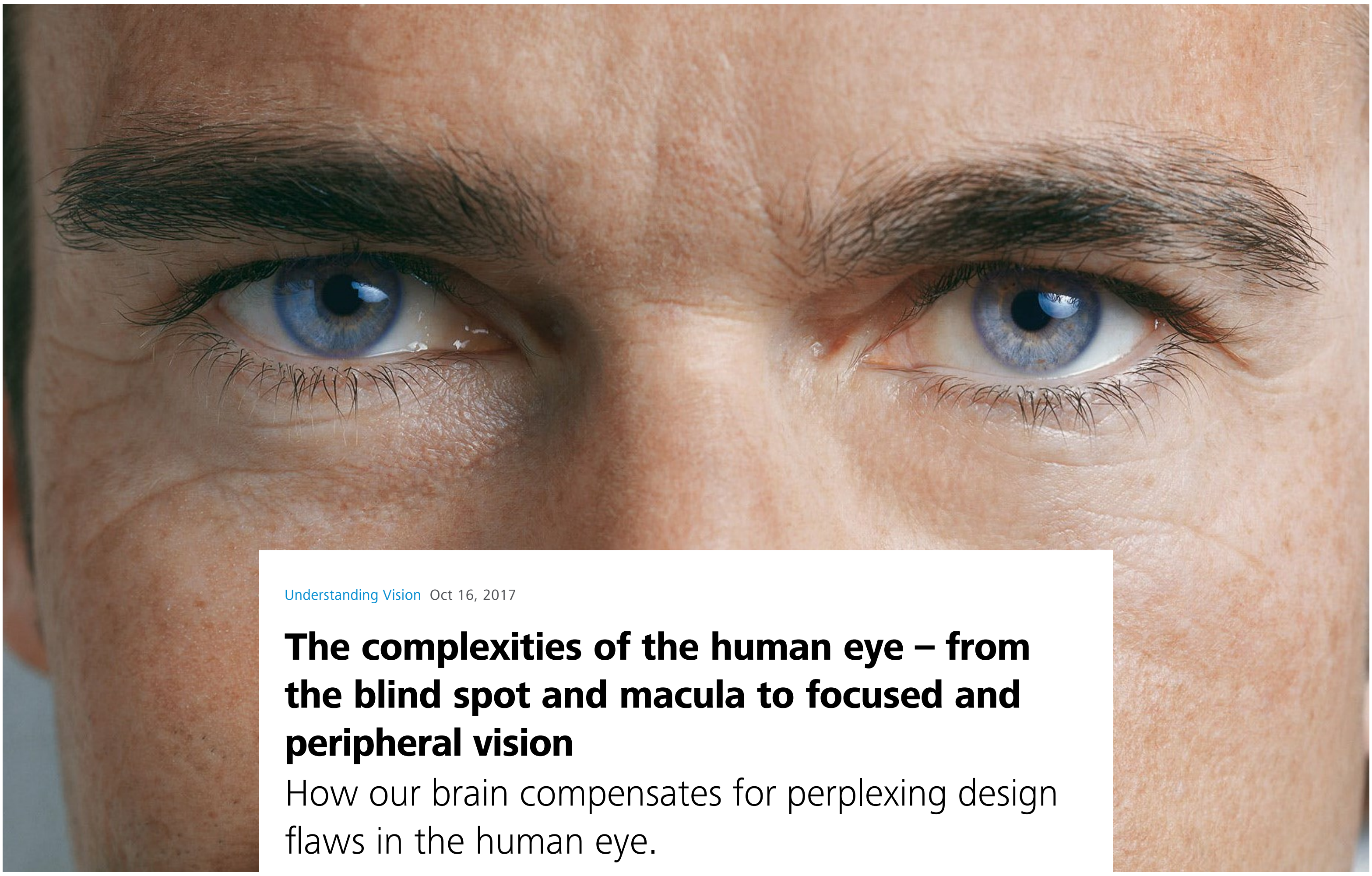


Understanding Vision Oct 16, 2017

The complexities of the human eye – from the blind spot and macula to focused and peripheral vision

How our brain compensates for perplexing design flaws in the human eye.

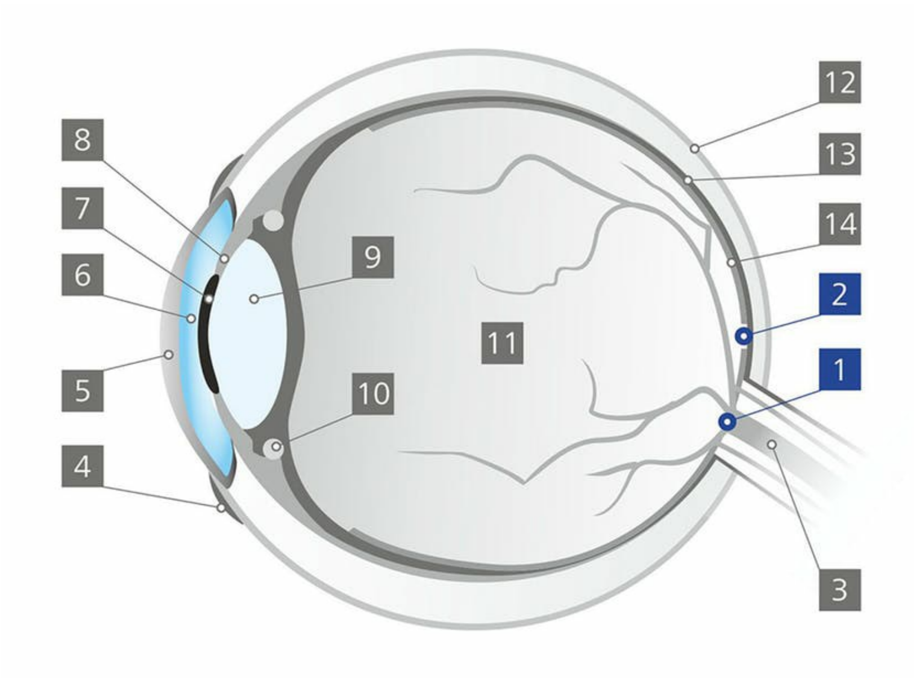
Over the course of the last 500 million years, evolution has produced an incredible variety of different eyes from a simple light-sensitive spot. This has proved to be a major evolutionary step, because sighted creatures enjoy clear advantages over blind species. Researchers remain divided on whether this variety stems from a single proto-eye or whether the eye has evolved independently on multiple occasions. Different organisms' needs have yielded different types of eye, from flat eyes, pit eyes, pinhole eyes, and compound or complex eyes to the lens-bearing eyes seen in vertebrates, including humans. This latter type of eye ranks as one of the most sophisticated organs of vision that evolution has produced so far. Development of the lensed eye enabled perception of the environment that was both bright and sharp at the same time. Yet even the human eye has its evolutionary weaknesses...

Working in partnership with > our eyes, our brain plays a key role in the complex world of human vision. Unnoticed and with minimal effort, it compensates for the weaknesses of our eyes. This is an example of teamwork at its very best!
When the lensed eye of vertebrates – and thus our own human eye – evolved, something odd happened. Unlike cuttlefish, for example, which have highly sophisticated bubble-shaped, lens-bearing eyes which arose through invagination of the outer skin, the human eye was – seemingly at random – formed quite differently as an outgrowth of the brain. At first glance, this may appear to be a minor difference, and it even offers advantages since it enables the same-sized eye to contain more photoreceptor cells. Yet oddly enough our photosensitive cells are positioned the wrong way around on the retina and point back into our body, while our nerve cells point towards the light source. This essentially means we have an 'inverted eye' which requires our brain to put things in the right perspective. It also means that humans and all vertebrates have what is known as a blind spot.

The blind spot (Fovea centralis)

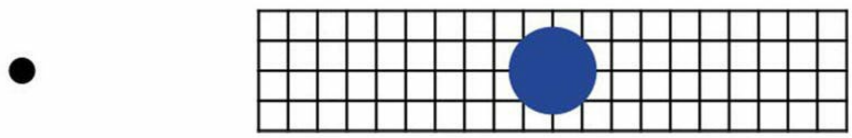
The blind spot, or scotoma, is the place in our eyes where the optic nerve passes through the retina to the brain. The pipeline of nerve cells that constitute the optic nerve produces a kind of 'hole' in the retina, a part of the field of vision that is not perceived due to the lack of light-detecting photoreceptor cells. This seemingly poor design of the retina, which produces the blind spot in our visual field, is referred to by experts as the inverted eye. The blind spot is located about 15 degrees on the nasal side of the fovea. Healthy humans do not generally notice this lack of visual information since our brain interpolates the blind spot based on surrounding detail, information from the other eye, and the calculation of different images resulting from eye movements.

The blind spot was first documented by Edme Mariotte, a French physicist, in 1660.



1. Blind spot
2. Macula
3. Optic nerve
4. Conjunctiva
5. Cornea
6. Ocular chamber
7. Pupil
8. Iris
9. Lens
10. Ciliary muscle
11. Vitreous humor
12. Sclera
13. Choroid
14. Retina

Demonstration of the blind spot



Here's how to do it:

Close your left eye and focus your right eye on the dot on the left. Place your eye at a distance from the screen which is approximately twice the distance between the dot and the center of the grid on the screen. Now slowly move your head backwards away from the screen. At a certain point you will notice that the missing center of the grid has been 'filled in.' This is the blind spot – the point at which the missing visual information is provided by the brain.

The blind spot's best friend: the macula

As well as a blind spot, every human eye also has an area of the retina that provides high-quality focused vision known as the macula or macula lutea. The center of the macula contains the highest concentration of cone cells, one of the two types of photoreceptor cells in the eye. This small, central pit – the fovea centralis – is located right in the middle of the macula and is responsible for sharp, central vision.

All cats are grey in the dark

Animals that need good vision at night generally have big eyes -- think owls, exotic animals such as tarsiers, and even cats. In fact cats also have a special retina containing a reflective layer which enables more light to reach the retina. The eyes of nocturnal hunters are built differently to the human eye. Compared to diurnal humans, nocturnal animals have far more rods (responsible for sensing brightness) than cones (responsible for color perception).

Our cones therefore play a key part in giving us color vision. We have three types of cones which have maximum sensitivity to either red, blue or green light, respectively, corresponding to the specific wavelengths of daylight. At night we lose the light of these three color wavelengths. As a result, we no longer have access to the color information so only our rods are active – and that's why everything looks grey.

Why we never actually stare at things

You could say that every creature has the eye it deserves. For animals that could be the next item on a predator's menu, it's important to have an excellent all-round field of vision. That's why rabbits, deer and other potential prey animals have their eyes on the side of their head. However, this makes it harder for them to judge depth and distance.

Thanks to our forward-facing eyes, we humans can judge depth and distance extremely well, though we don't enjoy a 360 degree field of vision, probably because we no longer need it.

Did you know that, strictly speaking, we're not actually staring at an object when we focus on it? The photoreceptor cells on our retina only react to changes in light conditions. So if we were really to stare at something, the motionless image would begin to fade. But nature, as always, has a solution: our eyes are continuously making tiny random movements without us even noticing to ensure we keep the object in focus while perceiving the things around us at the same time. So even when we are fixated on one point, our eyes are constantly making short and rapid movements known as saccades.

Focused vision versus peripheral vision

Peripheral vision is the part of our vision that is outside our central, focused gaze. The purpose of peripheral vision is to give us an initial impression or context before we focus in on something, so it works very differently to our focused vision. Peripheral vision covers well over 90 percent of our visual field even though it only has access to approximately 50 percent of the photoreceptor cells. Basically that means that the ability to discriminate fine details falls by the wayside in our peripheral vision due to its much lower visual acuity, or resolution. However, our peripheral vision is far better at perceiving movement, because we still need the ability to quickly identify potential risks.

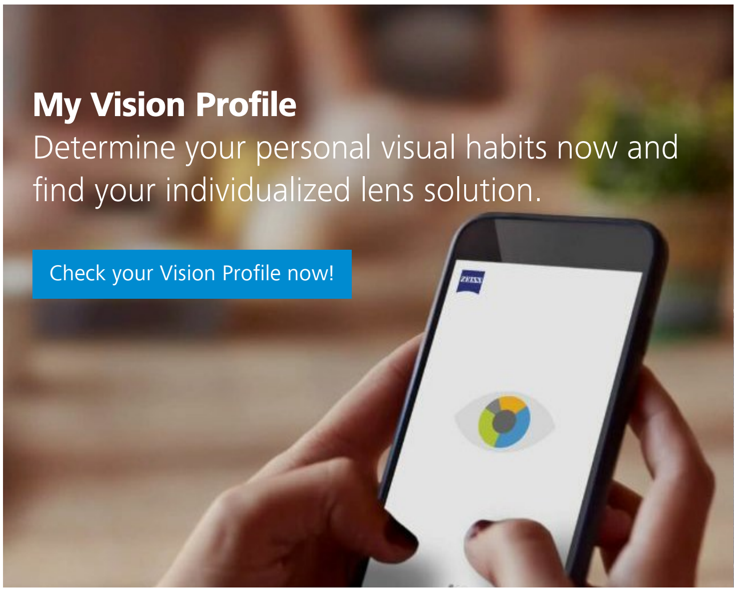
Peripheral vision and spectacle lenses

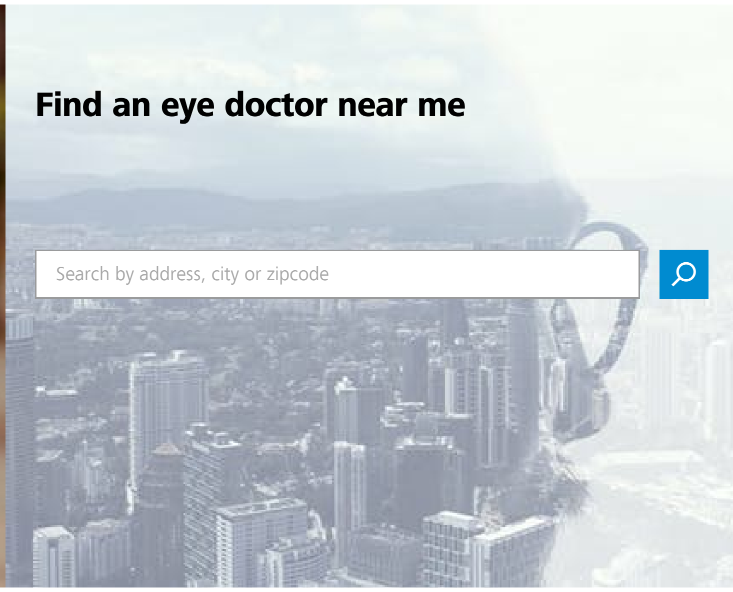
Everyone knows that when things start looking blurred it's time to get eyeglasses to correct the defects in our vision. But the real art of producing lenses is to create a lens design that not only restores our sharp central vision, but also gives us comfortable and relaxed peripheral vision. That's why the calculations performed in lens manufacturing require so much mathematical expertise and optical know-how. The aim is that the eyeglass wearer's peripheral vision when wearing eyeglasses should be no different to their peripheral vision with uncorrected eyes. This is particularly challenging when it comes to producing progressive or sports eyeglasses with wrap lenses.

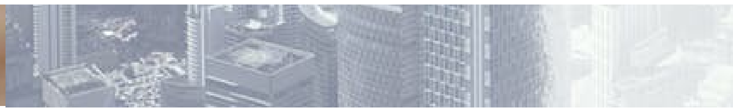
Did you know that it isn't our central, focused vision which determines how long it takes us to get used to progressive lenses in the near and distance vision zones and transitional range, but rather the changes to our peripheral vision? These changes can have a distorting effect which may be unsettling at first. But there's no need to worry – our brain quickly adapts to these changes, too. We soon get used to our new style of vision and eventually perceive the periphery as perfectly 'normal'.

There are two important things to remember, however:

1. Seek expert advice from your eye doctor to find out which progressive lenses are most suitable for you.
2. Wear your new progressive lenses almost continuously right from the start – especially at times when you're moving around a lot. This will help your brain get used to your new improved vision much faster.





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