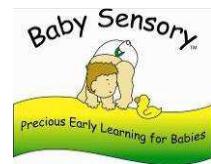


What do Babies See?



By Dr. Lin Day, Baby Sensory.

When a baby looks at an object, reflected light passes through the lens of the eye and falls on the retina at the back of the eye. The retina then transmits electrical signals along the optic nerve to the visual cortex at the back of the brain. What is so remarkable is that the act of 'seeing' depends on electrical impulses processed by the visual cortex, which is completely insulated from light.

The ability to see has fascinated scientists for decades. In the 19th century, examination of the eye was made possible by the microscope. Further research showed that the rod cells were insensitive to colour, while the cone cells responded to colour. It was also found that the rod cells could not function effectively in dim light without sufficient sources of vitamin A (night blindness). Since the discovery of the laser in the 1960's, numerous studies have been carried out to better understand the mechanism of eye disease and blindness. This is why more is known about the visual system than almost any other sensory area.

At birth, sight is the least developed sense. The ability to see objects and colours clearly depends on the development of the visual cortex, the maturity of the retina, coordination of the eye muscles and focusing ability. Until these complex systems have matured, images, shapes and colours will appear blurry.

By eight months of age, the ability to see clearly has nearly reached normal adult levels. The rapid pace of development is highly dependent on the amount of visual stimulation that the baby receives. If the baby is deprived of visual stimulation, cells in the visual cortex may decrease or develop abnormally which can have serious implications for hand-eye coordination later on. Other problems

may include clumsiness, difficulties in concentrating and reading and writing problems when the child goes to school.

Visual Cortex

The retina is connected to the visual cortex by the optic nerve, a tract of more than 1,000,000 nerve fibres. The optic nerve from the left eye is linked to the right side of the visual cortex and vice versa. Damage to one eye or one side of the brain can lead to changes in colour perception and object recognition on the opposite side.

Neurons (brain cells) in the visual cortex have different roles. Some are activated by dark lines on a bright background or by rectangles, circles and stars. Some are excited by the movement, position or orientation of an object, while others respond with remarkable specificity to depth and brightness or to colours. All of these aspects combine to produce what we see.

Visual stimulation causes the neurons to sprout thousands of new branches, which increases the speed at which information is sent and processed by neighbouring brain cells. The activities of certain proteins responsible for visually guided movements, such as the act of reaching for a toy or holding a pencil also increase. Neurons respond best to moving stimuli, notably objects that excite the movement of both eyes. If the baby has nothing to look at, then the neurons may become inactive or minimally active.

Maturity of the retina

The retina of each eye contains over 100 million rod and cone cells. Rod cells are sensitive to blue-green light and are used for vision under dark or dim conditions. This is why we can pick out black and white shapes, but not other

colours in hazy light. Rod cells outnumber cone cells by ten to one, except in the centre of the retina (fovea), where the high concentration of cones (about 180,000 per square mm) enables us to see things in colour and in fine detail. Animals that do not possess cone cells only see in black and white.

Cone cells operate in bright light and are extremely sensitive to the colours red, yellow and blue. However, it is the brain that has the capacity to mix colours in various proportions so that a wide range of different colours are perceived.

At birth, cone cells in the fovea are immature. The amount of light collected is about 350 times less than that collected by the normal adult eye, so colour vision is very limited. However, recent studies show that babies can see coloured patterns as long as there is enough contrast in colour and brightness. They can also distinguish between two shades of grey that contrast by only 5 percent, which is about half as good as adult sensitivity.

By comparison, the rods are fairly well developed and it is thought that babies can see details more easily in dim light. Even so, sensitivity to black and white is about one tenth that of the adult eye. The outline of the parent's face, the dark shape of the pupil and bold black and white patterns present the highest possible contrast to the eye.

By two months of age, cone cells migrate toward the centre of the retina, grow larger, and become more densely packed. This allows the baby to see colours and the outlines of shapes ten times better than at birth. The baby's visual acuity at this stage is about 10/100 adult vision. Even though the brain and eye areas responsible for vision are still immature, the ability to distinguish between one colour and another develops rapidly.

With the development of the cone cells, the baby becomes receptive to rich, bright, highly saturated colours such as yellows and reds. These colours have a long wavelength at the higher end of the visual spectrum. Recognition of the colour green follows shortly after, although sensitivity to the colour blue takes a little longer. This is because the photoreceptor cones for shorter wavelength colours at the lower end of the visual spectrum, take longer to develop.

By three months of age, the eye has made its most progress, and the baby can now see all colours, including blue. Development is so rapid, that by six months of age, the baby has about 20/50 adult vision. The baby can tell the difference between pastel colours and similar colour shades such as yellow and orange.

By eight months of age, baby can see all the subtle shades that make the world so rich and interesting. However, visual acuity (20/30) is not as sensitive as an adult's since the receptors and nerves in the fovea are not yet fully mature.

By the baby's first birthday, the fovea has a high density of cones and eye development is almost complete. However, it will take another four years or more before visual acuity reaches normal adult levels.

Eye muscle development

Tracking

When we look at the world with two eyes, we see one complete picture (binocular vision). However, it takes a few months for the baby to coordinate her eye movements. At first, one or both eyes may cross or wander in all directions. Eye teaming usually begins when the baby fixes on the parent's face. Later, she will pay close attention to the movement of her feet and hands. By two months of age, the movement of an object will be tracked, providing it is not too small and

it is moving at a modest pace. The baby will also look in the direction of the mother's voice as she moves around the room and will follow her movements.

If visual stimulation is continually provided, eye movements will be well coordinated by three months of age. The baby will be able to track the moving path of an object in a 180 degree arc and alternate her gaze between two objects. By six months of age, the ability to track moving objects up and down and side to side may be fully mastered.

Muscle control in the early months is critical for the development of later hand-eye coordination. If the eye muscles are weak or unequal in strength, then the baby may see two images instead of one. In extreme cases, the brain may ignore visual input from the weak eye completely. The condition may be impossible to correct later on and hand-eye coordination may be severely affected.

Focusing ability

It was previously thought that newborns could only focus on objects at distances of 7 - 12 inches (18 - 30cm). We now know that they can see objects at a distance from birth, but that the images appear to merge into each other. This is because the newborn has not yet learned how to control the ciliary muscles, which automatically contract the lens to project the image on to the retina. Even if a clear picture was projected on to the retina, the image will be blurred. This is because the visual cortex and the fovea are still immature.

Moving objects help the ciliary muscles to develop. Cot mobiles are particularly useful and moving objects and shapes outside the baby's focusing range. If visually stimulated, the baby will begin to see more clearly by two months of age. The ability to focus is usually refined by four months of age.

Depth perception

At birth, the baby's image of the world is two dimensional or flat. As the eyes start to work together as a team, three-dimensional vision or depth perception develops. Depth perception allows the baby to estimate the distance of an object in the environment and to respond accurately. For example, if a ball is rolled towards the baby, she will judge its distance and speed and respond by holding out her arms to catch it. Depth perception also allows the baby to tell what an object looks like from a different angle without turning it over. Babies that spend long periods of time in front of the TV see images in two dimensions and have little opportunity to exercise depth perception or far vision. Taking baby outside increases all aspects of visual development including the ability to see things at a distance.

Depth perception improves significantly once the baby starts to crawl. The baby will see an object across the room and attempt to move towards it, which also develops far vision. Depth perception also develops with the growing use of the hands. Bricks, stacking toys and nesting cups are particularly useful for enhancing hand-eye coordination at this stage.

Summary

Even though the baby's vision is not as developed as an adult's this does not mean that they cannot see colours, patterns, shapes and objects at birth. With the maturity of the brain and fovea and with the development of hand-eye coordination, visual acuity approaches adult vision. Even so, it takes several years to achieve full adult vision. This is why continual visual stimulation is so important in the early years.

Scientists suggest that sedentary activities such as watching the TV can lead to near sightedness, focusing difficulties and other eye problems. Being confined to a car seat or other container for long periods can also be harmful to visual development. In the continued absence of visual stimulation, the brain may ignore or suppress images received from the retina, which can prevent vision from developing normally.

At present, eye problems affect one in four school age children. Problems such as near sightedness, weak or misaligned eyes could be avoided by giving them plenty of opportunities to engage in action games and movement activities in a range of different surroundings early on.

Frequent eye checks in the first year are important. If the baby is unable to track or focus on an object by three or four months of age, then early detection and treatment could make all the difference. Premature babies are at a greater risk of developing eye problems, so special attention should be paid to their sight.