

WHAT CAN MY BABY SEE?

By Russell D. Hamer, Ph.D.* Revised by Giuseppe Mirabella, Ph.D.

Until recently, many people, even some experts, thought that infants could not see very much. This idea is not new. William James, the great 19th century philosopher and psychologist, argued that the visual world of infants is a "booming, buzzing confusion." Over the last 30 years, developmental and experimental psychologists have intensely investigated visual development. Curiously, many current baby books have not mentioned newer findings. This article attempts to summarize, in non-technical language, some of the most important findings about what your baby can see and when each of these visual abilities develop.

"How Far Can My Baby See?" or, a related question, "What Size Objects Can My Baby See?"

This first question asks about the focussing ability of infants, the *optical* part of vision. When you try to look at an object, special muscles inside your eye called the *ciliary muscles* automatically contract or relax the shape of the *lens* of your eye so that a clear image is projected onto the receiving surface—the *retina*—at the back of the eye. This is similar to adjusting the lens of a camera to get a clear photograph. Infants are born with the optical parts of their eyes fully capable of focussing objects at *any distance*, from the horizon to objects right in front of their nose. Yet many books about infant development still say that babies can only focus 7 to 10 inches from their face. While infants are able to focus at any distance, at first they do not have very good control of their ciliary muscles. This

means that during the first 2 months of life they may not focus accurately. Sometimes they focus too close (in front of the object), sometimes too far (behind the object). After about 2 months of age infants begin to be able to focus clear images onto the retina. Yet their vision is still not clear! Something more is needed for clear vision.

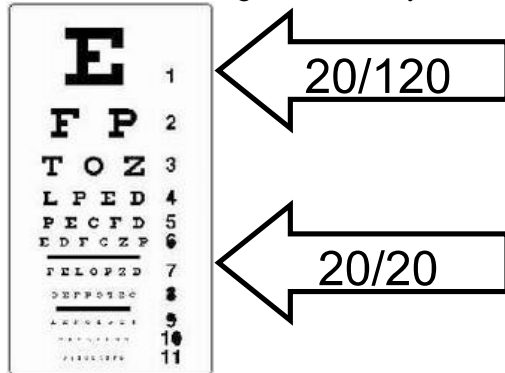
The reason their vision isn't clear can be answered by the second question, which asks about babies' ability to see *detail*, or their visual acuity. *Visual acuity* is dependent on the optical components of the eye (like the lens), but more importantly it is dependent on the functioning the retina and the brain. This means that even though the optics of the eye are mature, infants still can't see as well as adults because brain areas responsible for vision are still immature. To use the camera analogy, the reason that infants' vision is blurry is because of the "film", not the lens. The retina (the film of the eye), in addition to other visual parts of the brain are incompletely developed in infants.

The retina in each eye contains over 100 million cells that are extremely sensitive to light. The part of the retina that is specialized for good *visual acuity* (good detail vision), as well as for good color vision, is called the *fovea*. When we look at an object, what we are really doing is moving our eyes so that the image projected onto the retina falls on the fovea. The fovea is specialized for detail vision. In young infants, visual acuity is limited primarily because the fovea is quite immature. Thus, even when a young infant is able to focus a clear image on the retina, the fovea and

other visual parts of the brain are too immature to transmit a clear image, and even well-focussed objects will remain blurry.

"How Blurry is Blurry?"

Research conducted Smith-Kettlewell Eye Research Institute (San Francisco) and at the University of California (Berkeley), among other places, have measured visual acuity in many babies and toddlers. We have found that in the first month of life, babies have a visual acuity of about 20/120. That means that if they could read, they would be able to read the big "E" on an eye chart.



By 4 months of age, acuity has improved by a factor of 2, that is to 20/60 vision. By 8 months of age, the nervous system has matured enough to improve acuity by a factor of 2 again, that is to 20/30, and is now nearly as good as normal adult acuity (20/20). Over the next several years, acuity improves gradually to adult levels; *but the most dramatic change is over that first 8 months!*

We now know that a very young baby's acuity is at least 6 *times worse* than adult acuity. Again, this is not because infants cannot "focus" well. Rather, it is limited by immaturities in the nervous system. Nevertheless, they are still capable of having a rich visual world. Think of it this way. If you hold up your thumb at arms length, it will be about 6 *times wider than the big "E"*

! This means that a newborn infant can easily see many of the things most important to him or her: your eyes, your lips and smile, your nose, and his or her own hands, fingers, feet and toes.

"Are Black and White Toys Important For Visual Stimulation?"

Many modern stores that sell clothing, toys and accessories for infants and children carry items decorated with large, geometrical black and white patterns. Infants reflexively prefer to look at high-contrast edges and patterns. Large black and white patterns present the highest possible contrast (100%) to the eye and thus are the most visible and attractive to babies. But are high contrast patterns the only things infants can see?

It is true that objects with patterns having 100 % contrast (that is, black-on-white) are the easiest for newborns and young infants to see. However, it is now known that they can distinguish much subtler shades of gray. For example, in the first month babies can distinguish two shades of gray that differ by only 5 % *in gray level* (5 % contrast). As good as that is, by 9 weeks of age, infants' contrast sensitivity *becomes 10 times better*, so that they can see large patterns or objects that have less than 0.5 % contrast. This is nearly as good as adult contrast sensitivity (0.2 %). This means is that by about 2 months of age your baby is capable of perceiving almost all of the subtle shadings that make our visual world so rich, textured and interesting: shadings in clouds, shadows that are unique to your face; even see a white teddy bear on a white couch!

"When Can My Baby See Colors?" or, as some parents exclaim, "My Baby 'Likes' Red!"

Parents often say their baby prefers a certain color, often bright red or blue. Unfortunately, it is very difficult to tell what colors a baby prefers, or what colors he or she can see by simply noticing what he or she looks at. This is because their eyes might be attracted by the brightness, the darkness, or the contrast of an object against its surroundings, and not by the color alone. Recent studies at the University of California in Berkeley have shown that infants as young as 2 weeks of age have color vision and can distinguish a red object from a green one even when these are perfectly matched in brightness. Infants' color vision is not likely to be as rich and sensitive as adult color vision since the receptors and nerves in the eye that are most sensitive to color (again, in the fovea) are not yet mature. Thus, infants may not be able to distinguish very subtle color differences (like distinguishing between red and reddish-orange, or between very subtle pastel colors). However, they *can* see colored patterns as well as black and white patterns as long as the patterns are not too small and have enough contrast (difference in color or brightness).

But what about those black and white mobiles? Well, all this research tells us that *a normal visual environment without black and white toys is quite rich and stimulating to your baby*. This also means that anything pleasing to you is appropriate to decorate your baby's room. As far as the black and white toys are concerned, they may be highly visually attractive; but they are not visually necessary! That is, unless your baby were to have some visual problem, these toys are probably not necessary to promote normal visual development. In fact, you might consider giving your baby a rest from the black and white toys so that he or she can explore more subtle, and perhaps more

important objects (like your face and eyes, or his or her own hands and feet).

"My Baby's Eyes Sometimes 'Cross' or Don't Seem To Follow Objects Very Well. Is That Normal?"

We all know eye movements are a very basic part of the process of seeing. And if you stop to think about it, it is really quite remarkable that, even though we look out at the world through two eyes, each eye having a slightly different point of view, the world still appears as one, not like a "double exposure".

Double Exposure

Whether you look left, right, up or down, the eyes are coordinated to move together so perfectly that the world stays as one fused picture. Babies' eye movements and coordination are also maturing over the first months of life. These are important for developing eye-hand coordination, and for the development of good depth perception. *In fact, coordinated eye movements are critical for the development of other abilities like visual acuity and contrast sensitivity!*

For the first 2 months of life, infants' eyes are not well coordinated; one eye may "wander"; or the eyes may appear to be crossed (turned in toward the nose, or out) at times. This is normal for a newborn.

However, after this period you notice an eye wander continually, or turn in or out for long periods of time, consult your physician. If possible it would be helpful to your physician if you have some photographs of your baby that show the problem, since eye-wandering can be intermittent. By 3 months of age, infants' eyes are usually very well coordinated.

Even newborn infants will follow an object with their eyes (this is *tracking*) if the object is large enough, has enough contrast,

and is moving at just the right speed (not too fast or too slow). However, their eyes will tend to follow the object with "jerky" motions. They will not always track, especially if they are in a room with lots of activity, or if there are other things to look at. By 3 months of age they are able to follow an object with smooth eye motions, as long it is not moving too fast.

We are probably not born with depth perception. The image of the world that is focussed on the retina is *flat dimensional*, and not 3-dimensional. Our rich 3-D view of the world requires that the brain interpret the images from each eye to create the 3rd dimension. This requires visual experience, good muscle coordination of the two eyes, and sufficient maturity of the nerve cells in the eye and brain. Recent research has shown that infants first develop fine depth perception at 3 to 5 months of age.

"When Can My Baby Recognize My Face?"

Researchers at the University of Minnesota in the 1970s found that newborn infants will tend to look at the borders of objects, especially high-contrast borders. Thus, when looking at a human face, a newborn will look at the hairline or edge of the face. By 2 months of age, infants begin to pay more attention to internal features of the face such as eyes, and mouth, and by 4 to 5 months of age they can and to recognize your face from all others in the world.

In summary: Babies can see more than you might think!

Although their vision is not as good as adults', research has shown that babies have

many visual abilities, so that their visual experience is quite rich and well-organized. It is certainly not a "booming, buzzing", patternless confusion! Even at birth, a baby's acuity is good enough so that in your arms, they can see many of features of your face -- your eyes, your mouth, your nose, even a fly landing on your nose! Babies at 8 months of age have acuity that's within a factor of 2 of adult acuity. However, their sensitivity to light and dark, and subtle shading (contrast sensitivity) improves about 4 *times faster* than their visual acuity: thus, by 8 to 9 *weeks* (not 8 to 9 months !) of age, your baby will be able to distinguish two shades of gray that differ by only 1/2% in brightness, about half as good as adult sensitivity! In the first month of life a baby can see many colors, although he or she might not be able to tell the difference between very pastel colors. As the nervous system matures, especially in the fovea, color vision and acuity will improve and begin to approach adult vision.

In addition to all the sensory and perceptual changes that your baby is experiencing, your baby's eyes, brain and body undergo a dramatic increase in physical size and coordination during this time, requiring constant readjustment in order to preserve the accuracy of vision, eye movements and eye- hand coordination. (Imagine trying to learn to hit a tennis ball or a baseball if your arms and legs were constantly changing in size and strength!). Thus, the first year of life is a critical period of development, involving many complex changes necessary to create the rich experience of vision.

* Russell D. Hamer, Ph.D. received his doctorate in Sensory Science in 1979 at Syracuse University in New York. He has published many articles on visual development, including the development of color vision, night vision, acuity and contrast sensitivity, motion perception, and refractive eye development. He is currently an Associate Scientist at the Smith-Kettlewell Eye Research Institute, 2232 Webster Street, San Francisco, 94115. This article was originally published in *Parents' Press*, November, 1990, Vol. XI, No. II.