executive functions, motivation and the amount of energy someone has.
- Verbalising what you see promotes visuospatial understanding.
- Personal and social aspects play an important role in the development of visuospatial insight.

Recommendations regarding disorders in visuospatial perceptual functions

As pointed out in this chapter, visuospatial understanding depends not only on visuo-spatial perceptual functions. In particular global visual selective attention is essential, since it is responsible for providing overview. Executive and verbal functions, and personal and environmental factors play an important role as well. In case of disorders in visuospatial perceptual functions, we can try to reduce the limitations experienced by making optimal use of the other factors in learning how to compensate.
For general recommendations regarding fear of failure, increasing motivation and self-esteem, and disorders in executive and attentional functions, please see Chapter 3.

Recommendations to encourage independence

- Encourage the child to navigate; help the child, if necessary.
- Allow the child enough time to complete a task.
- Discuss landmarks or take pictures of them.
- If the child can follow a fixed route on his or her own, start with exploring a different route or walking to the landmarks from different locations.

Recommendation for applying executive functions to understand visuospatial information

- Teach the child to look, think and act in a systematic way.

Recommendation for applying verbal skills to understand visuospatial information

- Teach children to name what they see using words that they already use and know.

Illustrations that are used in the CVI passport and on the CVI key card to represent location, orientation and movement perception:

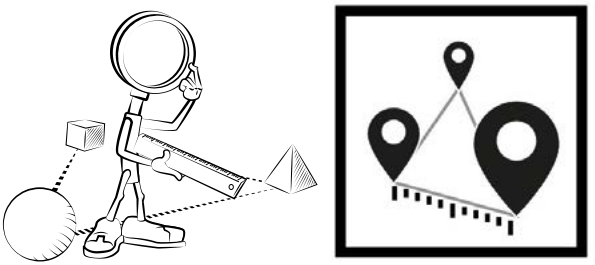


Illustration 1: Location perception

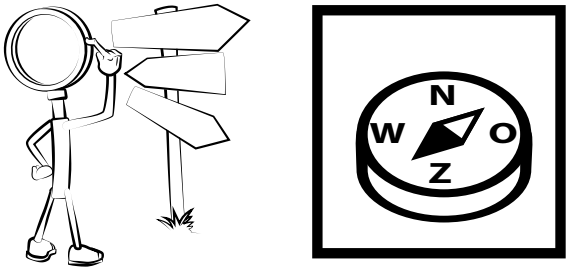


Illustration 2: Orientation perception

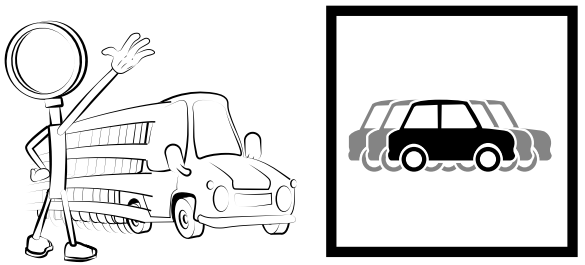


Illustration 3: Movement perception

9 Visual memory

What you perceive visually can be stored in various types of visual memory. You need these memories in order to recognise visual information and to form mental visual images. People with CVI may indeed have difficulties with visual recognition and creating mental visual images. Disorders in visual memory functions, however, are rare in CVI. When a person experiences difficulty recognising and understanding, the functions and factors that precede the memory functions are practically always at fault. They cause the information that is stored to be of lower quality. Likewise, difficulty in recalling stored visual images is generally not caused by disorders in visual memory itself.

Visual memory

When we speak of "**visual memory**" we mean the totality of visual information that is stored in our brain. What exactly is memory and what role does it play in the problems that children with CVI experience?

Children with CVI rarely have disorders in visual memory

Memory is information that is stored in your brain. Memory disorders result from damage to the parts of the brain where information is stored or in the connections leading there. This causes the memory information to be damaged or inaccessible. This rarely happens with people who have CVI. Nonetheless, their visual information is not always stored or retrieved easily. In the case of CVI, this usually results from poorly applied attention. This poor attentional employment can have different causes: weaknesses or disorders in executive and attentional functions, lack of motivation due to fear of failure, and/or fatigue. In this chapter we therefore look at the impact of these functions and factors on the storage and retrieval of visual information, in particular.

The images stored by children with CVI are usually of lesser quality

Aside from the influences of the general factors of *visual* hierarchy (*see page 137*), we also see a role for disorders in visual functions in impacting our visual memory. The quality of the visual functions that *precede* the visual memory – the low functions, the visual selective attentional functions and the visual perceptual functions – affect the quality of the images that are stored. When you do not see something clearly or do not understand it fully, you won't be able to store it properly. For example, if you cannot select large parts of your visual field, you will not understand the relation between its different elements. As a result, you won't be able to store them correctly. Thus, your memory will not contain a useful map of your town if you have never had an overview of its various elements. Even if nothing is wrong with your visual memory as such.

The essence of memory: recognition and recall

Your memory is only helpful when you can use the stored information. Using the information is

done for two purposes: (1) for **recognition** (and thus understanding and identification) of what you see, and (2) for **recall** or actively remembering stored information.
Without visual memory, everything that you see would be new, making it impossible to understand and recognise it. Most people have no problem recognising and quickly understanding visual information. For someone with a visual impairment it is occasionally quite a puzzle to identify what is seen. This is because the stored images are of lower quality, but also because a person's vision is simply not good enough.

Active recall of stored information

Active recall of visual images from memory allows you to see things that are not physically present. That may sound spooky, but it is not. You can see the face of your mother in your mind's eye without her actually being present. By giving attention to stored images of the face of your mother, they enter your thoughts. This applies to everything that you pay attention to. Active recall of images from your memory is called **visual imagery**.

Various types of visual memory

There are different memories for recognition and identification of objects and people, and for visuospatial information. These memories may be impaired independently, but they function in unison. For example, you can combine information from both types of memory into a picture of how familiar objects in your environment relate in spatial terms. Likewise, route descriptions can help to create a mental picture of where the old oak tree, the bicycle shed, your school, your home and the railway station are located in relation to each other. The image that you evoke, your visual image, generally consists of combined information from different types of visual – and sometimes other – memories.

Visual imagery is an active process

Which memory-based information you use to create your visual image depends on the purpose for which you want to use that image. Evoking a picture in your mind is not just passively accessing an image in your memory. It is an active and flexible process that involves steering your attention to select and combine the right memory information. In addition, it takes a lot of attention to vividly see the image in your mind's eye. Since visual imagery is so dependent on executive control, it is usually not regarded as a memory function but as a function of our **visual working memory**. We will discuss this in detail in the next chapter.

The role of attention in storing visual information

Attention plays an important role not just in the *active recall* of images. It also plays a key role in the *storage* of visual information. In general, the more attention we give to information, the more we are consciously aware of that information. The more consciously aware we are of something, the more readily we will store that information. As such, there is a close connection between attention,

conscious perception and memory storage. In that sequence. We see this reflected in the visual hierarchy.

The role of the executive functions

Not only the *extent* to which, but also the *manner* in which you use your attention to remember something you see (hear or feel) determines how well the information is stored. Through conscious, executive processes you can influence how you use your attention and thus how accurately the information is stored. With the right amount of motivation and stamina, you can direct your attention in such a way that the chance of the information entering and staying in your memory increases. The following general guidelines should be considered:

- try to connect the new information to your existing knowledge base in as many ways as possible
- try to repeat these imprinting processes

See the recommendations section of this chapter for a number of practical tips. By testing yourself to see how easily you can access the new information, you will find out whether you have internalised the new information sufficiently. If you discover that you cannot come up with the information easily, you need to return to the source of the information.

By using your attention correctly during the process of memorizing visual information, you will establish all sorts of connections with existing visual memory information, but also other memory systems, such as those for the other senses, those for descriptions and those for events. Repetition helps in strengthening the new connections. As a result newly stored information will be found more easily, and with less effort. Repetition or drilling alone is not enough, as you do not touch on things that you already know and therefore barely establish new connections. Even if the new information becomes stored, it will remain isolated and therefore difficult to retrieve.

Strong connections and associations

Some connections will become so strong through regular use of the information, that it may enter your thoughts just like that – automatically, without any extra attention - in the form of associations. These associations ensure that your memories, including visual memories and images, are hardly ever just visual. They are supported, enriched and altered by other types of information that comes from other types of memory.

CVI and the storage of new information

For someone who has CVI, delivering the extra effort to store information effectively and correctly is quite a task; simply looking and seeing already uses up lots of energy. Also, the potential fear of failure or additional weaknesses in executive and attentional functions do not make it any easier to apply memory strategies. In general, children with CVI have more trouble remembering visual but also other types of information.

Sufficient memory storage requires reducing environmental stimuli

Aside from the factors mentioned in the hierarchy, the characteristics of the person's surroundings affect their attention span. Distracting information can draw attention away from relevant information and the use of strategies, leading to poor storage of the information.

Using verbal memory to remember how to get from A to B

In spatial orientation, navigation, and the storage and updating of visuospatial information, not only conscious visual processes are at play. Subconscious visual and other processes are also important. In practice, many people with CVI experience problems with spatial orientation and navigation. What can help is translating the visual information into words. Although a route description is a verbalisation of (visuo) spatial information, in text form it requires less visuospatial capacities. Ideally, a route description is available in text format. If not, you need to remember the verbal information. A drawback of route descriptions is that they often involve a lot of details. For example: "You leave the house, and at the end of the path you reach the sidewalk. There you turn left. You stay on the sidewalk until it ends. You will have reached Oak Street. You cross Oak Street. You are then on the opposite side of the street. There you turn right and keep walking until you reach…". Another drawback, compared to a map, is that a descripted route is not very adaptable and so you run into a problem if the sidewalk is broken up. Nevertheless, many people with CVI prefer a written route description.

What have I read in this chapter?

- You need visual memory to recognise visual information and to generate mental visual images.
- Disorders in visual memory functions rarely occur in CVI.
- This does not imply that people with CVI will not encounter problems with recognition or visual imagery.
- Difficulties in recognising visual information also result from the visual impairment, as the stored images are of a lower quality.
- Visual imagery is an active and flexible process that requires a lot of attention and proper orchestration of attention.
- Difficulties with mental imagery in CVI result from fatigue, disorders in executive or attentive functions and, more specifically, the visual working memory.
- Attention plays an important part in the storage of visual information, as well.
- Not just the level of attention is important but also the way the attention is used.
- To optimize memory consolidation of new visual information, it needs to make as many connections with the information that is already stored in the various memories as possible.
- Executive effort and creativity help to achieve this.

Recommendations for better memory storage of visual information

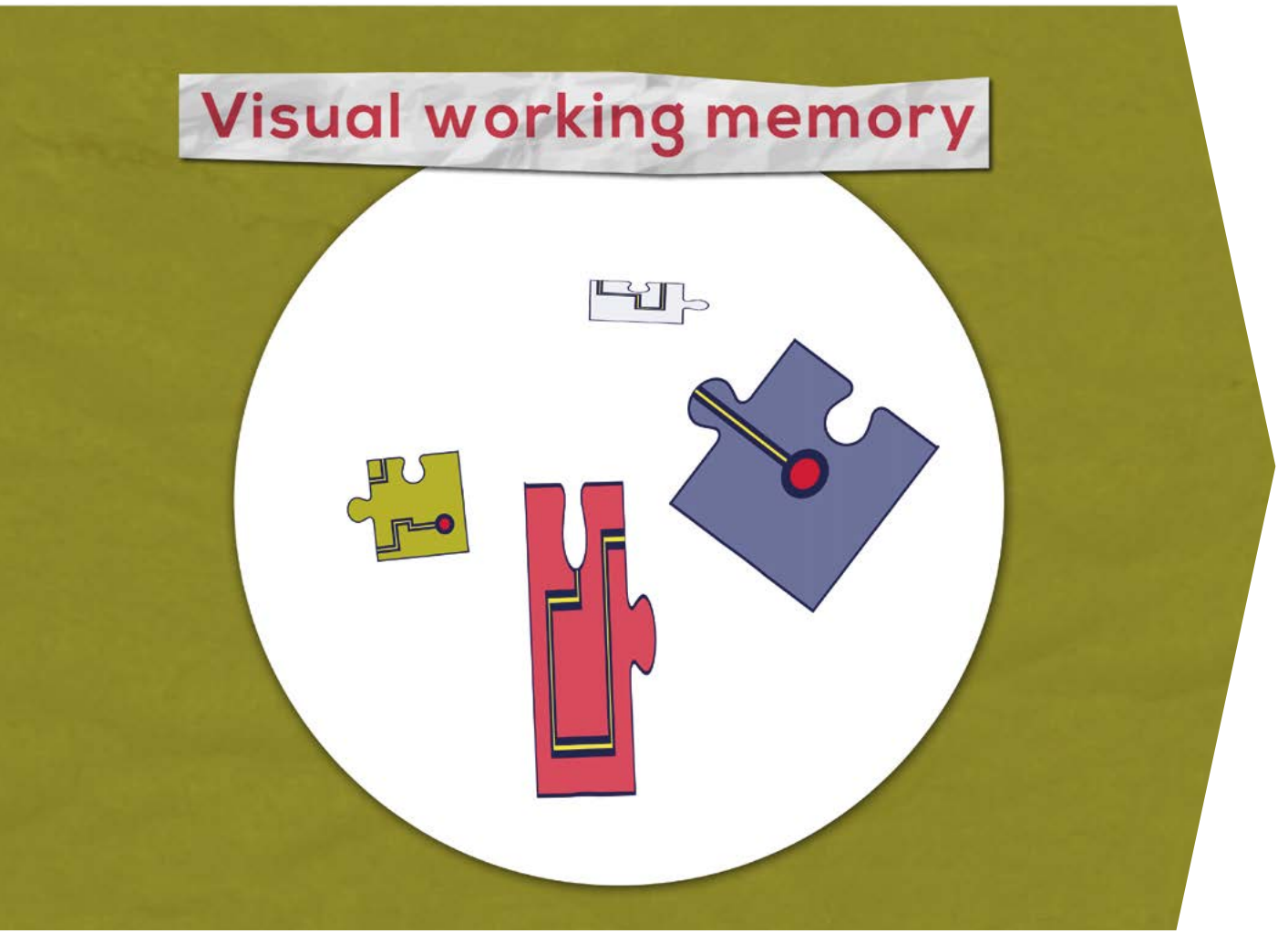
General recommendations

- Try to connect the information with as many different types of things that you already know as possible. What associations do you have with what you see? What does it make you think of? What mnemonics or reminders can you think of?
- If possible, use all of your senses; feel, listen, smell and taste. Pick up the object, move it back and forth and view it from different angles.
- Present different materials within the same theme, for example triangles: large, small, wooden, plastic, etc.
- Give the information an emotional context. What do you think of this? What feelings do you experience? What do you find beautiful, good or nice about it, and what do you not like about it? Why do you feel this way?
- Try to analyse the visuospatial properties extensively. Analyse it both globally and in detail.
- Try to verbally describe what you see or to discuss it with someone else.

Recommendations for learning different types of visual material

- Present new information by topic. Elements can best be interconnected right from the start. Sample topics are; colours, shapes, autumn, kitchen utensils, European countries, etc. For each topic you can systematically create new small networks of related items in a person's memory.
  To prevent these networks from remaining isolated from one another, it is important that you connect with information already present.

10 Visual working memory



Suppose you are really good at drawing an exact portrait of anyone, based on a photograph of that person. Does that mean that you can also draw a picture of the current Dutch King from memory? Or the logo of the National Railways? Nearly everyone will immediately recognise the logo but drawing the Dutch one from memory is not that easy. To do that, you need a mental picture of what it looks like. You do this by using your visual working memory. You also use your visual working memory to transform images in your mind. Just try to imagine what your name looks like in a mirror. That is not easy, as using your visual working memory takes a lot of your attention and requires executive control. Some people with CVI have one or more disorders in visual working memory. They generally find it quite difficult to draw things from memory, to understand incomplete visual information, to find things, to make jigsaw puzzles, to navigate in a flexible way, and to comprehend what they read in full.

Seeing things that are not present

We all see things that are not physically present. That sounds mysterious but have a look at Figure 20. Do you see a triangle? There isn't one, or in any case the figure only shows parts of a triangle. Your brain fills in the rest of the triangle automatically. Some things are automatically filled in by your brain, others are not. You need to envision them. Some things you even need to imagine entirely. Is your mother nearby? No? Then imagine the face of your mother. Do you see her in your mind's eye? Or imagine a yellow triangle that is upside down. Or imagine that you turn 90 degrees to the right: how is your body aligned with respect to the door? All of these things you do by using your **visual working memory**.

Two types of visual working memory functions

Using your visual working memory you create and manipulate visual images mentally. Creating visual images is called **visual imagery**. There is no separate name for mental **manipulation of visual images**. The images that you use might be stored

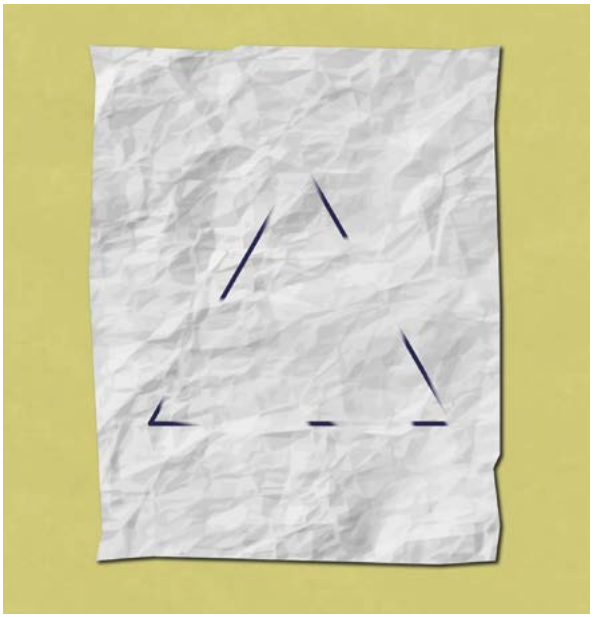


Figure 20. This is not a triangle. You see a triangle because your brain automatically fills in the information that is left out.

in one of your visual memories, but it is also possible that you mentally manipulate what you see at that very moment. Relatively many people with CVI have a disorder in their visual working memory. As a result, they find it difficult to create mental images and/or to manipulate them, leading to all sorts of difficulties in their daily life.

Working memory

Our *visual* working memory is part of our **working memory**. That in turn is part of the executive functions. The working memory is a special form of short-term memory. With our **short-term memory** we hold onto information for a short period only, that is to say, as long as we give attention to this information. Examples include repeating a telephone number or trying to remember what that telephone number looks like. If we are distracted, or if we actively direct our attention elsewhere, this information is quickly lost. Usually, we not only hold on to information, but we use it as well. We do this with our working memory. We us it for all of our thinking, calculating, combining, interpreting and assessing activities. We use the results of these processes to make decisions so that we can do what we are motivated to do at that particular moment.

Working memory is the content of our thoughts

Our thoughts are the content of our working memory: a temporary mix of all information that we pay attention to and use at a specific moment. Our emotions and needs are interpreted, weighed and converted into motivations in our working memory. These determine what information we consider to be necessary. We think about where we need to obtain this information in order to achieve our goals. For this we use various memories, including our visual memories.

Visual imagery

Visual imagery is an active and flexible process that goes beyond "merely" summoning up memory information such as "Athens is the capital city of Greece". It takes more executive effort and therefore requires more energy. The vividness of the image also strongly depends on the level of our attention and attentional control. You need to recreate the image time and time again and try to hold onto it. This is quite tiring, but it yields very flexible results. You can combine different images, and you can zoom in on and out from that image. Due to this, it is not clear whether you recall one or more pictures at the same time. Not only the things that you *see*, can be stored in your memory. If you imagine a green elephant balancing on a yellow triangle often enough, the combination of these images will probably be stored as a separate new image.

Some people are much better than others in creating mental images. The quality of the information that is stored in the various visual memories also differs from one person to the next. Someone with CVI and/or bad eyesight will usually have images of lesser quality to work with.

Visual imagery as basis for selecting, searching and finding

When looking for something, it helps to have a mental picture of what you are looking for. For example, when looking for your keys, it is helpful to have a mental image of what your keys look like. You then use your visual working memory to generate the image in your mind. Colour is a very helpful property in helping us find what we are looking for. If you are looking for your mother in the school yard and know that she is wearing a green coat, you can use this information to find her more quickly. You imagine the colour green and then scan the area for it. You then pay attention to everything that has roughly that colour, resulting in seeing everything of that colour. Here is an experiment you can try: examine the area around you and search for something red. Now choose the colour green. You will then immediately see things that you did not see before. If your mother normally wears a green coat but happens to wear a red one today, then it is quite possible that you will overlook her. In addition to colour, you can also make a selection by using shapes. For example, look now at all the round objects around you. Once again you will see different things.

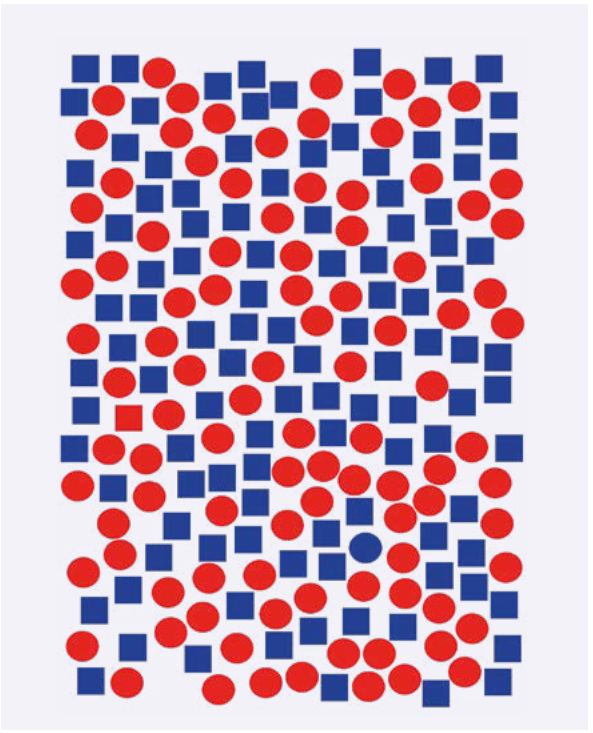


Figure 21. Finding the red square or the blue circle is easier when you imagine them visually. You do this with your visual working memory.

You can make a choice for red, green or round because you can imagine red, green and round, using your visual working memory. You can also choose various aspects at the same time. The more details you combine, the more important it is that you create a mental image of what you are looking for. For example, find the red square and the blue circle among the red circles and the blue squares in Figure 21.

If you are looking for a certain object, it is obviously quite useful to have an image in your mind including multiple details. There are more mothers wearing a green coat. It is easier to find your mother when you have a mental image of your mother that includes a combination of visual aspects that are unique to her, for example red hair, a round face with glasses, and a green coat.

Visual imagery as the basis for learning to write and drawing from memory

Why is drawing the National Railway logo by heart more difficult than drawing a triangle? There are various reasons for this. The logo is more complicated than a triangle and it consists of various parts. You have not consciously examined the logo or tried to imagine it very often, and you probably have not drawn it before. When you see it more often, then analysing it consciously, copying it, and subsequently trying to draw it from memory, will perhaps get easier.
Compare this process with writing the letters of the alphabet. Letters are in essence no different from the railway logo: they too are complicated visuospatial figures. It takes quite a few visual functions to understand them and also considerable practice before you can draw them from memory. For a child who is still learning to write, it is quite difficult to produce individual letters from memory. By repeating moments for writing over and over again, it will eventually become unnecessary to create a mental image of the letters to be able to write them correctly. However, until a child reaches that stage, it is just as difficult for them as drawing the railway logo from memory.

CVI and writing

Reading and writing are very complicated skills as they involve many functions. The visual working memory is actually only a small element in the process of learning to write. Consider the influence that disorders in selective attention and visual perception functions have on understanding the letters of the alphabet and how they interrelate. Unfortunately, a relatively large population of children with CVI also have difficulty performing writing movements themselves because of disorders in **fine motor skills** and in their visual control over these motor skills (see next chapter). Disorders in **automation**, which make it more difficult to master writing movements, also occur frequently in CVI.

Visual imagery and comprehensive reading and listening

"With an elegant movement the hunter pulled Little Red Riding Hood and her grandmother out from the belly of the wolf, alive and well and radiant with joy." Or: "The schooner sailed with softly billowing sails, in the yellow light of the semicircle moon high in the sky, towards the barely visible horizon". If you cannot picture what you read or hear, it is more difficult to comprehend it and thus harder to remember as well.

Visual closure

Much of the information that we see is only partly visible. We interpret the information and fill in the incomplete information where necessary in order to complete the picture and to match it with our interpretation. Sometimes this goes automatically, as in Figure 20. At other times we are misled and misinterpret the image we see, as in Figure 22. At times we do not recognise what we see and need to take

Figure 22. Your brain fills in the incomplete picture and wrongly making it an elongated aurochs.

Figure 23. Sometimes it takes a lot of our attention and executive puzzling to mentally complete a picture.

action "to make something of it", using our visual working memory. Have a look at Figure 23. One prerequisite to figuring out what this figure represents is that we select the inkblots as a whole, using global visual selective attention. Once we have done that, we can then fill in the empty spaces by using our visual imagery.

Visual imagery as a basis for navigation and spatial orientation

Without TomTom, Google Maps or other navigation tools, there are two ways to get from A to B: a written description of the route to take or by reading a map. Maps contain a lot more information than written descriptions. They contain all of the information that is needed to describe and imagine all the possible routes. Usually, we don't have a map of our surroundings with us. Most people have a mental map of their living area at their disposal. You need a well-functioning visual working memory to create a map in your mind and also to use it.

What if you cannot create a mental image of where your home, the railway station, the old oak tree and the supermarket are in relation to each other, due to a disorder in your visual working memory? Then you need to rely on fixed and familiar routes. Suppose you ride your bike from your house to school and also from home to the supermarket regularly, but that you have never gone directly from school to the supermarket. Would you then be able to go from school to the supermarket just like that, without practice? The answer is no, not without visual imagery. Without a mental map you cannot interconnect the different locations of the landmarks in your environment. With a disorder in mental imagery you cannot combine the separate routes into a map. So, you will first have to go from school

to your house and then from your house to the supermarket. Consequently, a disorder in imagery affects the degree to which you can comfortably and adaptably move around in your direct surroundings.

Visual working memory and the manipulation of visual information

This applies even when you *are* able to create a mental picture of your town or when you *do* have a map of your town. To be able to use (mental) maps easily, you will need to use them in a different and additional way. For example, when taking a left or right turn, it is quite handy if you can rotate the map in your mind. Or that you can imagine what the environment looks like, or how the surroundings change when you yourself turn the corner. This is called **mental rotation**. Navigation is a tiring activity for someone with a disorder in the mental rotation of visual information.
Mental rotation is just one example of mental manipulation by means of our visual working memory. In our mind we can make objects that we see bigger or smaller, more skewed, more angular or rounder. We can imagine that they move, as well. It all depends on your particular goal.

The role of visual working memory when making puzzles

Another example of a skill where we absolutely need our visual working memory, is making jigsaw puzzles. For a puzzle without an example, you first need to imagine what the end result will look like. If you know that it will be a lion, then you can put the pieces with the nose or a paw in roughly the right place. You also need mental rotation to make a puzzle quickly and efficiently. The individual pieces are usually rotated in all directions. To quickly recognise what a specific piece represents, it is helps if you are able to rotate it in your mind and to "see" if the piece is the right shape to fit in the spot where you think it may go. With a disorder in one of these main functions of visual working memory, making a puzzle can be a time-consuming and frustrating experience.

Visual working memory and the visual hierarchy

Visual working memory plays a special role within the visual hierarchy. It appears twice: right at the bottom of the list of visual functions, but also as part of the executive functions. As an element of our working memory, it constitutes part of our thoughts. We use our thoughts to decide what we are going to do, how we will do it and in what sequence. Visualisation is tremendously helpful when doing this. Be aware, though, that people with a disorder in the visual working memory find it more difficult to make plans and to achieve their goals.

What have I read in this chapter?

- Visual working memory is a part of our working memory, and thus an important element of our executive functions.
- Our visual working memory enables us to have visual thoughts.
- We use our visual working memory to actively create and manipulate images in our mind.
- Actively creating visual images in our mind is called visual imagery.
- By employing visual imagery, we can make selections based on colour, shape or combinations of visual properties, making it easier to find what we are looking for.
- When we mentally manipulate visual information, we actively combine, turn, enlarge, minimize it, etc.
- Mental rotation is an important manipulative function that is applied in all kinds of visuospatial tasks.
- Our visual working memory plays an important role in finding things, drawing, learning to write, spatial orientation, navigation, making jigsaw puzzles, and much more.
- People with a visual working memory disorder experience restrictions in these tasks, which may inhibit their progress at school and/or delay them in terms of mobility.
- Disorders in visual working memory also have consequences for visualising sequences of actions or plans.

Recommendations regarding disorders in visual working memory

Disorders in visual working memory functions lead to various problems in daily life.

Recommendations regarding difficulty in finding things

- Make sure that objects are always located in the same place.
- Make sure that what needs to be found stands out: separate the item from other objects, make use of a clear contrast and/or mark with a deviant colour. For more recommendations on this topic, see Chapter 6.

Recommendation regarding problems in learning to write

- Have the child copy and/or trace letters or short words until the writing movements are automated.

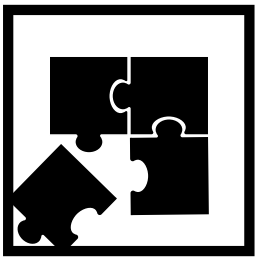
Recommendations regarding difficulty in navigation

- Have the person use a navigation system.
- Teach the person fixed routes from home to important landmarks, or have an occupational therapist teach them.
- Teach the person how to navigate between all important landmarks.

Recommendations regarding difficulty in reading comprehension

- Allow extra time for reading and have the person read out loud and explain what has been read.
- Stimulate the person to “translate” the contents of the text to the other senses: how would it feel, sound, smell or taste?

Illustrations that are used in the CVI passport and on the CVI key card to represent the visual working memory:



11 Visuomotor processing

Your alarm clock goes off (once again) and you want it turned off as quickly as possible. What if you first needed to make a detailed visuospatial analysis of the alarm clock's exact location? What if you needed to think about how to get your hand on the snooze button? Or suppose that the ball you want to catch is already past you, before you are ready to extend your arm? When you have a disorder in visuomotor processing, the automatic, quick and precise connection between seeing and doing is disrupted. Disorders in visuomotor processing are relatively common in CVI. Depending on which specific disorder(s) you have, goal-directed actions, such as picking up an object, kicking a ball, writing, or making your way through a narrow doorway will go slower and with less accuracy. On top of that, they require lots of attention and energy, making you tired.

What is visuomotor processing?

Seeing invites doing. To be able to do something with what you see, you first need to get hold of it. Preferably all at once and without having to think about it. As discussed earlier, you use location perception to analyse where an object is exactly. But that takes a lot of time and energy. If you want to pick up a glass of cola, you don't think about where the glass is exactly, or how to bring your hand to the glass. When a ball is thrown at you, you don't have time for analyses like these. Location perception is therefore hardly a suitable function when you want to move yourself or part of your body in a specific direction with speed and precision.
To pick up, catch, throw or kick an object, or to walk to something quickly and with precision, we use a different group of functions called the visuomotor functions which do our **visuomotor processing**. When these functions work well, your eyes seem to steer your body automatically. Your eyes obviously cannot do this; it is the brain that does this. Your visuomotor functions analyse the location, orientation and movement of what you see and combine this information with information about the position of your body and your limbs at that same moment. Visuomotor processing ensures that your body "knows" where the ball is at and how you can get your hand to it. Only this specific visuomotor processing allows your **motor functions** to carry out a quick, precise and agile movement. Visuomotor processing represents the connection between seeing and doing. If you have disorders in this regard that restrict you in daily life, then you have CVI.

Different types of visuomotor processing

You can carry out goal-directed actions with different parts of the body. If your hands are involved, we call this **eye-hand coordination**. Between your hands and your eyes there is the brain. The brain performs the visuomotor calculations that are necessary to ensure that your movements are quick and precise. These are used for catching, picking up, throwing and pointing at an object, but also for drawing a line in the right direction on paper, or putting letters at the right spot on the line. There is also eye-foot coordination, necessary for when you kick a ball and preventing you from stepping in a pile of dog

poop. Eye-head coordination you use when you head-butt a football. Eye-body coordination also exists. You use this when you unthinkingly work your way through a crowd or walk through a narrow doorway. Often, different visuomotor processes operate in combination, for example when you need to jump to head-butt a football.

Different disorders in visuomotor processing

For every movement that you have ever practiced, a tiny network lies ready in your brain. In principle, each of the different visuomotor functions that we have mentioned can be affected, independently from each other. A disorder in eye-hand coordination does not automatically imply that you also have a disorder in eye-foot or eye-head coordination.

Processes preceding visuomotor processing

If everything works properly, then visually directed movements seem to go automatically. Before your visuomotor and motor functions can do their job, all sorts of things happen behind the scenes. Where exactly does visuomotor processing fit in the visual hierarchy?

Suppose someone throws a tennis ball at you from the side, and you catch it. How do you accomplish that? The ball moves at the outer edge of your visual field. The light-sensitive cells in your eyes respond to the movement and send a signal to your brain. In turn, the brain, exogenously, ensures that you direct your attention and your eyes to the ball. That way you automatically select the ball. You see the ball consciously and can decide what you want to do with it. At the same time, by selecting it, you have also chosen the ball as possible target object for a movement towards the ball. Will you knock it away with your hand, will you kick it away, are you going to catch it? Whatever you decide, from the moment you do, your visuomotor processing and your motor functions will do the rest. All happening without you even being aware of how you accomplish it.

Visuomotor processing and visuospatial perceptual functions operate independently

Therefore, visuomotor processing has a place within the visual hierarchy, *after* the visual selective attentional functions (*see page 137*), just like the perceptual functions. The visuomotor and visuospatial perceptual functions operate independently from each other. You don't have to consciously assess where the ball is to be able to catch it. You actually don't need to do anything at all except decide that you want to catch the ball. The visuomotor processing areas analyse the visual information. No conscious effort is required on your part. Your visuomotor processing improves as you keep practicing goal-directed movements. Trying to remember how you make the movement does not lead to better performance. In the hierarchy there are, just like in the brain, two parallel routes: one for visuomotor processing and one for thinking consciously, storage and recall of visuospatial information.

Understanding visuospatial information is not required to be able to use visuomotor processing

To be able to catch a ball, you don't need to understand where the ball is. The fact that visuomotor processing and visuospatial perceptual functions operate independently from each other can lead to confusing and seemingly contradictory situations. A person with a disorder in location perception may not know whether the ladybugs in Figure 24 are in the same or in different spots on the window but can still grab them easily and accurately. On the other hand, a person with a disorder in visuomotor processing will know exactly where the ladybug is, but it will take him lots of effort to pick up the ladybug.
The same applies to orientation. See Figure 25.

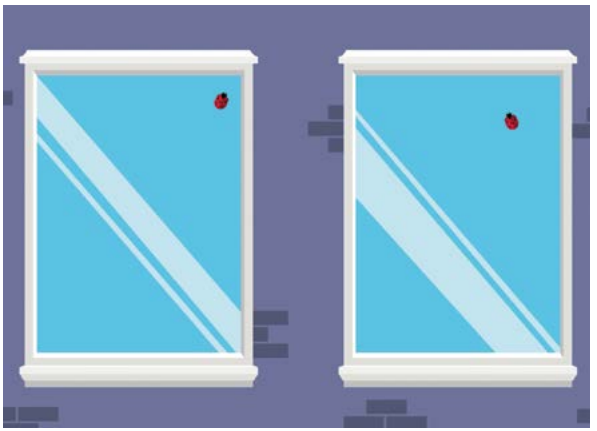


Figure 24. To be able to understand whether the ladybugs are in the same or in different spots on the window, you need location perception. To be able to grab them easily, you need visuomotor processing.

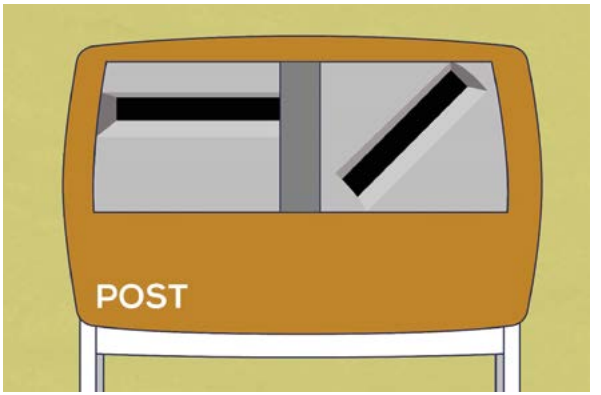


Figure 25. To understand the orientation of the two slots, you need orientation perception. To slide a letter through the slots accurately, you need visuomotor processing.

There are people who are unable to determine whether the location of the slots of the post boxes are identical or different, but they can slide an envelope through the slots without a problem. And vice versa. It all depends on whether you have a disorder in your visuomotor processing or in your orientation perception.

Disorders in visuomotor processing and fatigue

Visuospatial *perceptual* functions are generally not used to carry out goal-directed actions. But what if have a disorder in eye-hand coordination and you want to pick up a glass of lemonade? Unfortunately, in this case you are entirely dependent on your visuospatial perceptual functions. You need to consciously make visuospatial analyses to pick up the glass. Plus, you need

to continue to analyse where the glass is and where your hand is, during the movement you are carrying out. You consciously move your hand in the right direction until it is where it needs to be. Opening your hand to just the right size also needs to be done consciously. All this takes time and a lot of attention and energy. Therefore, someone who has one or more of these forms of CVI is likely to tire much quicker as well.

Motor skills and visuomotor processing develop in combination

People with motor disorders also move slower and less precise. It is often difficult to determine the exact cause of these kind of problems. That is because motor skills and visuomotor processing develop in combination. When you experience problems with eye-hand coordination, making it more difficult to catch or pick up objects, you will also have less opportunity to practice catching or picking things up smoothly. As a result, the motor skills that you need for these movements will not develop properly. If you are unable to make a smooth catching movement due to *motor* disorders, your visuomotor processing will adjust to the motor restrictions and subsequently develop differently. Relatively many people with CVI also have motor disorders.

Visuomotor processing and disorders in preceding visual functions

Be aware that the speed and accuracy of goal-oriented movements are enhanced by the precise information that binocular depth perception provides about the location of what you want to pick up, catch or kick. It is therefore necessary to first determine whether clumsiness or poorly directed movements may be caused by a lack of binocular depth perception. Similarly, if your eyes provide blurred information, if you have a hole in the centre of your visual field, or if you are unable to select accurately, then this also has consequences for the development of your visuomotor processing and motor skills.

Drawing, visuomotor processing and other high visual functions

Drawing and writing are often called visuomotor tasks. To learn to draw and write well, however, you need every function that is discussed in this book. It is therefore not correct to refer to drawing and writing strictly as visuomotor skills. Suppose you try to accurately copy Figure 26. What skills do you need to be able to accomplish this? For now, let's just confine ourselves to the high visual functions and forget about motivation, general cognitive functions and low visual functions.

Before you actually start drawing, you first need to fully understand the figure in a visuospatial sense. That requires an overview of the figure. Without your global visual selective attention, you will only see individual flowers and not the big picture which will lead to missing the triangular lay-out. Even with a good overview you still don't exactly know the distances between the flowers. To be able to estimate those, you need location perception. By mentally closing the spaces

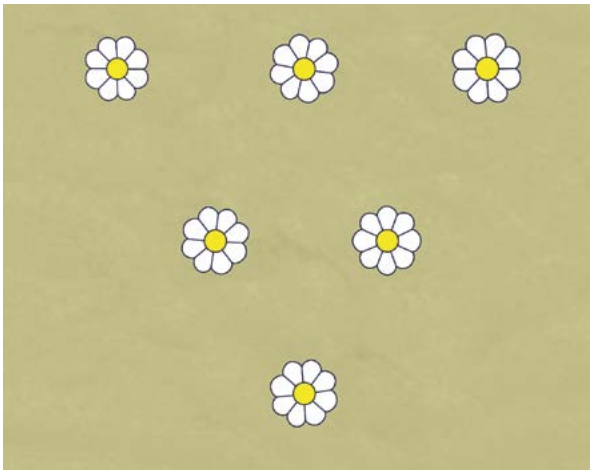


Figure 26. To be able to copy this relatively simple figure accurately, you need all functions listed in the visual hierarchy.

between the flowers, using your visual working memory, you will be able to see the sides of the triangle. To get the locations of the flowers in the right orientation, you need orientation perception. Once you have overview and understanding, you can start drawing. To draw the individual flowers, one by one in the right place, you need to assess – using your global visual selective attention and location perception – where exactly on the paper you want to position your pencil. You select that spot very carefully using your local visual selective attention. Then you aim your pencil at the visually selected spot by means of visuomotor processing. Your pencil will hopefully then land on the right spot. To be able to see what the flowers look like in detail, you need your local visual selective attention. The flowers also need to be analysed spatially using your visuospatial perceptual functions. Next you draw a small flower. You will likely need your full attention for that. Also, to see the flowers well, you need to accurately select your small drawing as well as the point of your pencil, using your local visual selective attention.

Visuomotor processing and visuospatial perceptual functions often operate together

For each movement which requires your attention, which you need to think about and consciously direct or adjust, you use not only your visuomotor functions but also your visuospatial perceptual functions and your executive functions.
This becomes evident when thoughts come to mind such as: "Is my pencil moving in the right direction, maybe I need to adjust it just a bit, oh no, this line is crooked, let me start over and let me direct my pencil with a nice round curve to where I started ..." In short, when drawing or copying, the selective and perceptual functions and the visuomotor and motor functions constantly work together, all under close supervision of the executive functions.

Visuomotor processing, writing and CVI

With enough attentive practice of the same drawing movement, no matter how complex, it will eventually become automatic, even with complicated figures such as letters and letter combinations. Then you can write, without having to think about or look closely at what you are writing. Writing on the lines also becomes

automatic. At this stage, your visuomotor processing has completely taken over from your conscious processes. Disorders in eye-hand coordination therefore consequently delay the process of learning to write and cause a person's handwriting to continue to be irregular and sloppy.

Visuomotor processing and tool use

It is quite common for us to use instruments and to – without having to think about it - make goal-directed movements with those as well. An example is using a pen or pencil and also using a tennis racket, a rake, a fork, spoon or knife, or riding a bicycle or driving a car all require visuomotor processing. How is this possible? After all, these instruments are not part of our body. If you handle a tennis racket often enough, your brain will eventually know it so well that it develops a special little visuomotor network for the use of it. The result is that it seems like the racket has become a part of your body. The same applies for a bicycle or car, or a wheelchair for that matter. At a certain moment you no longer need to think about how to navigate your wheelchair through a narrow opening. You simply feel it, it goes automatically. For each new racket, new car or new wheelchair your brain needs to get used to it again, and that takes practice. The existing network requires a few adjustments before things go automatically again.

As a consequence, disorder in visuomotor processing can also have consequences for all sorts of instruments and appliances that we use to perform spatial actions. If you keep bumping into objects with your wheelchair, for example, this could be due to a disorder in your visuomotor processing.

What have I read in this chapter?

- To pick up, kick, or catch things or to head-butt a ball, we fortunately do not need to make any conscious visuospatial analysis.
- Visuomotor processing is the high-speed, precise and automatic connection between seeing and making goal-directed movements.
- Disorders in visuomotor processing are also a part of CVI.
- When visuomotor processing works properly, it seems as if your eyes direct your body.
- Eye-hand coordination is a type of visuomotor processing. Eye-foot, eye-head and eye-body coordination also exist.
- Disorders in visuomotor processing can cause clumsiness and slow, poorly directed hand, foot, head or body movements.
- Disorders in eye-hand coordination lead to difficulties in catching objects, drawings with poorly directed and positioned elements, and sloppy and irregular handwriting.
- Visuomotor processing develops through practice.
- With practice, instruments such as pencils, tennis rackets or wheelchairs can become part of visuomotor processing.
- People with visuomotor processing disorders are forced to use their visuospatial perceptual

functions to execute visually directed movements.
- People with visuomotor processing disorders tire faster.
- Visuomotor processing and motor skills are interdependent in terms of their development.

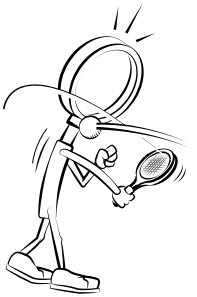
Recommendations regarding disorders in visuomotor processing

For people with one or more disorders in visuomotor processing, continuing to practice is useless. The disorder may make some sports unsuitable. If you continue to wobble and almost lose your balance when riding a bicycle, it might be better to simply avoid busy traffic situations. For some important skills, such as writing, there are good adaptation possibilities and alternatives.

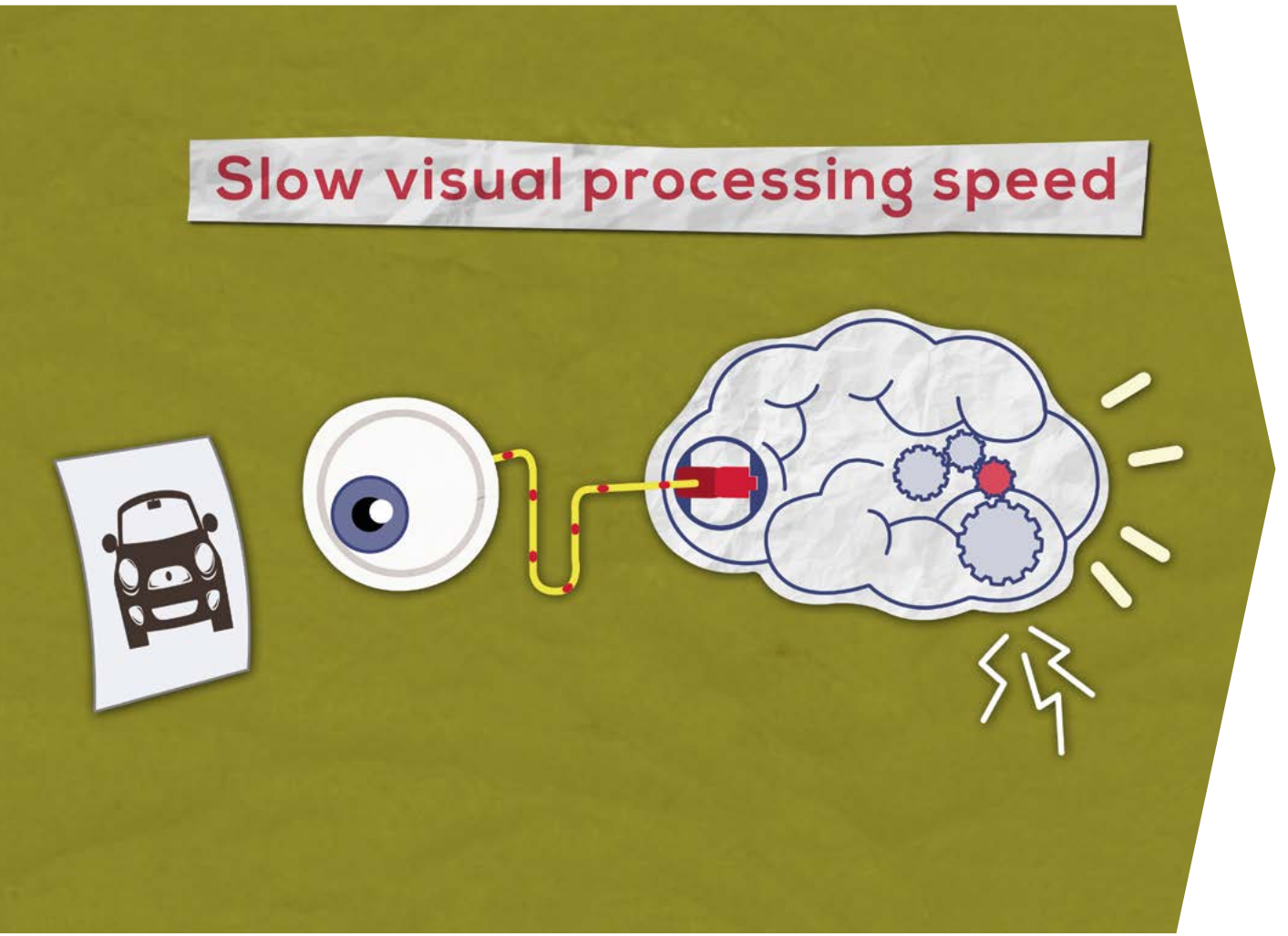
Recommendations in case of difficulties in writing
- Set lower requirements
- Allow more space to write
- Allow more time for writing and drawing
- Teach the person to touch type.
  This requires no visuomotor processing, since you do not use visual information when carrying out this particular kind of directional finger movements.

Please note: Disorders in fine motor skills, however, can definitely pose limitations for typing. It is therefore important to know whether the limitations experienced are caused by a visuomotor or motor disorder. In that case observation of the quality of actions, conducted with the eyes open and the eyes closed, may provide useful information.

Illustrations that are used to represent visuomotor processing in the CVI passport and on the CVI key card:



12 Visual processing speed



Suppose you can see as well as almost everyone else, but it takes just a bit longer before the visual image gets through to you or before you understand it. As if it simply takes a bit more time to "connect the visual dots". The cause could be a disorder in visual processing speed. This disorder hampers school, sports performance and makes participating in traffic outright dangerous.

What does a disorder in visual processing speed entail?

If visual information takes longer to get through to you compared to other people, and if this is not due to one or more disorder in visual functions, then you have a disorder in your **visual processing speed**.

Are you visually impaired if visual information takes time to get through to you?

Particularly at school, during physical education and especially in traffic situations, seeing *well* is not good enough; seeing must also happen fast enough. If visual information takes longer to enter your mind and making you feel limited in your daily life activities, you have CVI. Maybe it is best to speak of slow vision instead of bad vision. After all, people with "merely" a disorder in their visual processing speed may see well, but they need more time. This distinguishes them from other forms of visual impairment. All other people with poor vision actually see the world differently. What all types of visual impairment have in common is that – not just those with a disorder in visual processing speed but - everyone with a visual impairment needs more time.

How often does it occur?

It is hard to estimate how many people have slow vision; it is a disorder that is not very common. There are relatively many people whose processing of almost all information takes longer, but that does not mean that they are visually impaired or that they have slow vision. These people need more time in general. Therefore, describing their problems as a disorder in visual information processing speed is not sufficient.

The cause of slow vision

Little is known about slow vision. If your visual processing takes more time, it is presently difficult to identify the cause. It may lie in any one of the different elements of the visual system, but also in any of the preconditional functions, such as attention or executive switching between information sources. Together the various processes lead to consciousness and understanding of visual information, and together they determine how quickly the visual dots are connected. Delay can occur in all of these processes and in their orchestration.

What have I read in this chapter?

- For some people it takes (a bit) longer before the visual image gets through to them or before

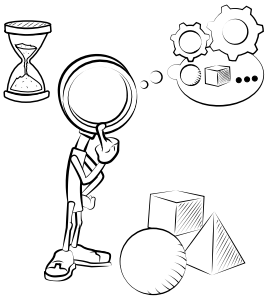
they understand it, without this being caused by a disorder in their visual or preconditional functions.

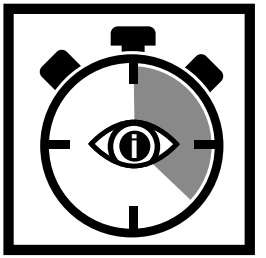
- If this leads to limitations and/or restrictions in daily life, we speak of CVI.

Recommendations in case of slow visual processing

People with this disorder need more time to react to visual information and to execute visual tasks. They therefore must be given more time. Various games and sports will be less suitable. Situations where slow vision can lead to dangerous situations, such as busy traffic, should be avoided. Learning to deal with slow vision can, however, lead to safer handling of busy traffic situations. At school, students with this disorder will need more time. A possible solution is to give the student fewer assignments.

Illustrations that are used in the CVI passport and on the CVI key card to represent visual processing speed:





13 Caring for people with CVI (in The Netherlands)

If you have CVI or suspect that you may have it, it is important to know that you are not alone. In the Netherlands, Royal Dutch Visio can investigate whether you have CVI or not. With a broad assessment programme, involving many different professionals, the restrictions and limitations you experience in daily life, their causes and other relevant factors are identified. The assessment is ultimately aimed at minimizing these restrictions and limitations and, just as important, it will also highlight your strengths needed to achieve this. In collecting and connecting all the data, Royal Dutch Visio makes use of the ICF, the International Classification of Functioning, Disability and Health, and the visual hierarchy that is described in this book. After assessment you receive personal recommendations. If you indeed have CVI, you will receive training and guidance by the professionals of Royal Dutch Visio. In addition, we provide information to the key people in your life about your CVI and all the factors that affect it, so that they have a better understanding of you and your personal needs.

If you don't see well

If you or someone close to you thinks that you do not see as well as you should, you will probably go to an optician. If it turns out that glasses do not sufficiently help, or that you don't need a pair, then a visit to an ophthalmologist and/or orthoptist is the next step. They will examine your eyes and your low visual functions. If they conclude that your visual difficulties cannot be explained by the quality of your eyes and your low visual functions, then the ophthalmologist can refer you to Royal Dutch Visio for further assessment.

CVI is not always recognised

Unfortunately, CVI is not very well known yet, even among ophthalmologists and orthoptists. The restrictions and limitations that people who have CVI experience often differ from the problems experienced when the eyes cause poor vision. In toddlers and pre-schoolers, when the quality of their eyes is sufficient and therefore a problem with the eyes doesn't not explain the child's behaviour, the symptoms are often attributed to lack of concentration, clumsiness or stubbornness.

Unsatisfactory school results and intelligence tests

With many children who have CVI, it is not until they reach elementary school that it becomes clearer that something is not going right. If their school results are below average, it is often concluded that the child may not be smart. This is commonly assessed by means of an intelligence test. Aside from using intelligence tests to determine a person's performance levels at a variety of tasks, they can also be used to signal CVI. That is because intelligence tests that are most commonly used have a large visual component. In the case of low performance on the visual tasks of the– especially in combination with signals of fear of failure – CVI should be

considered. Familiarity with CVI and alertness to CVI signals by professionals in healthcare and education can help to identify CVI in children

Everyone experiences their own limitations and restrictions

When someone is referred to Royal Dutch Visio, all we usually know is that the person experiences visual difficulties. Which specific limitations and restrictions are experienced can significantly differ from one person to the next. Everything you do in life and your personal characteristics together determine what specific limitations and restrictions you experience. If you play football or field hockey, you will experience different problems than when you need to read music for your guitar or piano lessons. Whether you go to school by bus or by bike can also make a big difference. Before we can try to deal with the limitations and restrictions, we need to first identify these carefully. This is done during the **assessment interview**.

The assessment interview yields a complete overview of a person's limitations and restrictions

Upon registration, an ophthalmologist and a behavioural scientist of Royal Dutch Visio first review all medical and healthcare data that are already available. If there are enough indications for CVI, the child, together with the parents/caregivers, is invited for an assessment interview. When collecting data, we use the **ICF**, the international classification of functioning, disability and health that was developed by the World Health Organization (WHO). This system comprises all life areas. In addition, it provides a framework for classifying all factors that may play a role in the origin, persistence and minimization of the problems. See Figure 27.

With ICF a person's entire functioning can be analysed

The nine life areas that ICF lists, chart a person's entire daily functioning:

- Learning and application of knowledge
- General tasks and demands
- Communication
- Mobility
- Self-care
- Domestic life
- Interpersonal interactions and relationships
- Major life areas
- Community, social and civic life

By applying the schedule in Figure 27, the assessment interview provides a full description of the limitations and restrictions in the boxes "Activities" and "Participation" for each life area. The other boxes are completed in order to identify all factors that may play a role in the problem.

ICF provides clear terminology

In addition to providing the basis for a complete picture of a person's functioning and of the factors that play a role, ICF also establishes a common language within the field of healthcare. For example, the word "limitation" is used only in

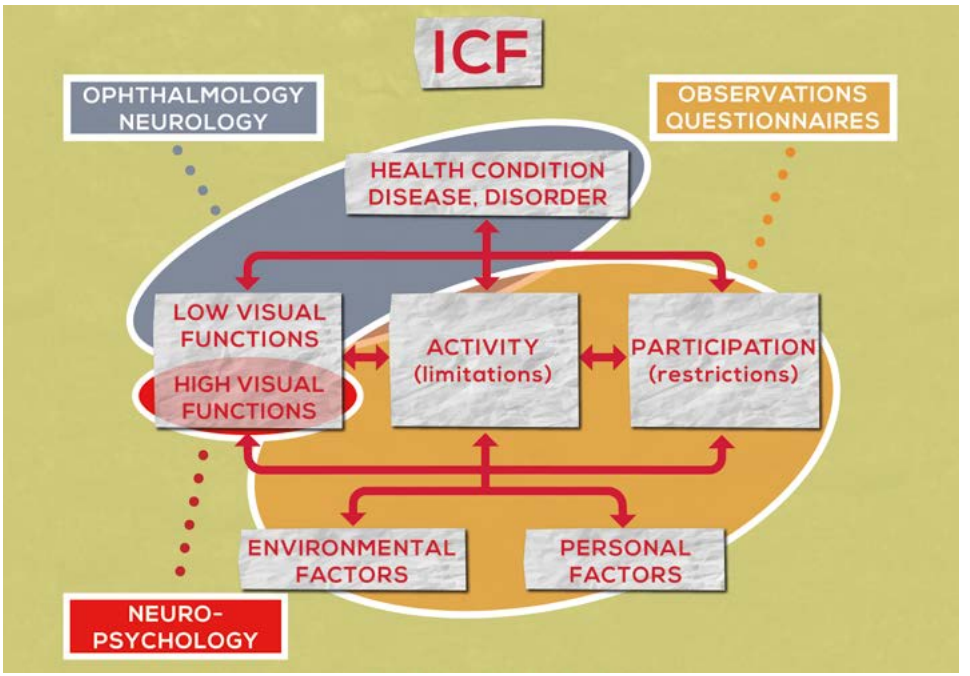


Figure 27. Completion of the ICF-schedule for all life areas yields an overall picture of the limitations and restrictions that a person experiences and of all possible factors in the person's life that may play a role in their origin, persistence and minimization. Different professionals and various methods are used to collect the data.

relation to activities, things that you do. In other words, if you have difficulty reading, you experience a "limitation" in the activity of reading. The term "restriction" is only used for participation, meaning participating in social and life situations. So, only if your limitations in the activity of "reading" lead you to fall behind in your reading development at school do we speak of a "reading restriction". If the quality of a function is so low that it causes a restriction or limitation, we then speak of a "disorder" in that particular function. When a number of visual functions are only slightly weaker, however, it is possible that in combination they lead to significant limitations and restrictions in the execution of visual tasks. If that is the case, you are visually impaired, even if there are no "real" disorders in functions.

Common language provides clarity about the level at which a problem occurs

This agreement on the terminology provides clarity about the level at a specific problem occurs. Are we dealing with difficulties in the execution of activities or participation in society? In addition, common terminology provides clarity about how restrictions and limitations can be explained: at

the level of the basic functions of body and mind, including emotions and needs and the personal and environmental factors that impact these. This is reflected in the visual hierarchy.

ICF: a framework for insight into all factors and their relationships

Aside from its explanatory role for functions, ICF links the general health condition to the problems in daily life. If your physical condition is poor due to an illness, if you tire easily or regularly miss school, this has direct consequences as it limits and restricts you in daily life (Figure 27, the box "Health condition, disease, disorder"). If you have a disorder that causes damage to the centre of your retina, this has consequences for your visual acuity, visual field and recognition of colours (the box "Low visual functions"). Directing your eyes and selection functions will be more difficult as well (the box "High visual functions").

How you deal with your disease and the problems that it leads to depends in turn on who you are and how your surroundings respond to you and your condition. If you are inclined to immediately ask for help, you might not experience a restriction as quickly (the box "Personal factors"). If your teacher is familiar with CVI and adapts your assignments and exercises for you, you will then probably experience fewer limitations in various tasks and thus fewer restrictions in school subjects (the box "Environmental factors"). As you can see, arrows between the various elements in Figure 27 point in two directions: everything has impact on everything else. And, in principle, anything may play a role in the way things function.

Using ICF, the collection of medical and healthcare data, and detailed assessment information, a total picture will gradually unfold. Nonetheless, most of the time additional information is needed to understand the situation fully. Further assessment is then necessary.

The diagnostic process

All additional assessments that we need in order to identify all relevant factors and how they interact are part of the **diagnostic assessment** process. It consists of various steps. With each step we look to see whether we have enough information to be able to explain everything and whether we can start with **interventions**: actions to try to reduce the problem. If not, then at each step we form ideas or **hypotheses** about which other factors might play a role. Each step brings us a bit closer to understanding which factors are crucial in causing the problems. This continues until we have a total picture in which everything falls into place. Only then will it be clear which recommendations and what interventions are most suitable.

Some problems are non-visual

People with CVI may also experience problems that are not directly related to seeing. Royal Dutch Visio assesses whether such problems exist and, if necessary, will refer the individual to another specialist, for example a neurologist,

physiotherapist or speech therapist. The visual problems will obviously be addressed by the team of professionals at Royal Dutch Visio.

ICF, the visual hierarchy and protective factors

With visual problems, we hypothesize about possible visual causes such as disorders and/or weaknesses in visual functions. Using the ICF framework, we conduct diagnostic assessment to search actively for data that provides information about the factors and functions in the visual hierarchy. Such as the high visual functions, the possible role of weak attentional functions, or a teacher who through overestimation or lack of understanding of a child's visual capacities contributes to a child's fear of failure. However, good diagnostics are not aimed solely at understanding limitations and restrictions, but also at uncovering **protective factors**. These are the strengths of the individual with CVI and his surroundings, which can be used to reduce the limitations and restrictions. The challenge for the assessors is to relate all the information to the various levels of the visual hierarchy.

Examination by the ophthalmologist and orthoptist: the low visual functions

The various specialists at Royal Dutch Visio each examine specific elements of hierarchy. The most important examiners in the diagnostic process are the ophthalmologist, the orthoptist and the behavioural scientist. The ophthalmologist and the orthoptist usually conduct all or part of the so-called **visual functions assessment** (which assess only the low visual functions) and the **ophthalmic examination**. They have more time for this than regular ophthalmologists and orthoptists. These examinations usually take one hour, in which there is time to assess several low visual functions in different ways. If needed, there is enough time to measure the lesser commonly assessed functions as well. The results are discussed in detail with the behavioural scientist and, if necessary, the **optometrist**. When, in consultation with these two specialists, it is clear what further diagnostic steps need to be taken, the next possible steps will be discussed with the client and/or the parents/ caregivers. If necessary, the optometrist will do further assessment to identify the best suitable aids, such as special glasses or a magnifying device.

The behavioural scientist

When CVI is suspected, assessment of the high visual functions and all other possible factors in the hierarchy is nearly always necessary. This assessment is carried out by the behavioural scientist, usually a **neuropsychologist** or **remedial educationalist** who has been specially trained within Royal Dutch Visio. The behavioural scientist conducts three different assessments: a cognitive **capacity assessment**, a **psychological assessment** and a **neuropsychological assessment**. Usually, these assessments are conducted during two sessions of roughly three hours each. That way there is plenty of time to make the client – usually a child who may be quite

tense – feel at ease, to allow for short breaks and enough time to relax, and to talk with parents/ caregivers, who can witness the assessment, usually from a different room.

The cognitive capacity assessment

The behavioural scientist normally starts with a cognitive capacity assessment, usually consisting of an intelligence test. We use the term "cognitive capacity assessment" since it is not intended to capture the cognitive qualities of the client in an IQ score. The behavioural scientist especially tries to identify the client's strengths and weaknesses and the impact of any visual disorders on task performance. The performance on various visual tasks leads to hypotheses about factors that affect the performance. The way the test scores come about is at least as important as the scores themselves.

CVI and the interpretation of scores on intelligence tests

An intelligence test usually consists of a minimum of four and a maximum of fifteen tasks. These include both visual and verbal tasks. Some visual tasks require not just visual processing but also motor actions or deeper analysis, such as solving a puzzle or copying a block pattern. These are called **performance tasks**. Verbal tasks are aimed at assessing knowledge, language comprehension and the ability to explain.
It is to be expected that someone with one of the forms of CVI would not do as well on (some of the) visual and performance tasks. Which tasks that person finds difficult, heavily depends on the quality of his or her visual functions. And of course of their attentional functions, their level of insecurity, their ability to compensate, insight in their own abilities, etc. In short, all factors and functions in the visual hierarchy have impact.
Verbal and motor functions also contribute to the specific scores on an intelligence test.
By observing the client working on different tasks, we see a reflection of the limitations and restrictions that may arise in the person's daily life. This leads to several hypotheses about which of the factors and functions in the hierarchy may play a role.

Information about motivation, emotions and needs

Performance and test behaviour provide direct information about the motivations, emotions and needs of the individual when carrying out various tasks. They reveal to what extent the person feels comfortable with a particular task. If the person feels uncomfortable with the task, he or she is likely to behave differently, especially in the case of children. Some tend to withdraw, while others start talking a lot or use tricks to try to avoid the task. Others may act silly or become rebellious, or may put in extra effort. Tasks types in which the child feels comfortable and empowered give direct information about the type of activities that help motivate the child in an intervention situation.

The role of alertness and of attention and executive functions

Alertness and the attention and executive functions also play a role in the execution of all kinds of tasks. The questions that behavioural scientists ask themselves with each task include: How alert is the person? How task-oriented is he or she? Is he or she easily distracted, and if so, why? How does the person approach difficult tasks? Does he or she look in a systematic way? Does he or she pick up on hints? All of this is important information to be able to interpret intelligence test performances correctly, and also of added value for school. Besides this, it leads to direct hypotheses for the neuropsychological assessment.

The role of functions that are not included in the hierarchy

Motor skills do not determine how well a person can see and are therefore not included in the visual hierarchy. They obviously do contribute, however, to the execution of visual tasks that involve motor actions. It is therefore important that the quality of a person's motor skills is taken into account. This calls for close observation during the assessment of the persons cognitive abilities. Before starting with any type of intervention, further physiotherapy assessments may be needed.

Verbal functions can play an important role in compensating visual problems. The verbal elements of intelligence tests can give a good impression of the various verbal skills of a child, but sometimes a more specific linguistic assessment is needed. Strong verbal skills can be a disadvantage too. If you are a smooth and easy talker that understands verbal information quickly, people expect that you are good with visual information as well. They may overestimate you and make unrealistic demands, leading to insecurity and fear of failure.

Improper use of intelligence test scores

Intelligence tests are only beneficial when used in a responsible way. It is not a perfect device magically showing a person's abilities. The scores on intelligence tests are a result of a person's physical, cognitive and emotional functions combined and as such reflect the problems in daily life. They cannot be used as a direct cause of the problems. The causes are to be found at the level that ICF and the visual hierarchy direct us to: the level of our cognitive and physical functions, our emotions, motivations and needs, and personal and environmental factors. These are the building blocks on which human functioning is founded and that explain our limitations and restrictions. The capacity assessment, for most behavioural scientists, functions mostly as a step-up to the assessments that aim directly at these building blocks.

The psychological assessment

The psychological assessment is intended to discover the personal and environmental factors that play a role in the motivations, emotions and needs of the client. This assessment is conducted

by means of questionnaires that are completed by parents, caregivers and/or a teacher. From the age of twelve, clients may complete these questionnaires themselves as well. In this assessment we actively try to identify protective factors.

The neuropsychological assessment

Lastly, the behavioural scientist conducts a neuropsychological assessment. This assesses in particular the quality of the high visual functions and of the executive and attentional functions. In addition, we actively seek alternative explanations for the problems. Protective factors are actively looked for as well.

Neuropsychological assessment up to the age of six

Until the age of two-and-a-half, we can only get an idea of the quality of the various high and cognitive functions through observation. During this observation we can experiment with how the child responds to various materials that are offered. Keeping the visual hierarchy in mind, we can get an idea of the quality of the various factors and functions through observation. In addition, observation charts are available by means of which the levels of various types of skills can be listed. When visual skills lag behind compared to other skills, this could be an indicator for CVI.

As from roughly the age of four, limited neuropsychological assessment is possible. Using the visual components of intelligence tests and several visual perception tests, we can get an indication of a child's visual skills, but we cannot make any firm statements regarding the quality of the high functions yet. For reliable and neuropsychological assessment aimed at functions, a child must have developed a certain task-oriented attitude. The older the child, the greater the predictive value of the assessment results.

Neuropsychological assessment from the age of six

From the age of six, the neuropsychological assessment is directed at measuring the high visual functions. This is generally done with tests conducted at a table. When interpreting the test scores, the visual hierarchy is of utmost importance. For all of these tests, a certain degree of alertness and motivation is necessary, for some tests more than for others.

Tests may also involve (visuo) motor processing and/or executive functions or may require verbal responses. In tests of the visuospatial perceptual functions, the quality of the low visual functions and visual selective attentional functions always have a role. As a result, the scores on these tests do not mean much on their own. The way the scores come about is equally important.

In addition to using tests to measure high visual functions, we also use tests to assess executive and attentive functions. Unfortunately, many of these tests are of a visual nature. In interpreting the results of these tests, observation is particularly important. Fortunately, there are also aural tests to measure attention functions and

questionnaires to get an idea of the quality of a child's various executive skills.

The behavioural assessment report

The results of the cognitive capacity assessment, of the psychological and neuropsychological assessments are generally combined in an integrated behavioural assessment report.
This report briefly describes the entire diagnostic process and presents the outcome of the three individual assessments. Usually, it starts with a description of observations and interview data.
The sequence of the description of the test results reflects that of the visual hierarchy.
The description of each factor and function ends with a conclusion about the quality of that particular factor or function. The observations are used to interpret the test scores. The descriptions lead to an overall conclusion, which solves the diagnostic puzzle forming a complete picture of problems and their causes, by explaining the problems at the level of functions.
The behavioural scientist, the orthoptist and the ophthalmologist contribute to the solving of the puzzle through mutual consultation.
If CVI is diagnosed, a clear description is given of what types of impairment are involved and how they relate to the problems in daily life.
Any additional and or alternative explanations are discussed, as well as the protective factors.
Lastly, personal practical tips are provided, as well as recommendations regarding the next steps in the follow-up process, both within and outside of Royal Dutch Visio, are given.

Assessment outcome consultation

When the report is completed, it is discussed with the parents/caregivers and/or the client personally, depending on his or her age. The purpose of this consultation is to ensure that both client and parents/caregivers understand the contents of the report to the best of their abilities and to give them the opportunity to respond and ask questions. The recommendations are discussed and arrangements for the follow-up process are made. Interventions must also be decided. There are different types of interventions: treatment/training, guidance and CVI education.
Generally, the report is handed over at the end of the consultation, as it belongs to the client and the parents/ caregivers. They decide who, besides Royal Dutch Visio, is allowed access to the report.

Practical recommendations

In this phase the practical recommendations are still rather general. The assessment setting obviously differs from the client's everyday life. During the assessments there are no books or laptops, nor is there a teacher, let alone an entire class. Restrictions in mobility are hardly solved by means of desktop tasks. Not until after occupational therapists and development support workers do their own assessments, the general recommendations become customized.

Therapists and counsellors

There are different types of therapists and counsellors, each with their own role and expertise. Some therapists and counsellors

provide long-term counselling, such as the **child development specialist** and the **itinerant teacher**. As they counsel the children for extended periods of time and are in regular contact with the parents/caregivers, they also have a close monitoring role.

The child development specialist

The child development specialist is involved with young children and their parents/caregivers, from infancy to the age of six. They support the parents/caregivers in the child's development through giving advice and providing coaching/ training. The child development specialist tries to stimulate the child's visual development by connecting with the interests and the potential of the child. Initially, the child development specialist will, together with the itinerant teacher, be involved at school with the development of the child, advising teachers and other counselling personnel.

The itinerant teacher

During the transition from kindergarten to first grade, when the educational process takes on a less playful and more structured format, itinerant teachers come into the picture more and more often. Itinerant teachers have an overall knowledge of the educational system in general and of the specific regional school situation in particular. They know the benefits and drawbacks of the various teaching methods in relation to visual disorders, including different types of CVI, and are familiar with tools that could make things a lot easier for children with CVI, such as magnifying devices, rulers, exercise books with different lining, books with large print or other adaptation devices, ICT applications and adaptations, and audio books. They also give recommendations regarding adjustments of the materials used, the classroom situation and the child's workspace in the classroom. Finally, they provide coaching and training about CVI to school representatives and address the child's social and emotional development as well as the effects of CVI in that regard. The itinerant teacher visits at appointed times during the school year and have the possibility to visit the child more often, should he or she need it. The visits usually vary from two to seven times per school year. The itinerant teacher is involved with the child for an extended period, if necessary, during the child's entire school career.

Assessment and treatment by therapists

Occupational therapists provide short-term treatment. To be able to translate assessment conclusions into effective treatment, these therapists must also conduct assessments themselves. They do this there where the restrictions and limitations occur and/or using the materials involved. Following this, the occupational therapist makes a rehabilitation plan.
This includes a description of the restrictions and limitations to work on, how this will be done, and how much time will be needed.
Some occupational therapists are specialised in specific types of problems. Some focus on

improvement of educational skills, using methods that teach children to look, think and act more systematically. For example, they help children who are verbally strong to apply their verbal skills to get more of a grip on visual information. Other therapists are specialised in **mobility training**, which involves teaching individuals specific routes on how to get from A to B and learning to deal with traffic situations. There is, for example, a specific programme called AutO-Mobility that assesses whether a drivers licence would be safe and achievable. Lastly, there are **ICT trainers**, specialised in teaching computer, tablet, laptop, and smartphone skills.

Group training sessions

Aside from the individual training sessions, there are also group sessions for children with CVI and their parents/caregivers. These include rehabilitation groups for children with CVI of different ages that focus on self-confidence, social skills and peer contacts. In some regions there is a course offered for parents and caregivers of children with CVI called: "Understanding CVI". This consists of two evening sessions that address CVI and focuses on peer contact. In some regions, summer camps are organised for children with CVI and other forms of visual impairment.

The healthcare psychologist

For clients with CVI who have suffered social and emotional damage, there is the healthcare psychologist. This psychologist conducts meetings with the parents, caregivers and/or the child. Together they look for opportunities within the family setting to let the child grow emotionally, to boost or regain self-confidence and to reduce fear of failure. If the issues involved are serious and call for a long and intensive course of action, the healthcare psychologist usually refers the child to another healthcare institution.

CVI in the picture

At Royal Dutch Visio we work hard to ensure that people with CVI get the best possible support. There are cooperative efforts with universities and with institutions similar to Royal Dutch Visio. This book is online available for each and every one. We also invite you to watch the film "CVI in the picture" available online. As of 2019 the interactive experience workshop of the "CVI in the picture" project is being used in training sessions regarding CVI. For those close to a person with CVI, experiencing what it must be like to have CVI, might well be the best eye opener.

What have I read in this chapter?

- To collect and classify all data about a client, Royal Dutch Visio uses ICF, the international classification system of the World Health Organization for functioning, disability and health.
- This system identifies nine life areas in which limitations and restrictions may occur.
- ICF serves as the foundation for the diagnostic

process. This involves identifying all functions and factors that cause and sustain limitations and restrictions, as well as those that may reduce these limitations and restrictions.

- Only after the diagnostic puzzle is completed, we can carry out effective and efficient interventions in an effort to reduce the problems.
- The ophthalmologist and orthoptists focus on the eyes and the low visual functions.
- The behavioural scientist carries out three different assessments: a cognitive capacity assessment, a psychological assessment and a neuropsychological assessment.
- The cognitive capacity assessment usually consists of an intelligence test. It gives an indication of the strengths and weaknesses of the person and yields additional ideas or hypotheses about where the problems in daily life may originate.
- The psychological assessment is directed at the mental state and the social and emotional development of the child.
- The psychological assessment thus establishes the link between ICF and the motivations, emotions and needs from the visual hierarchy.
- The neuropsychological assessment aims at the high visual functions and the cognitive preconditions for seeing, specifically the attention and executive functions.
- The behavioural assessment report interlinks the outcomes of individual assessments.
- This report is discussed in detail with the child and/or parents/caregivers. It culminates advice about the follow-up processes and general practical interventions.
- These general recommendations are customised by the therapists and counsellors who work with the client.
- Long-term counselling is provided by development support workers and itinerant teachers.
- The training sessions given by the occupational therapist focuses on any aspect of everyday life and is usually extended over shorter periods of time. Occupational therapists teach the client to compensate, to look, think and act more systematically and/or to perform tasks in a more adequate way.
- There are group rehabilitation sessions for children with CVI, aimed at social skills and self-confidence.
- Group rehabilitation sessions about CVI are also available for parents and caregivers.
- For psychological issues related to CVI or visual impairment in general, it is possible to get counselling from a healthcare psychologist.

Summary

If you don't have the time to read this entire book, or if you feel the need for an overview of the most important information upon reading the book, then this summary is for you. The film "CVI in the picture", easily available for viewing online, offers a more concise overview. For further explanation and in-depth knowledge, for illustrations providing more insight and for recommendations, we refer you to the individual chapters.

What is CVI?

Seeing involves more than just the eyes.
The brain processes the visual information and provides the prerequisites for seeing: being rested and alert, motivation, and attention for the visual information. Without these conditions you do not see consciously. What you see depends on how well you can direct your eyes and pay attention to the object you want to see. How well you understand what you see depends on the quality of your visual image, how well your brain understands the visual information, how well it stores that information, and how well you can think in images. An additional component of seeing is that you use what you see to perform an action quickly and accurately. In the case of CVI, something goes wrong in one or more of these steps.

If your brain does not process the visual information properly, so that you experience limitations and/or restrictions in daily life, you have CVI. CVI is the abbreviation for cerebral visual impairment. It is the collective name for all forms of visual impairment that can occur as a result of damage to or abnormal development of parts of the brain. If you do not see well, you will easily feel restricted, and that in turn leads to poor performance in all sorts of areas: at school, in traffic situations, in establishing social contact or while playing with friends.

CVI is not very well-known. Nonetheless, it is the most common form of visual impairment in children. Unfortunately for many people it takes a lot of time and effort before it becomes apparent that CVI is involved. The problems experienced are often confused with attention and/or motor disorders, or simply attributed to stubbornness or rebellious behaviour. What hinders the recognition of CVI even more, is that relatively many people with CVI suffer, aside from visual disorders, from disorders in attention or motor functions.

The limitations and restrictions caused by CVI often arise during the early years of life. At what age CVI becomes noticeable depends on the type and seriousness of the disorder, but also on the extent to which the people in the child's surroundings are alert to possible indications. In the case of more subtle disorders, the restrictions do not manifest until the child is in elementary school. Since CVI is not commonly known, some children do not find the way to the right care institution until adolescence.

Although CVI starts in a child's early years, it is not a children's condition. CVI does not go away.

It usually arises as a result of abnormal development of particular parts of the brain, but it can also be caused by non-congenital brain damage. Since a child's brain is constantly developing, the outcome of brain damage in children is not as predictable as with adults. But the functions and factors that determine how well someone sees are the same for everyone. This book describes these functions and factors and their mutual relationships. It teaches us how we can understand the limitations and restrictions in daily life, and how we can ultimately reduce these.

Prerequisites for the processing of visual information

The processing of visual information is dependent on very general preconditions. Before we can understand how the brain enables us to see properly, we must first have some knowledge of how the brain functions operate and of the role that the **senses** play in human functioning.

The brain processes visual information in a number of steps. The first step is ensuring that you see anything at all. The brain does this by directing **attention** to the information that the eyes then send to the back of the brain. Only then do you become aware of the visual information, and you see. Maybe you have the feeling that you always see consciously when your eyes are open, but in truth that is not always the case.

We do not need our visual sense to the same extent at all times. Suppose you have an important phone conversation. Your eyes are open and probably move around, but you are actually not looking consciously. The visual information does not enter your conscious mind. That is because – during the call - your attention is mainly focused on your sense of hearing (on what the person at the other end of the line is saying), on your thoughts on the subject and on your own contributions to the conversation. When you are on the phone, your purpose is listening and talking. As a result, you pay very little attention to what there is to see.

Your visual sense is merely an instrument that you use to reach your goals. There are all sorts of information sources that we can switch on, as it were, or select with our attention. As such, there are the senses, which give information about the outside world: sight, sound, touch, smell and taste. Also, your brain contains information, lots of it, but you only become aware of it when you give it your attention. How do you feel? What did you eat last night? What is the capital city of Greece? Not until you pay attention to this information do you become conscious of it. Only then does the information enter your thoughts enabling you to use it.

The trick is to select only the information that fits your goal at that specific moment. In some cases, your visual sense is very handy or even necessary to reach that goal: when you are in busy traffic, when you learn to read, when you look for your car keys. At moments like that it is necessary to

select your visual sense by using your attention.

But what if you are tired or ill, or if you have slept poorly? Seeing clearly is then much more difficult since you are less **alert**. That is because your level of alertness directly determines the amount of attention you have at your disposal. When you are ill or tired even the simplest of activities, like getting up or rolling over to your other side, require effort. Also, your goals and **motivations** change. If you do not feel well, you will not be motivated to solve a math problem, or to look for your car keys in a crowded room.

Since attention depends on alertness and motivation, these are conditions for seeing well. What you are motivated for depends on your **needs** and **emotions**. When you are riding your bicycle in busy traffic, you will be motivated to have your eyes wide open because you want to stay alive. When you need to solve a visuospatial math problem for homework and you suddenly hear your favourite song on the radio, you might not be so motivated anymore for a thorough visual analysis of visuospatial properties and you allow your attention to drift away to the song. You'll be staring at that math exercise, but the information will not reach your mind.

The battle of the attention systems

We all have an attention system that we can steer the way we want: the **endogenous attention system**. Even when motivated to look, it may be that the visual information does not get through to you. Some people are simply distracted more easily than others. There is always a battle going on between how you want to employ your attention and the disruptive influence of distracting stimuli. These distracting stimuli make use of a different attention system, the so-called **exogenous attention system**. The two systems complement each other. Some stimuli are so intense and/or unexpected and potentially threatening that they pull your attention away (exogenously) from what you meant to do (endogenously). For example, a loud noise that startles you from your homework. Or suppose you place your hand on a hot stove. Sometimes this type of stimuli will change your goal completely (e.g. looking to see where the noise comes from). When a stimulus coming from your exogenous system does not contribute to what you want to do at that moment, then you want to be able to suppress it. You need to be able to quickly regain control over your attention. Otherwise, you won't be able to achieve the goals you have set for yourself (such as doing your homework).

The functions whereby you endogenously gain control over your attention and thus over your thoughts and actions, we call **executive functions**. By having strong control over your attention, you can make efficient use of all the information sources. The quality of your executive functions determines whether and how well you can use your visual sense when you want.

The prerequisites for seeing

In short, there are certain preconditions that allow us to be able to see at all, and to use our visual sense the way we want to.

From top to bottom:

- *Being rested* and *alert* determines how awake you are and the level of attention that you have at your disposal.
- *Motivation*, based on your emotions and needs, determines your goal at that particular moment.
- *Executive functions*: the control over your attention determines to what extent you are able to achieve that goal, specifically by selecting the right information sources at the right time, one of which is your visual sense.
- *Attention determines* to what extent you experience visual information consciously.

For people who have CVI, these conditions often play an important role in how well they see. Due to their problems with sight, people with CVI generally tire faster. Seeing simply takes up a lot of their energy, whereas they are expected to perform as well as everybody else. Due to their fatigue, they are less alert and therefore have less attention to give to visual information. This fatigue also diminishes their motivation to try to see to the best of their abilities.

There are also other reasons why many people with CVI are less motivated for visual tasks. Many have developed a **fear of failure**. They have experienced repetitive failure when carrying out visual tasks. An important factor in the origin of fear of failure is the reaction of others, as people often do not understand why the person fails. As a result, disappointing performance is blamed on slacking, whereas the person actually did his or her very best. When this is not sufficient and the person repetitively fails despite the extra effort, then something gives. A child will become insecure and feel misunderstood by those around him or her. These experiences hurt so much. The child will want to avoid this pain at all cost and as a result be less motivated to carry out visual tasks.

Unfortunately, quite a few people with CVI not only have visual disorders but also problems with their executive and attentive functions. As we are dealing with brain damage or abnormal brain development, the functional effects are usually not confined to only one function.

Visual functions

There are two types of visual functions: **low and high visual functions**. The low functions pertain to the quality of the visual field and of the eye movements. The **sensory functions** determine the quality of the visual field, while the **oculomotor functions** determine the quality of the movements of the eyes.
The low functions are usually thought to relate to the eyes, but in all low functions the brain is also involved. This becomes clear when you realise that the visual field, your conscious visual image of the outside world, lies not in the eyes but in

the brain, at the back of the head. The quality of this image, the **visual field**, is determined by the sensory functions. Not just the eyes, but also all areas and pathways from the eyes to the back of the head, determine the quality of the visual field. The most important sensory functions are **visual acuity**, the size and shape of the visual field, contrast perception, **colour perception** and the **adaptive functions** (how fast these functions adjust to changes from light to dark and vice versa). The visual field preferably gives **binocular depth** information about the central part of the visual field, providing additional information about where an object is at in the space nearby.

The brain also plays an important role in the oculomotor functions. The eyes do not move on their own. The brain directs the movements of the eye, the eye muscles carry them out. The most important oculomotor functions in relation to CVI are the **saccades** (quick, goal-directed eye movements), the smooth pursuit eye movements, and the converging and diverging movements of the eyes towards and away from each other. There are also movements inside the eye that are directed by the brain: the rounding of the lens and the enlarging and contracting of the pupil.

Since the brain plays such a key role in the quality of all low visual functions, you may have CVI as a result of a disorder in the low visual functions. We speak of a functional disorder if its quality deviates so far from what is normal, that it directly causes limitations and/or restrictions in daily life. It may also be that there are no functional disorders but that some functions are of somewhat lesser quality, together causing major visual problems in daily life. When this is the case, you are also considered to be visually impaired.

The high visual functions

The low visual functions have been known and well understood since quite some time and are described in detail in the literature. This is not the case with the high visual functions. These functions further process the information within the visual image. All high visual functions are carried out by the brain. CVI particularly includes disorders in the high visual functions. The high functions that are relevant for CVI have only become understood in the past fifteen years. All functions that play a role in vision – the prerequisites for seeing, the low visual functions and the high visual functions – as well as how they work in combination with each other, are now known at last. This has led to the **visual hierarchy**. The hierarchy can be found on *page 144* of this book. We will discuss the high visual functions in sequence.

Visual selective attention

Only by giving attention to our visual sense, do we see. But within the visual field there is usually much more to see than we can process at once. We must therefore make a selection *within* the visual field as well. We become consciously aware only of the visual information that we select, and only then does it enter our thoughts. We can then

reflect on the visual information and use it to reach our goals.

The selection within the visual field is done by means of the **visual selective attentional functions**. These functions represent the first category of the high visual functions.
This category is of major importance, as most people with CVI have a disorder in one or more of these functions.

The selection of visual information involves two steps. The first step is directing the eyes to what you want to see. Where you focus your eyes, is where the visual image is sharpest. But how do you get your eyes where you want them? You can steer your eyes through your visual image, exactly the way you want to. Give it a try: steer your eyes all the way to the left. By doing so, you follow the levels of the visual hierarchy, from the top down. You are alert enough, you are motivated, and you have so much executive control that you succeed in moving your eyes and your attention in that one specific direction.

When directing your eyes, however, stimuli in the outside world play a role as well. Sometimes the visual image will contain a very prominent piece of visual information that automatically attracts your attention by way of your exogenous attention system. Take, for example, a lamp that suddenly turns on in a dark room. Your eyes and attention will automatically move towards the lamp. Or take a black horsefly on a white wall. In this kind of situation, the outside world distracts you from what you really want to look at or do.

These exogenous attention processes can also help you find what you are looking for. Suppose you are searching for your car keys and suspect that they are somewhere on the kitchen table. In this case, it is quite practical that dark-coloured objects on a light-coloured surface attract your attention. Your eyes will be drawn towards noticeable objects on the table, and not towards the empty parts.

The exogenous attention system works best in the periphery of the visual field. The endogenous attention system, on the other hand, operates especially in the central part of the visual field, where you see sharpest.

Global and local visual selective attention

Following the movement of the eyes, the brain performs a second step in the selection of visual information within the visual field. Even though your eyes are always directed at a single point (assuming that they cooperate properly), you normally see more than just that one point, but usually not everything in the visual field. What do you actually see? That depends on what you do with your attention. You can focus your full **visual attention** on the one point that your eyes are directed at. In that case you only fully consciously see that one point. But usually, we don't focus our attention on a single small location. Instead,

we distribute our visual attention over an entire object or part of it. Or over various objects all at the same time, so that we have overview of different objects.

In short, we can make the area that we pay attention to larger or smaller. Selecting a larger area of the visual field is called **global visual selective attention**: we spread out our visual attention so that have a better overview of the elements or objects without seeing them in detail. If we do want to view elements or smaller objects in detail, we need to focus our visual attention. This is referred to as **local visual selective attention**.

Using global and local visual selective attention, we can see different things without having to move our eyes. What you see depends on what you select to see. What you select depends on your goals and motivations. Suppose you are in busy traffic. To gain overview of the situation, you distribute your attention over, for example, the car in front of you, the cyclist to the right, the car coming from the opposite direction, and the side street on the right. You are able to do so by using your global visual selective attention. With global visual selective attention, you don't need to make any eye movements to still see everything globally. But you don't see details, not even the detail that your eyes are directed at in that very moment. Maybe you have your eyes directed at the letter "K" on the licence plate of the car in front, but if your brain has spread out your attention too much, you don't see that "K" consciously at all. Not until you focus your attention on the "K" with your local visual selective attention does it enter your thoughts, and you see it consciously.

Normally speaking, we look on the basis of overview. By expanding our visual attention globally, we get a general impression of what there is to see. Next, we move our eyes to what we want to look at more closely and zoom in with local visual selective attention. If any of these visual attention processes is disrupted, this has major consequences for your visual functioning.

A disorder in global visual selective attention

In case of a global visual selective attention disorder, you cannot distribute your attention over a larger part of the visual field or over the various details. As a result, you constantly select small pieces of visual information. You only see details. To still get an overview of the details, you need to try to link them together in your mind. Orienting yourself, whether outside or in a large building, becomes difficult, time-consuming and tiring. Traffic situations are outright dangerous. Also, when searching, you first need an overview of what there is to see. During sporting activities, are you able to assess the movements of the ball or of your fellow players without an overview of the playing field?

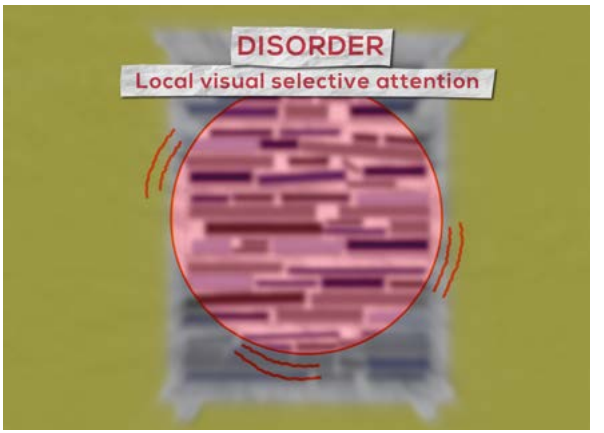
There are various types of disorders in global visual selective attention. Some people do not have a good overview of large parts of the visual field. Others experience general difficulties overseeing details, regardless of the size of these details. People who have this form of CVI are likely to experience difficulties in learning to read. They read letter by letter since they are unable to see the letters together as words. Even learning individual letters, which each consist of smaller details, can take longer. Understanding and developing a sense for quantities, and thus mathematical development, can also lag behind in this type of CVI. Counting is difficult too when you lack overview of the objects to be counted. All this is quite inconvenient, because in elementary school you are assessed particularly on your ability in reading, writing and arithmetic (the three Rs).

In people with a disorder in the global visual selective attention, we often see a delay in the development of the understanding of geometrical forms and problems in understanding topographic maps and graphs, due to the lack of overview. In many cases, the social development is also affected. Consider, for example, that the recognition of faces and facial expressions is hampered by the excessive focus on details. Social clues between people are easily missed as well. As a result of the focus on details and the social problems resulting from a disorder in global visual selective attention, autism is sometimes incorrectly inferred. Thorough assessment is needed to reach a proper diagnosis. If the focus on details is strictly visual, the problem is usually CVI instead of autism.

A disorder in local visual selective attention

People with a disorder in local visual selective attention are unable to focus their visual attention on details. As a result, they see more than they would like and thus experience visual chaos. They experience problems with finding and seeing specific details, especially when these are surrounded by other visual details. Disorders in the local visual selective attention vary in nature. Some people with this disorder are unable to select a small part of the visual field, or they find this very difficult. Others are able to do this, but find it increasingly difficult to zoom in on the details when tired.

Individuals with a disorder in local visual selective attention experience problems in visually chaotic



situations, such as crowded shopping centres, busy traffic and parties. Pages filled with text and pictures are also a disaster for them. Since they do not see the separate details but a vague visual blur instead, they are often inclined to reduce their viewing distance. The closer you get to the paper, the bigger the details, making selection therefore easier. In grades two to five, the print size in textbooks gets smaller making reading, writing and math tiring and frustrating activities. Since reading and writing are the basis for subjects, such as biology and history, these too become increasingly difficult.

Some individuals have a disorder in both global and local visual selective attention. These people lack overview and in addition often do not know the details they lack overview of. People with a visual selective attention disorder are always lag behind. They are regarded as being slow and clumsy, causing them to experience problems in social settings as well.

Visual perceptual functions

The fact *that* you see something does not automatically imply that you *understand* what you see. To be able to understand what we see, we need visual perception functions. There are two types of visual perception functions: **identification functions** and **visuospatial perceptual functions**.

CVI rarely involves disorders in the identification functions. That does not mean that someone with CVI cannot experience problems with identifying or recognising what is seen. Should this occur, the cause practically always lies in one or more of the functions that we have previously discussed: the visual functions that precede the visual perceptual functions. If a person with CVI is able to capture an object with their attention, and there is sufficient light and the image is sharp enough, then the person will usually experience no difficulty in recognising the object.

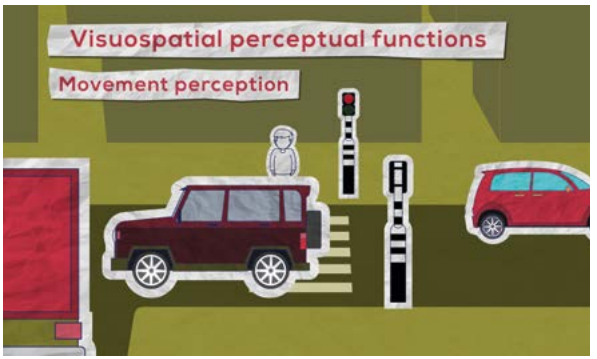
Disorders in visuospatial perceptual functions do, however, regularly occur in people with CVI. They experience problems with one or more of the following visuospatial perceptual functions:

1. **Location perception:** understanding where objects are in relation to each other.
2. **Orientation perception:** understanding how objects are oriented.
3. **Movement perception:** seeing whether an object moves and, if so, understanding how fast it moves and in which direction.

People with a global visual selective attention disorder also have more difficulty understanding the visual space. After all, overview of spatial characteristics is essential in order to understand them. As a result of poor overview, their visuo-spatial perceptual functions will also not develop properly. There are also people, however, without any disorder in their global visual selective attention, who have considerable problems estimating spatial properties. They have a disorder in one or more visuospatial perceptual functions.

The basic properties of visual space, regardless of whether this pertains to the surroundings or visuospatial figures, are location and orientation. If you know where all things are and how they are oriented in relation to each other, then you know all spatial properties of the environment. The important locations in a spatial environment, for example in the town where you live, are called **landmarks**. If you know where these landmarks are in relation to each other as well as the directions in which the connecting roads run, then you know your surroundings. The same applies for visuospatial figures. The vertices of a triangle you can call the landmarks and the sides of the triangle are the connecting roads. Individual letters are just like small visual spatial figures that differ from each other in terms of the location and orientation of the key elements.

A disorder in location or orientation perception inevitably leads to limitations and restrictions in spatial orientation. Also, learning visuospatial figures, such as shapes and letters, will be difficult. In daily life this leads to getting lost and falling behind in academic skills.



Although part of our visuospatial insight comes to us without much effort, it takes careful analysis and devising strategies when it comes to more subtle spatial assessments. In that case visuospatial perception calls for more than just visuospatial functions. It requires alertness, motivation, attention and executive effort, but also knowledge in terms of centimetres, metres, kilometres and degrees.

Visuospatial perception does not become any easier when objects start to move. Location and orientation also constitute the basis for the concept of movement. When parts of the environment (or figure) move, they change location. The faster their location changes, the faster they move. The movement direction is determined by the orientation of the movement that they make. Although movement perception functions are based on location and orientation, they can occur regardless of disorders in location or orientation perception. Disorders in the perception of movement cause problems in particular in sports and in traffic situations.

Visual memory

The things that you perceive you can store in different types of memory. Visual information is stored in various types of visual memory. In CVI we seldom, if ever, see disorders in the visual memory functions themselves. If you are visually

impaired however, this means that you will miss a lot of visual information that in turn does not enter into your memory. On top of all of that, the things that you actually can see you don't see as well. This immediately negatively impacts the quality of the images that you store in your memory.

Attention is a precondition for anything to enter your memory. Aside from the *amount* of attention that you give to something, the *manner* in which you employ your attention also plays a role. If you want to remember something, you need to connect it as much as possible to knowledge that you already have. Optimal storage of visual information requires that you use all of your visual functions to register what you see both globally and locally and to understand it as well as possible in visuospatial terms. Asking yourself what it looks like and formulating the visual information into words is important. In addition, use your other senses as well. All of this ensures that the information becomes anchored in various memory networks in your brain which allows you to retrieve it in various ways.

Just like perception, visual memory follows different pathways for identification and visuo-spatial information. Visual memory is directly needed for visual identification. Without stored images we cannot recognise things. Context and expectations also play an important role in identification. For example, you will recognise a dark object on a dark stairway quicker as a cat if you expect to find a cat there.

The **visuospatial memory** that we use in navigation consists of various types of memory: one for the landmarks that we have seen, one for *where* we have seen the landmarks and one for the *order* in which we have seen them. In each of these types of memory, the storage of the information involves both conscious and subconscious processes.

Visual working memory

The images that we have stored we can use for recognition, but we can also actively recall them. We use our **visual working memory** to generate and manipulate mental images. Our visual working memory is part of our **working memory**. This is an important part of our executive functions, in which we control our behaviour. The content of our working memory is the content of our thoughts. All information we pay attention to arrives here, so that we can reflect on it. Our visual working memory enables us to have visual thoughts. The active process of generating mental visual images is called **visual imagery**. It uses the images that are stored in visual memory. Mentally **manipulating visual information** involves actively combining, rotating, enlarging, reducing or whatever else you want done to the images.

Our visual working memory has a special place in the visual hierarchy (*see page 137*). It is found both at the top level of hierarchy (among the executive functions) and also at the

bottom (below all functions that we have discussed so far). What you select to see, you perceive consciously. What you have perceived may be stored, and the images you have stored can be consciously (re)constructed and manipulated by your visual working memory.

Our visual working memory is very much involved in activities such as searching, drawing, learning to write, making jigsaw puzzles, navigation and many other visual tasks. Disorders in visual working memory are relatively common. People with disorders in visual working memory experience restrictions in these activities, with possible consequences for their school progress and/or spatial orientation.

When looking for something, you need a mental image of what you are looking for. If you are looking for your green gloves, it is useful to have a picture in your mind of their exact colour. When you then scan the room for that colour, you are likely to find them quickly. An idea of their shape and knowing the size of what you are looking for also helps you to find them. When drawing a picture from memory, it is necessary to see what you want to draw in your mind's eye first. This is far from easy, even for things that you have seen often. Just try to draw the logo of the Dutch Railway by heart. The same applies for letters. Someone who is just starting to learn to write may find it quite difficult to draw an individual letter from memory. Only when the motor skill

that writing involves has taken root, so that your fingers and hand know exactly how to write the different letters of the alphabet, will "drawing" them by heart become much easier.

When navigating we employ our ability to visually imagine, update and interconnect visual information from the surroundings. This also requires the ability to imagine how things change when we turn around in visual space. When solving a jigsaw puzzle, it helps to have a mental picture of the end result, as well as being able to mentally rotate the pieces of the puzzle. In that way you can mentally see whether the pieces fit, without having to actually try them out in the puzzle.

Visuomotor processing

We want to *do* things with the things we see. In order to pick things up, to kick or catch them, or to walk through a narrow doorway, we fortunately do not need to make a detailed and conscious visuospatial analysis. For this we have **visuomotor processing**: a part of our brain is specialised in calculating quick and precise goal-directed movements. Visuomotor processing translates visual information into spatial information that our **motor processing** uses to perform goal-directed actions. All this happens without the need for any conscious spatial assessment. We only have to decide that we want to do something with what we see. The rest goes automatically. You can catch a ball effortlessly, without being aware of how you do it. You don't need to think about how you step over a doorstep. With visuomotor processing your body knows what it needs to do.

There are different types of visuomotor processing. Eye-hand coordination is one of these, but there is also eye-foot, eye-head and eye-body coordination. Disorders in visuomotor processing occur relatively often. The different disorders can occur independently. They are marked by clumsiness and by slow and/or poorly directed hand, foot, head or body movements towards objects. Disorders in eye-hand coordination are reflected, for example, in difficulty in catching things, irregular handwriting, and drawings containing poorly directed and positioned elements. Be aware, however, that clumsiness and poorly directed movements can also result from of the absence of binocular depth perception and/or motor disorders. Motor processing and visuomotor processing are difficult to separate from each other since they are interdependent in terms of their development. If one is affected, the other is also unlikely to develop properly.

Also realise that drawings with poorly positioned and directed elements do not necessarily reflect disorders in motor or visuomotor processing. Other visual and general functions can also impact a person's ability to draw, such as motivation, overview and zooming in with global and local visual selective attention, location and orientation perception.

Visual processing speed

To be able to see well and to use our visual sense in a flexible way, we need all of the functions and factors of the visual hierarchy. Interestingly, it may be that although all factors and functions are of good quality, it nonetheless takes longer for visual information to become conscious or to be understood. In that case, the visual processing speed is too slow. A person with this disorder needs more time to process and to be able to use visual information. At school this is a problem and in traffic it can be outright dangerous.

Care for people with CVI in The Netherlands

Upon registration at Royal Dutch Visio, a person's medical history is obtained and examined first. This is followed by an assessment interview focused on the limitations and restrictions that the client – usually a child – and the child's surroundings experience. There is also focus on the things that go well as these provide useful information. To ensure that no information is missed, the international classification system of the World Health Organization (**ICF**) is used. ICF gives a complete overview of one's functioning and of all the factors that may play a role therein. It identifies nine areas that chart a person's entire life. It thereby serves as the basis for the **diagnostic assessment** process, the process that involves uncovering:

- the causes of limitations and restrictions
- factors that cause the problems to persist
- factors that may play a role in reducing the problems, the so-called protective factors

Only after the picture is completed, we can start with targeted and efficient interventions in an effort to reduce the problems.

Based on the information already available and the listing of the problems experienced in daily life, we try to determine to what extent the problems are explained with the information already available. In general, there is always more information needed. An assessment programme will follow to find the missing data. Royal Dutch Visio employs various professionals, each with a specific expertise.

The **ophthalmologist** and the **orthoptist** address the eyes and the low physical functions through a **visual function assessment**. The **optometrist** looks into how the visual functions can be optimised with specific auxiliary devices. If after these first assessments limitations and restrictions remain unexplained, which is often the case with CVI, a further step is needed, involving several behavioural assessments.

The **behavioural scientist**, usually a **neuro-psychologist** or **remedial educationalist**, carries out one or more of the following assessments: a **psychological assessment**, **a capacity assessment** and/or a **neuropsychological assessment**. The psychological assessment is directed at the child's personal and environmental factors and the interactions between the two, and as such on how the child feels and on his or her social and emotional development. In this

way, this type of assessment establishes the link between ICF and the motivations, emotions and needs in the visual hierarchy. The capacity assessment usually consists of an intelligence test. This gives an indication of the child's strengths and weaknesses. The strengths give information about any protective factors, while weaker performances lead to additional ideas or **hypotheses** regarding the possible causes of the problems experienced in daily life. In all assessments it is crucial that the child feels at ease. Whatever is necessary to ensure this, is done before the assessment(s) start.

The neuropsychological assessment is an important part of the overall assessment by the behavioural scientist, especially in cases concerning CVI. It addresses the high visual functions and the cognitive prerequisites for vision, namely the attentional and executive functions. Possible alternative explanations are also tested or explored, such as dyslexia, autism or developmental coordination disorder (DCD).
For young children, the assessment tools are quite limited. Young children cannot be effectively tested due to poor task attention. Moreover, the predictive value of test results of young children is very limited.

Reliable neuropsychological testing is more or less possible for children from the age of six and up. Before the age of six we depend on close observations with the visual hierarchy in mind, on using the visual elements of intelligence test, on

general developmental assessment and on more general, non-standardized visual tasks. In that way we can come to a reasonable assessment of whether CVI is involved. From the age of six and up we use specific tests which allow us to achieve a good understanding of the quality of child's high visual functions. We are thus able to draw clear conclusions as to whether CVI is in the picture, about what functions are involved, and about the role that they play in the various limitations and restrictions. In addition, the role of attentional and executive functions is also clarified. Finally, the likelihood of potential other diagnoses is established.

A report on the various behavioural assessments brings together all the available data. The interpretation of this data follows the visual hierarchy. The conclusion is based on all of the data.
The protective factors and their possible role in reducing the problems are also highlighted.

The report is discussed at length with the client and/or the parents/caregivers. This leads to advice and recommendations concerning further treatment possibilities and also general practical advice. This advice is individualised by the therapists and counsellors who work directly with the client.

More long-term counselling is provided by **child development specialists** and **itinerant teachers**. Child development specialists supervise children until the age of six. They stimulate their development by aligning with their individual possibilities and personal characteristics. Their work involves advising the parents, caregivers, the childcare professionals and the teachers concerning school and developmental issues. Itinerant teachers supervise the children during their entire school career, they support the child and the teacher. Tips on how school supplies might be used or adjusted, specifics concerning the classroom situation, and the positioning of the child's desk in the classroom are all provided by the itinerant teacher.

Occupational therapists give short methodical training sessions that cover all possible facets of daily life and address problems and restrictions as efficiently as possible. This involves teaching the child to compensate, to look, think and act more systematically, and/or to perform tasks in a different way. There are also group training sessions directed at social skills and self-confidence, and other group sessions for parents/caregivers about CVI. For psychological issues related to CVI or visual impairment in general, it is possible to get counselling a healthcare psychologist.

Aside from these efforts for individual clients, Royal Dutch Visio works hard to help CVI become more well-known. Projects such as "CVI in the picture" and alliances with universities contribute to people with CVI getting quicker access to the care they need.

Key Words

achromatopsia – total colour blindness
adaptive functions – the low functions that determine how fast our eyes adapt to different light conditions
alertness – the degree of mental awareness
assessment interview – interview aimed at obtaining as much relevant information about a client's daily life as possible
associations – strong connections in the brain between different pieces of information, which make your thoughts automatically progress the information that you may need
attention – the process that leads to awareness of specific information
attentional functions – the building blocks of the process that leads to awareness of information
automation – a learning process in which new skills eventually no longer require conscious attention
behavioural scientist – a person with a university-level degree in human behaviour
binocular depth perception – coordination of visual information from both eyes, allowing more accurate perception of where a nearby object is in three-dimensional space
capacity assessment – assessment of a person's cognitive abilities
central visual field – the small part of the visual field where the image is sharpest
cerebral visual impairment / CVI – visual impairment caused by damage to or abnormal development of one or several parts of the brain
child development specialist – a therapist who supports children and their parents/caregivers until roughly the age of six
client file examination – examination of data that are already known about a client
colour blindness – impairment in the representation of colours in the visual field
colour perception – processes that enable us to distinguish and understand colours
comprehension and perception – functions that we use to understand what we perceive
diagnostic assessment – the process of analysing the origin(s) of problems and limitations and of factors that cause these to continue, and of identifying factors that may contribute to their minimization
direction perception – the visuospatial perceptual function that enables us to understand the direction of a moving object
disorder – an indication of the poor quality of a function
dividing/divided attention – important attentive function whereby the attention is divided over various streams or sources of information
dyslexia – a condition where reading and writing abilities are behind due to disorders in the processing of sounds and/or the connections of sounds to related characters
emotions – elementary feelings and signals

that result in a qualitatively positive or negative mental state

endogenous – from within, directed by the executive functions

endogenous attention – attention that is directed from within

environmental factors – the characteristics of the various environments of the client that play an actual or potential role in causing, prolonging or reducing problems

executive functions – the functions that allow us to have control over our thinking and behaviour and that try to direct our behaviour endogenously

exogenous – literally "from outside", not directed by executive control

exogenous attention – attention beyond our control, that interrupts or otherwise impacts our endogenous attention

eye-hand coordination – visuomotor processes that enable us to direct our hands visually

fear of failure – fear of failing caused by experiences of having failed, fed by a lack of understanding of and/or excessive demands made by persons who are important to us

fine motor skills – the ability to make well-coordinated movements, especially with fingers and hands

functions – the fundamental cognitive, physical and emotional building blocks that constitute the basis for all of our behaviour

global visual selective attention – the simultaneous selection of a large part of the visual field and/or multiple details, by expanding the visual attention

hierarchy – classification based on the order of importance

high visual functions – the visual functions which further process the information in the visual field

hypotheses – testable ideas about which factors underlie the problems and limitations experienced in daily life

ICF *International Classification of Functioning, Disability and Health* – the international classification system of the World Health Organization (WHO) for functioning and health

ICT trainer – an occupational therapist specialised in using technological applications as part of an intervention

identification functions – functions used to identify or recognise what we see

inhibition – executive suppression of reactions to stimuli

intervention – coaching, training or education aimed at minimizing the problems and limitations experienced by a client in daily life

itinerant teacher – a teacher who visits and supports visually impaired pupils at their school

landmarks – the important objects and points in a spatial environment or figure that determine its visuospatial characteristics

light-dark adaptation – adjustment to variations in lighting conditions

light sensitivity – the discomfort caused by excessive light

local visual selective attention – the selection of a smaller part of the visual field, usually directed at a single detail through the focusing of our visual attention

location perception – visuospatial perceptual function that serves to identify the location of an object or element
low visual acuity – disorder in the acuity of the visual image or the centre of the image
low visual functions – the functions that describe the quality of the visual field and the eye movements: sensory and oculomotor functions
manipulation of visual information – function of the visual working memory whereby visual information can be changed mentally
memory – the storage of information
mental rotation – a visual working memory function that allows us to rotate visual information in our mind
mobility training – training aimed at learning to move around independently
motivations – the incentives which drive our behaviour, determined by the interpretation of our needs and emotions
motor functions – the functions that determine how well movements are executed
motor processing – the totality of motor functions
movement perception – the visuospatial perceptual function that enables us to determine whether an object is moving
needs – the things we require in order to survive and, at a higher level, to lead a comfortable life
neuropsychological assessment – diagnostic assessment of general cognitive as well as high visual functions
neuropsychologist – a psychologist who is specialised in assessment of the quality of cognitive functions
nystagmus – involuntary, repetitive movements of the eyes
oculomotor functions – the functions that are responsible for the execution of movements of and within the eyes
ophthalmologist – a medical specialist in the physiology and functioning of the eyes
ophthalmic examination – examination of the physiology and functioning of the eyes
optometrist – an expert in visual aids
orientation perception – visuospatial perceptual function that enables us to understand the orientation of an object or element
orthoptist – expert in the assessment of the low visual functions
perceptual functions – functions that enable us to understand what we perceive
performance tasks – tasks that involve looking, acting and analysing
personal factors – characteristics of the client that may play a role in causing, prolonging or reducing problems
protective factors – characteristics of the client and his/her environment that may play a role in the reduction of problems
psychological assessment – assessment conducted by a behavioural scientist, aimed at identifying various personal and environmental factors
recognition – knowing what something is, because it corresponds with or is similar to something seen before
recall of memory information – active recollection of information that is stored in memory

remedial educationalist – a behavioural scientist specialised in the development of children
saccades – fast and goal-directed eye movements
selection – selecting specific information by means of attention
senses – the various channels through which our brain receives information about the outside world
sensory functions – the low functions that describe the qualities of the visual field
short-term memory – temporary storage of information for immediate use
smooth pursuit eye movements – eye movements that are used to track a moving object
sources of information – sources in our head and in the outside world that we use to achieve our goals
speed perception – visuospatial perceptual function that enables us to judge how fast something moves
sustained attention – the ability to select the same type of information for an extended period of time
thalamus (pl. thalami) – structure in the centre of the brain whereby the level of attention for the sensory systems and the distribution of attention within the sensory systems can be adjusted
V1 / primary visual cortex – the area in the back of the head where our visual field is located
verbal functions – functions that are used to understand and use language
verbalisation – putting information into words
verbal memory – collection of various memories for verbal information, both spoken and read
verbal tasks – tasks where verbal information, whether spoken or read, plays a fundamental role in understanding or presenting it
visual acuity – the low visual function that defines the acuity of the centre of the visual image
visual attention – attention for visual information
visual field – the visual representation of the outside world in the back of our head
visual functions – the fundamental visual building blocks of our visual sense
visual functions assessment – assessment of the low visual functions
visual identification functions – high visual functions that enable us to recognise and identify objects and faces
visual imagery – the ability to create mental visual images
visual impairment – the experiencing of problems and limitations in the execution of visual tasks in daily life, caused by poor quality of one or more visual and/or conditional functions
visual memory – collection of various memories for visual information
visual processing speed – the time it takes for information to enter our consciousness or to be understood
visual selection – the selection of visual information by means of attention
visual selective attention – attention whereby information is selected within the visual field
visual selective attentional functions – high visual functions that enable the selection of information within the visual field

visual sense – the totality of visual and conditional functions that enables the awareness and use of visual information
visual working memory – functional unit, part of the executive functions, that enables mental imagery and manipulation of visual images and visual thinking as such
visuomotor processing – the totality of images that makes visual information accessible for the motor system through unconscious processing, by integrating visual information with spatial physical information
visuospatial memory – memory where visuospatial information is stored
visuospatial perceptual functions – high visual functions that together enable us to understand visuospatial information
word image – the way in which words are stored in our visual memory, namely as a picture
working memory – a functional unit, part of the executive functions, in which all information that we attend to is gathered and combined, thus constituting the content of our thoughts

Appendix: Vision and the Brain

This appendix briefly discusses the functional neurological mechanisms behind the processing of visual information. We follow the visual hierarchy in this. The words printed in bold can be found in the related figures (and not in the list of key words).

The brain

Have a look at Figure 28. The brain consists of different parts. The outer layer – the cortex – consists of four areas: **the frontal, occipital, temporal** and **parietal cortices**. Each of these areas has its own function in the visual hierarchy. Below the cortex we find the **limbic system**, which plays a role in our needs and emotions, and the left and right **thalamus** (T in Figures 29 and 30), which play a key role in the attention for visual information. Below the limbic system and thalamus lies the **brain stem**. This is responsible for alertness, exact directing of eye movements and for attention within the visual field.

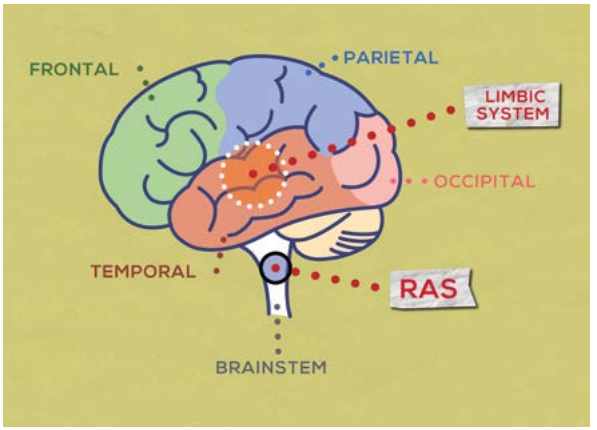


Figure 28. Side view of the brain showing parts of the cortex, the limbic system and the brain stem.

Alertness

The amount of mental alertness depends on the **reticular activation system** (**RAS**) in the brain stem. Our health and general physical condition directly impact the activation within the RAS. This system connects with all parts of the brain and determines the basic activation level of the brain.

Motivations, emotions and needs

Our motivations are based on our emotions and needs. These are formed by the **limbic system**, which consists of various nuclei, each with its own role. The limbic system yields raw, basic information which is not clear in itself: it needs to be interpreted to become meaningful. This is done particularly by the **prefrontal cortex** (**PFC** in Figure 29), the area where our executive functions are found. Context and expectations are important factors when it comes to interpreting the signals from the limbic system. The interpretations of emotions and needs, as well as their prioritisation by the prefrontal cortex, determine our long-term and short-term goals.

Executive functions and the endogenous control over our visual attention

Once goals have been established, the prefrontal cortex works to achieve these. It does this through its control over attention, with which it has access to numerous information sources. All selected information ends up in our **working memory**. This way the prefrontal cortex controls our thoughts and determines our behaviour and plans. When the prefrontal cortex decides that it needs visual information, it gives attention to the visual information that the eyes provide. As described in Chapter 4, this causes the **thalami** to let the information pass through to the **primary visual cortex**, or **V1**, in the back of the head (the **occipital cortex**). A visual representation of the outside world is located there, called the **visual field**. The **low visual functions** describe the quality of the visual field.

Exogenous control over attention and eye movements

The control of the prefrontal cortex over the attentional functions is not absolute. Unexpected, intense and potentially threatening events in the body and environment, as well as emotional alarm bells from the limbic system, can easily lead to the attention being diverted. The same applies for visual stimuli. Strong contrast, changes and movements, in particular in the periphery of the visual field, attract our attention, whether we want this to happen or not. See Figure 29. The **Parietal Eye Fields** (**PEF**) are responsible for the visual scanning of the

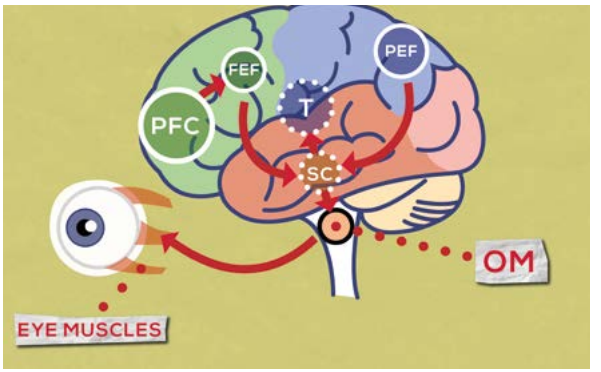


Figure 29. Side view of the brain showing the areas that are responsible for controlling our attention and the eye movements.

environment for unexpected visual stimuli. This area registers visual stimuli, even when we give no attention to our visual sense. The **superior colliculi** (**SC**), a paired structure on top of the brain stem, also receive direct information from the eyes. The SC and PEF together activate the thalamus to transmit the visual stimulus to V1, which enables further analysis (see visual selective attention and visual perceptual functions in this appendix). If the stimulus is intense and unexpected enough, the superior colliculi transmit the location of the stimulus on to the deeper areas in the brain stem, the **oculomotor nuclei** (**OM**). These control the eye muscles so that the eyes are directed at the stimulus, without the prefrontal cortex being able to influence this in any way.

Endogenous control over visual attention and eye movements

Following interpretation of the stimulus – and assuming that no other, unexpected or intense visual stimuli pop up – the prefrontal cortex once again takes control over the attention. In doing this, the prefrontal cortex also controls voluntarily directed eye movements. It sends a signal to the **Frontal Eye Fields** (**FEF**) with information about where it wants to direct the eyes to. The FEFs send a signal (via the **SC**) to the oculomotor nuclei with information regarding where exactly in the visual field the eyes must be directed to.

Global and local visual selective attention

When we pay attention to information from our visual sense and our eyes are focused on a specific spot, we first need an overview of all there is to see. We can obtain this overview by distributing our attention across a larger part of the visual field. We do this with our global visual selective attention. Usually we spread out our attention around the spot that our eyes are directed at. See Figure 30. This spreading of our attention is done by means of a network consisting of the thalamus, V1 and the ***right* temporo-parietal cortex** (**TP**). A signal from TP to the thalamus results in the selected area to being enlarged. The degree to which the attention is expanded partly depends on our goal and is therefore also partly controlled by the prefrontal cortex. However, the context and characteristics of what there is to see also determine more

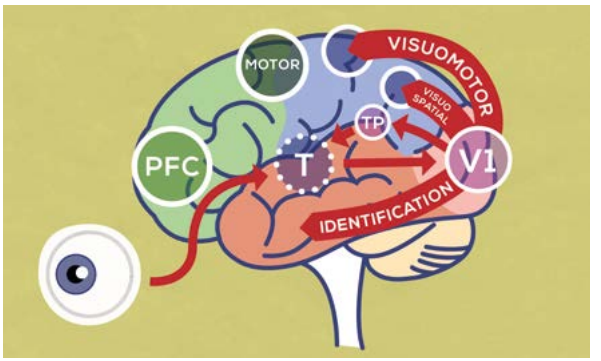


Figure 30. Side view of the brain showing the areas that are responsible for global and local visual selective attention, the perceptual functions and visuomotor processing.

exogenously, via TP, to what extent our visual attention is expanded.
Using the global impression of all there is to see, the prefrontal cortex selects a new spot to direct the eyes to and maybe zoom in on a specific detail. This process might be facilitated by striking details that exogenously attract our attention. Zooming in takes place by focusing the attention on that detail: local visual selective attention. Focusing the selected area smaller, or constricting it, is enabled by the network of thalamus, V1 and the ***left* TP**. The visual information that is selected using the visual selective attention functions is activated more strongly in V1 than the rest of the information.

Visual perceptual functions

Leaving V1, the selected information is processed in three routes. Two of these houses the percep-

tual functions, while the third route is responsible for visuomotor processing. The first route takes care of identification and recognition by connecting the incoming visual images to the stored visual images. It enters the **temporal cortex**, which contains our "picture database", our visual long-term memory. The second route relays the visual information to the **parietal cortex** for further processing of the visuospatial properties of what has been selected. From these two routes, routes also project back to V1. These connections allow the context and our expectations to influence what we see or what we think we see.
The input from our eyes and our expectations come together in V1. This image finds its way to the prefrontal cortex, which uses the image to achieve its goals and possibly carries out further analysis of the image.

Visuomotor processing

The third route, the one for visuomotor processing, projects the visual information to an area higher-up in the parietal cortex. Here the selected visual information is quickly combined with information about where the various parts of our body are located in space. There is no feedback to V1 and therefore no forwarding to the prefrontal cortex. The information is only forwarded to our **motor system** (in the frontal cortex). In that way the movements can be carried out quickly if necessary.

Visual memory

We cannot point to one single area where our visual memory is located. There are different types of visual memory, each with their own specific area. One of these is the visual long-term memory as mentioned earlier, which enables recognition and identification of objects and individuals. It is located in the temporal cortex and in the hippocampus (not shown), which is part of the limbic system. This latter structure is essential for all memory processes, including the visual.

Visual working memory

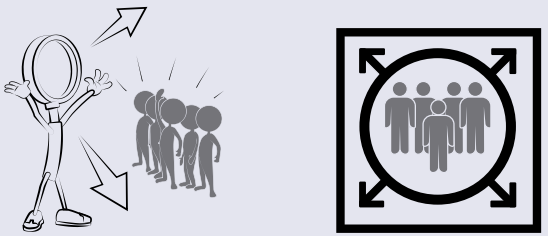
Aside from all endogenous processes mentioned earlier, the prefrontal cortex also coordinates the functions of our visual working memory. Through its control over the attentional functions, the prefrontal cortex enables us to have visual thoughts, which we can use to achieve our goals. Using our knowledge of the visual world, which is stored in visual memories and visuospatial processing areas, the prefrontal cortex can generate mental images and combine and transform these as needed.

Visual processing speed

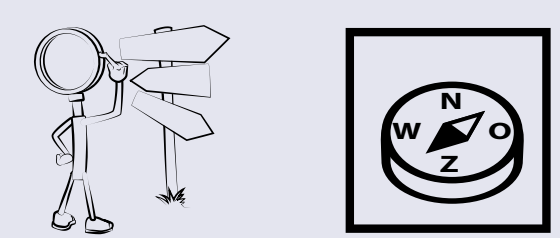
Delays can occur in all processing pathways shown.

Illustrations in the CVI passport and on the CVI key card

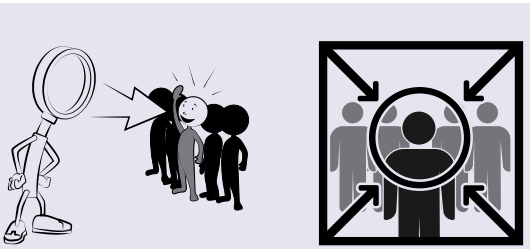
Global visual selective attention:



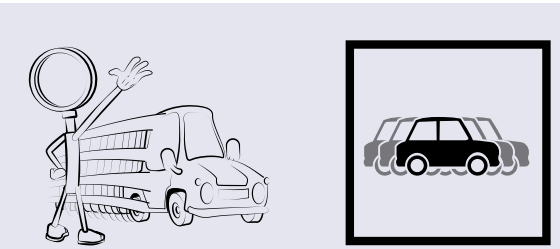
Orientation perception:



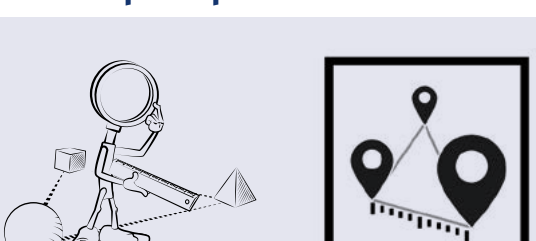
Local visual selective attention:



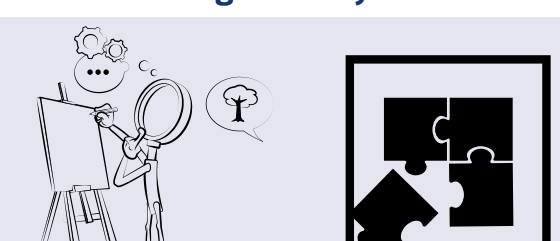
Movement perception



Location perception:



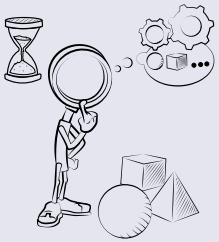
Visual working memory:

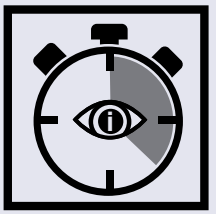


Visuomotor processing (hand):

Visuomotor processing (foot):

Visual processing speed:





About the author

Sander Zuidhoek (1972) worked in the northern office of Royal Dutch Visio from 2005 until September 2018, as a neuropsychologist for children and adolescents. As a doctor of neuropsychology, Sander is fascinated by questions such as how the brain enables us to have conscious thoughts, and how we are able to make efficient use of the enormous abundance of information in and around us.

In 2000 he graduated cum laude from the University of Utrecht. His final thesis focused on the neurocognitive basis of visual awareness and attentional processes in the periphery of the visual field. After his graduation he conducted research on haptic spatial perception.
This culminated in 2005 in his PhD dissertation "Representations of Haptic Space". An important finding of his dissertation is that mental visual processes help us to better understand the space that we experience with our haptic sense.

In 2005 Sander came in contact with Royal Dutch Visio in Haren (near the city of Groningen), where a neuropsychologist was needed to increase the understanding of CVI. His background and growing experience with the target group quickly led to a new, neuropsychological view on CVI. From 2010 to 2017 he served as chairman of the National CVI Expert Group. In 2013 the group launched their first section of Royal Dutch Visio's formal view on CVI, which currently serves as the basis of various Dutch and international projects.

The current book articulates the neuropsychological basis for the vision on CVI. It is part of the project "CVI in the picture", an initiative by Sander to raise the level of understanding of CVI.
The project also includes a film plus an interactive workshop that enables the different forms of CVI to be experienced. Sander's most recent and currently running initiative in the field of CVI is a project, to develop a neuropsychological test battery to enable improved assessment of the high visual functions.

Sander shares his knowledge about CVI through training sessions and lectures in the Post-Master Healthcare Psychology and the Post-Master Remedial Educational Therapy training programmes of the University of Groningen. In September 2018, after a brief period as education coordinator and senior lecturer in Diagnostics in the Psychology Master's degree programme at the University of Tilburg, Sander took on a new challenge as neuropsychologist in the Northern Autism Team of Lentis|Jonx.

A word of thanks

Writing a book is not a one-man job. The content of this book is based on a particular view on CVI. I developed this view by building upon what already existed, and by testing my ideas by discussing them with others.

In 2005, when I started at Royal Dutch Visio in Haren, the existing knowledge about CVI was predominantly the result of the efforts of remedial educationalist and healthcare psychologist Paul Looijestijn. With his PhD dissertation "The visual profile" and several other publications, he laid the foundation for the care for children with visual problems and for all people with CVI in particular. Using the ICF as a basis, is vision defines and specifies how to create an overall individual picture in order to optimally help people with visual impairments. All relevant factors and their interrelationships must be clear. The causal neuropsychological mechanisms that play a role in CVI are therefore only part of the complete picture. Paul, thank you for the important insights you have given me and for the wonderful collaboration that we had between 2005 and 2014.

While getting started in the CVI-assessment during those initial years, I had the privilege to learn from remedial educationalist and healthcare psychologist Sjoukje Stuiver and remedial educationalist Karin Zondervan.

Also, the collaboration with psychologists Thalia Albracht and Jeffry Looijestijn, plus my supervisory role during Jeffry's internship and graduation research on CVI, stimulated the expansion of my ideas about CVI. Thank you all so much!

In 2010, I became chairman of the national CVI Expert Group of Royal Dutch Visio. We committed to the development of an organisation-wide view on CVI. The interdisciplinary nature of the group led to the further development and completion of my ideas about CVI and culminated in 2013 with the internal publication of the formal view of Royal Dutch Visio on CVI. My sincere thanks go to orthoptist Hélène Verbunt, remedial educationalist and healthcare psychologist Henriëtte Lijnders, neuropsychologist (now also a healthcare psychologist) Christiaan Geldof, psychologist Eva Bos, occupational therapist Marieke Steendam, development support worker Jorg van Wanrooij, and itinerant teacher Gerard Koning, for their contributions.

There are three other important members of the CVI Expert Group who are not in this list, who deserve an extra thank you. The first two are occupational therapist Femke Oude Lansink and itinerant teacher Henk Benjamins, both direct colleagues of mine at the northern office of Royal Dutch Visio. Our close collaboration, their

expertise, experience and unwavering dedication have inspired and stimulated me enormously. Femke and Henk, thank you very much! The third person is developmental support worker Ria Waelen, also project leader of "CVI in the picture". Ria, thank you for keeping us all moving in the same direction and for your valuable contributions to the realisation of the products of "CVI in the picture".

Aside from Ria and myself as project leaders, two other people were intensely involved in the "CVI in the picture" project. Firstly, Henk Benjamins, already mentioned above, who showed an unrelenting drive within this project to make it the best of all the products. Thank you also for this, Henk. The other person is occupational therapist Femke van der Veer, who with her great experience and down-to-earth attitude helped in keeping the products of the project strong and to the point. Thank you, Femke!

Two other individuals who did so much to streamline the contents of this book are editor John van Enckevort and remedial educationalist Eline Kreuze. Thank you both! Thanks also to knowledge broker Lianne Nooteboom, communication advisor Antonietta Asta and programme managers Daniëlle Kistemaker and Alida Drenth, for your work behind the scenes to realise this project. KEI director Joost Heutink, many thanks for your support and for being a trusted colleague. Roy de Haan, Bas van den Ing and all other employees of Elevator Productions, thank you for the beautiful pictures that enrich this book and, above all, for your patience, unbridled dedication and expertise in creating the film "CVI in the picture".

Warm thanks to Amanda Hall Lueck, Sylvie Chokron, John Ravenscroft and Nicola McDowell for your inspiration, support and cooperation.

A special thanks to Femke van der Veer and Marieke Steendam for their invaluable work in coordinating the translation of this book.
An extra special thanks to the people who voluntarily contributed to the realisation of the film and many of the pictures in this book: Floris, Bertine, Christy and their parents.

Finally, a big thank you to my sons Eelke and Siem and my daughter Jetje. For your love and patience during the many hours I spent working upstairs on my days off. My greatest thanks go to my wife Fleur. Thank you for making everything I do in my life possible – and especially for making it a party too! Also, for ever so gracefully, catching every ball that I drop. I love you.

Sander Zuidhoek

About the author

Sander Zuidhoek
Sander Zuidhoek (1972) graduated cum laude from the University of Utrecht, majoring in visual consciousness and attentional processes in the visual field. In 2005 he obtained his PhD, following his research on haptic spatial perception. Through his work with blind people, he came into contact with Royal Dutch Visio, where he worked from 2005 until September 2018 as a neuropsychologist for children and adolescents. He has authored several scientific publications, including articles and book chapters on CVI. As chairman of the national CVI Expert Group, Sander was the principal author of Royal Dutch Visio's formal view on CVI.

The levels of visual hierarchy

The ability to see well depends on general requirements and visual functions. Levels 1 to 4 below describe the preconditional functions and factors. The visual functions are listed under 5.

1. **Being rested and alert:** We need to be sufficiently rested and alert to be able to see well and to carry out visual tasks.
2. **Motivation:** We need to be sufficiently motivated to look accurately and to carry out visual tasks. What motivates us is determined by our emotions and needs, and these in turn depend on personal and environmental factors.
3. **Executive functions:** These interpret our emotions and needs, and thus determine our goals. They also determine our thoughts and behaviour, as they have access to all information sources (emotions, needs, memories and senses) through their control over the attentional functions.
4. **Attentional functions:** Through endogenous and exogenous attentional processes, we become conscious of information from the various information sources, so that we can use them in order to reach our goals. One of these sources of information is our visual sense.
5. **The visual sense:** Engagement of our visual sense depends on the preconditional functions and factors mentioned above. The quality is further determined by A) the low visual functions and B) the high visual functions.

A) **Low visual functions:** functions whose quality is determined by the eyes and the brain.

1. **Sensory functions:** determine the quality of our visual field.
2. **Oculomotor functions:** determine the quality of our eye movements.

B) **High visual functions:** are performed by the brain; they process the information that is provided by the low functions.

1. **Visual selective attentional functions:** select within visual information
   - **Global visual selective attention:** spreads out the visual attention
   - **Local visual selective attention:** focuses the visual attention

   What we select a) we perceive and b) we can use to act on or with

2. **a) Visual perceptual functions:**
   allow us to understand what we perceive by means of
   - Visuospatial perceptual functions
     - location perception
     - orientation perception
     - movement perception
       - speed perception
       - direction perception
   - Identification functions

2. **b) Visuomotor functions:**
   uses visual information to allow fast and accurate goal-directed actions. What we visually perceive, we can store in our various visual memory systems.
3. **Various visual memory systems**
4. **Visual working memory functions:**
   allow visual thoughts through
   - Visual imagery
   - Manipulation of visual images
5. **Visual processing speed**
   The above processes must be carried out by the brain at sufficient speed

Royal Dutch Visio
Centre of Expertise
for blind and partially
sighted people

Seeing involves not just the eyes. More and more, we realise that it is the brain that causes visual problems in children. These children have CVI, Cerebral Visual Impairment. They are visually impaired because their brain does not process the visual information properly. These children experience limitations and restrictions in daily life, which they themselves and also people in their surroundings often find difficult to understand. CVI is complex, and everyone with CVI is unique. That makes proper treatment and coaching of children with CVI difficult. Being able to help them requires a thorough understanding of CVI.

This book gives parents, caregivers and therapists the knowledge and information needed to understand children and adolescents who have CVI. This book is part of the "CVI in the picture" project. In order to increase and broaden the understanding of CVI and to reach as many people as possible, the project consists, aside from this book, of a film about CVI and an interactive CVI experience workshop.

www.visio.org