

WHAT CAN MY BABY SEE?

Milestones of Visual Development

By Russell D. Hamer, Ph.D.

Introduction

Until recently, it was thought, even by some experts, that infants could not see very much. This idea is not new. William James, the great 19th century philosopher and psychologist, once described the sensory-perceptual world of infants as a "blooming, buzzing confusion" (James, 1890). The image James painted raises profound questions, both pragmatic/scientific and philosophical: **how can we know what an infant sees, or any being that cannot tell us, via language or other unambiguous communicative gesture, their internal experience?***

**An article written by Dr. Hamer (Hamer, 2016) detailing one of the important methods used to objectively measure an infant's visual ability can be found at <https://www.americanscientist.org/article/the-visual-world-of-infants>

In fact, William James did not know – *could not know* - what an infant's perceptual world was like. Thus, for many decades after James a series of myths and erroneous ideas about infants' sensory world were propagated. In fact, researchers as recently as the mid-1950s believed that newborn infants were not capable of pattern vision due to immaturities in the optics of the eye, the retina and the visual cortex (Fantz et al., 1962). Moreover, as recently as the 1970s, some physicians, including ophthalmologists, told new mothers that their newborn could see almost nothing, essentially blind (Teller, 1997).

What is the infant's visual world really like? If we were to adopt a Jamesian view of the infant's perceptual world, we might reasonably envision a newborn's view of the world to be a sort of jumble, like a dynamic Jackson Pollock or a Picassoesque montage of deconstructed elements of objects, impoverished in color, spatial detail and contrast, without organized perceptual meaning.

However, many lines of neuroscientific findings and carefully designed perceptual tests spanning the last 5 decades now give us good reason to believe that such a characterization is very far from the truth. The newborn infant's visual world is almost certainly neither a Jamesian confusion nor a patternless haze nor the equivalent of blindness. **We have high confidence that it is a highly organized, albeit immature, rapidly developing version of adult vision, rich in pattern and contrast and color, and some remarkable abilities for discrimination and complex pattern recognition.** Yet curiously, many current books and internet resources on this topic do not incorporate the newer findings. This article attempts to summarize some of the most

important findings about what your baby can see and when each of these visual abilities develop. It is organized around the most common questions parents tend to ask.

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

The **first question** asks about the focusing ability of infants, the *optical* part of vision. When you look at an object, special muscles inside your eye called the ciliary muscles automatically contract or relax, changing the shape of the lens of your eye in order adjust the focus to deliver a clear image 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.

While infants are physiologically and optically able to focus at any distance, at first they do not have very good control of those ciliary muscles. To change focus from far to near, for example, the ciliary muscles must contract and release tension on the lens, permitting the lens to become more spherical. The more spherical the lens, the more it can refract (bend) the light so that very close objects can be brought into optical focus. Someone who is emmetropic (neither near- nor far-sighted, needing no spectacle or contact lens correction) is naturally focused at the horizon, and focuses objects close by making the lens ever more spherical.

Contrary to what some baby books and internet resources say, a high percentage of infants are born far-sighted (hyperopic, not myopic, i.e., not near-sighted), meaning that they have to exert some effort, make the lens of their eye a bit more spherical, just to focus distant objects (i.e., at the horizon).

Research has shown that infants are born with the optical parts of their eyes capable of focusing objects at virtually any distance, from the horizon to objects right in front of their nose, from the moon to their hands: their lenses are very pliable and capable of changing shape so as to focus an image coming from any distance. Yet many popular resources about infant development still say that newborns can only focus about 18 – 25 cm (7-10 inches) from their face. This myth has been disproven many times since about 1965. However, during the first months of life they may not focus accurately: sometimes they may focus too close (in front of the object), sometimes too far (behind the object). By about 2 - 3 months of age infants begin to be able to focus images onto the retina, and to change their focus appropriately to be able to see objects at different distances (Tondel & Candy, 2007; Candy & Bharadwaj, 2007; Candy et al., 2009). **Yet their vision is still not clear, still not adult-like. Something more is needed for clear vision.**

Beyond The Optics: What About The “Film”, The “Pixels”?

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**. To develop good detail vision – high visual acuity – of course requires good optical focus of images, but more importantly it requires maturation of the retina and brain. Accurate optical focusing of the lens requires a neural signal to “tell” the visual parts of the brain when an image is in focus or out of focus. How else can the brain know how to adjust the lens of the eye appropriately? But the retina and visual parts of the brain are incompletely developed in infants. This means that even if the optics of the eye were in perfect optical focus, infants still could not see as much detail as adults because the retinal and brain areas responsible for vision are still immature. To use a camera analogy, the optics of the infant eye are like a high-quality lens of a Leica (very high-quality, expensive SLR camera!); the immature retina and visual cortex would be like using this lens to project an image onto a grainy, low-resolution film (or digital camera pixels) that cannot capture fine spatial detail. **The reason that infants' vision is blurry is mainly because of the (neural) resolution, not the quality of the optics.**

To summarize: The retina in each eye contains over 100 million photoreceptors – rods and cones photoreceptors - 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 neural image, and even well-focused objects will remain perceptually blurry.

How Blurry is Blurry?

How we characterize the **visual acuity** of infants is a kind of “glass-half-empty vs glass-half-full” kind of comparison. Visual acuity refers to how much detail they can see, the finest details that they can distinguish. When we take an EyeChart test, normal adult visual acuity (when you are wearing your glasses or your contact lenses if needed) is called 20/20, and it means you can read one of the bottom lines of the EyeChart from 20 feet. (see the upside-down EyeChart below).

Glass-Half-Empty: Research conducted at the 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 using a non-invasive brain wave technique called the Visual Evoked Potential (VEP). Using this technique we have found that in the first month of life, the visual part of the baby's brain (visual cortex) responds reliably to patterns comprised of

elements whose dimensions correspond to a visual acuity of about 20/120 (6/30 metric). That means that if they could read, most babies would only be able to read the big "E" on the standard Snellen eye chart (20/200; 6/60) or slightly smaller (see chart below).

Scientific data from many laboratories, using both VEP (e.g., Norcia & Tyler, 1985; Hamer et al., 1989) and careful behavioral measurements (e.g., Mayer et al., 1982, 1995; Birch & Stager, 1985; McDonald et al., 1986; Salomão et al., 1995) corroborates this picture: a very young baby's acuity starts out in the range of 6 to 20 times worse than adult acuity, limited primarily by immaturities in the retina of the eye and brain. From an adult perspective, that seems like very poor acuity indeed.

Glass-Half-Full: But let's consider what an acuity of 20/200 represents for an infant's visual world. If you hold up **your thumb at arm's length, it is about 2 degrees of visual angle**. That is, it's about **12 times wider than the line-strokes of the big "E"** on the eye chart. This means that a newborn infant in your arms can easily see the important features of your face: your eyes, your lips and smile, your nose. (S)he can also see his or her own hands, fingers, feet and toes. The irises of your eyes (about 1.3 centimeters in diameter) would be visible from 4.5 meters (more than 14 ½ feet!); your whole eye would be visible from about 12 meters (almost 40 feet!); your mouth would be visible from about 22 meters (more than 72 feet!). Your newborn could also easily see something the size of the moon: the visual size of the moon is ½ degree, about 4 times smaller than your thumb at arm's length, but it is 3 times larger than the line-strokes of the 20/200 (6/60) big "E" in the EyeChart. **This is also about the same size as a 70-meter-long Boeing 747 aircraft when it is 24 kilometers (almost 15 miles) away!**

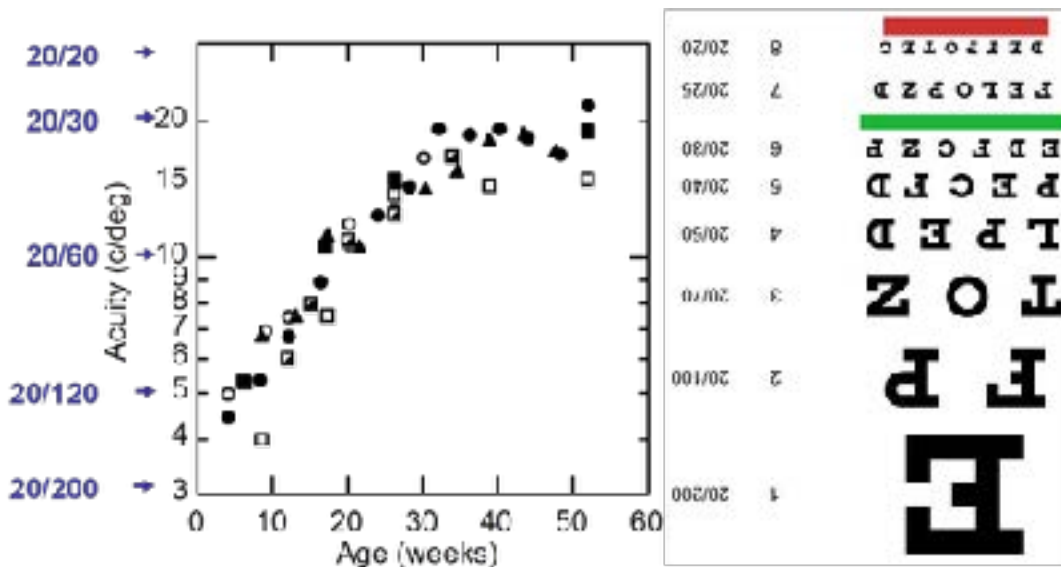
DEFINITELY A "GLASS-HALF-FULL PERSPECTIVE" ON BABY'S ACUTIIY!

How Fast Does Acuity Mature?

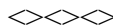
A newborn's visual acuity improves rapidly. For example, by 4 months of age, VEP acuity has improved by a factor of 2, that is to 20/60 (6/18) vision. By 8 months of age, the nervous system has matured enough to improve VEP acuity by a factor of 2 again, that is to 20/30 (6/9), and is now nearly as good as normal adult acuity (20/20; 6/6). Over the next several years, acuity improves gradually to adult levels; but the most dramatic change is over that first 8 - 12 months!

Development of acuity measured using the VEP as described above is illustrated in the data figure below, adapted from a review article by A.M. Norcia (1993) on visual development.

[sVEP Acuity Development Plot w/upside-down Snellen here]



This graph summarizes the results of 6 studies of acuity development, using the Sweep VEP brainwave method, over the first year of life. Note that the equivalents of the Snellen eye chart acuity levels are written to the left of the graph, and an inverted Snellen eye chart is shown on the right, with the big “E” at the bottom (202/200 acuity) and the 20/20 (6/6) letters at the top. At about 4 months (16 weeks), the VEP acuity is about 8 c/deg or close to 20/75, or only 4 times worse than normal adult acuity (20/20). That’s approximately the 3rd line (from the bottom as shown here).



There have been many other studies of visual acuity in infants using reliable *behavioral tests*. The most important of these is the **Forced-Choice Preferential Looking (FPL) technique** developed at the University of Washington by Dr. Davida Y. Teller starting back in the 1970s. This technique took advantage of infants’ reflexive looking behavior: their visual attention is preferentially drawn to look at patterns over any homogeneous field. And so, Teller and colleagues used infants’ looking behavior to reliably estimate their visual acuity, the finest detail they could see, at each age (see Hamer, 2016).

The concept of the FPL test was simple and brilliant, and revolutionized behavioral approaches to the study of vision not only in pre-verbal children, but also in animals: pigeons, goldfish, falcons and monkeys, for example. Measuring visual acuity in human infants using FPL went something like this:

An infant was held facing a large gray screen. On each trial, a patch of black-and-white stripes were presented randomly either on the left (L) or right (R) of the screen as shown below. An observer, hidden behind the screen, viewed the infant through a peephole and (s)he did not know where the stripes were. On each trial, she had to guess whether the stripes were on the L or R based *solely* on the baby’s behavior (e.g., eye or head movements). The observer could either be

correct or incorrect: *an objective outcome*. If the stripes were easily visible to the infant, the infant would orient (glance, turn head etc) towards the stripes and the observer's guesses would be correct on 100% of the trials. If the stripes were *not* visible to the infant, the infant's behavior could not reliably signal the location of the stripes to the observer, and so her guesses would be random, and (on average) she would be correct on only 50% of the trials (like a coin-toss).



FPL: On each trial, test stripes were presented randomly on the L or R of the gray screen. If the infant's acuity were not developed enough to resolve the bars of the grating, it would appear like a gray patch, indistinguishable from the background or from the circular gray patch on the other side of the screen.

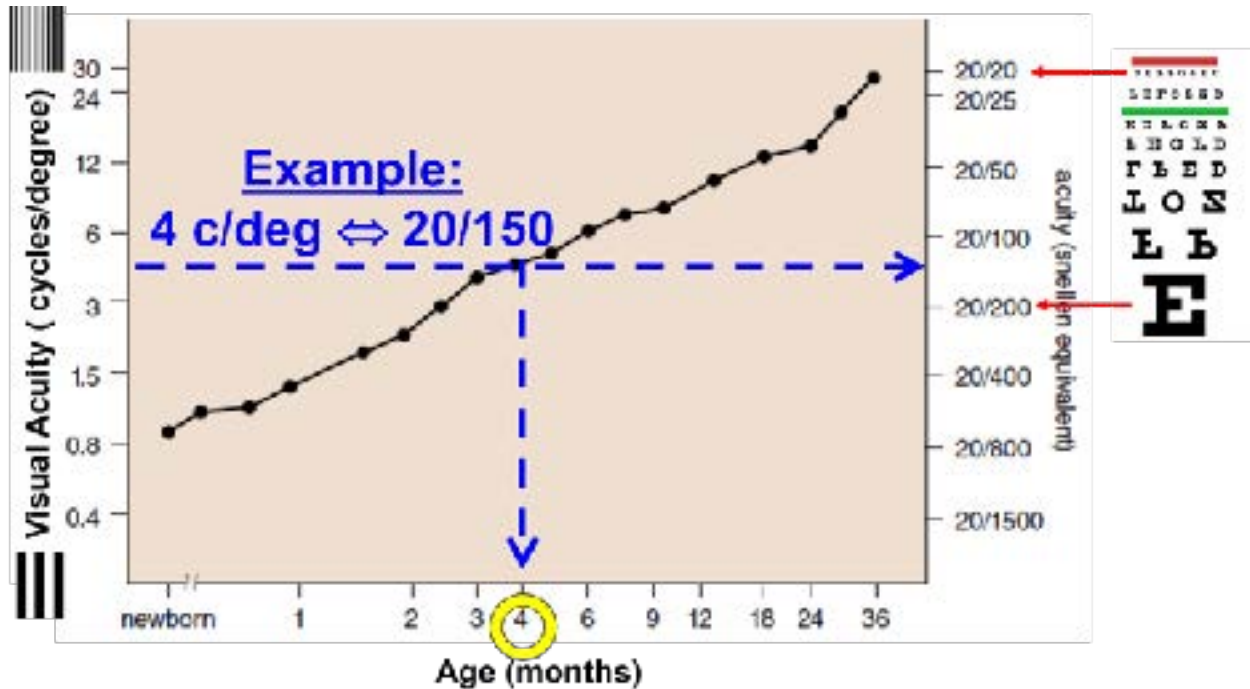
But suppose that for a given stripe size, the observer were correct on 5 out of 5 trials. The probability of that happening by chance is about 3% (the probability of correctly guessing a coin-toss 5 times in a row): a pretty good bet the infant was seeing the stripes. If the observer were correct on 10 out of 10 trials, the probability of that happening by chance is very small indeed - less than 0.1% - and so it is almost certain that the infant could see those stripes. In fact, the infants were tested with 20 trials for each stripe size, and thus the FPL data were extremely reliable indeed.

The FPL procedure was repeated for each of several stripe sizes, and for each the observer's percent correct was recorded. An example with finer stripes is shown below.



After testing a full range of stripe sizes from very coarse (where the observer guessed correctly nearly 100% of the time) to very fine (where the observer's guesses were at chance, 50%), we can estimate the stripe width for which the observer was correct on 75% of the trials (half way between perfect performance and chance, 50% correct). This is our estimate of the infant's acuity.

A summary of many FPL studies of infant and toddlers' visual acuity is shown below:



You can see here infants' behavioral acuity develops very regularly over the 1st 3 years. The behavioral estimates of acuity are generally somewhat lower than the VEP measures. This graph shows that at 16 weeks, the average infant's acuity is about 20/150, about half the VEP estimate (20/75). Scientists are still not sure why the two methods come up with different numbers. But both are quite reproducible. And from the "Glass Half-Full" discussion on p. 4 above, you can see that an acuity of 20/150 permits your baby to see a vast range of objects, including all the details of your face, as well as many details important for development and learning.

When Can My Baby See Colors?

or, as some parents say,

My Baby 'Loves' 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 (hue) alone.

As early as the 1970s and 80s, FPL studies measuring infants' looking behavior conducted at the University of Washington proved that young infants have some color vision (e.g., Peeples & Teller, 1975; Hamer et al., 1982). Two-month olds could distinguish saturated colors from a white background, but did not respond reliably to some desaturated, pastel colors. But this may have been because desaturated colors also present low brightness contrasts to the infant eye. When saturated colors are used (red or green square on a yellow background), about half of 1-month olds could see the square. By 3 months, more than 90% of infants could see the red or green square (Hamer et al., 1982).

Other studies at the University of California in Berkeley, using the Visual Evoked Potential technique, 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 (Allen et al., 1993).

Summary: 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 (in the fovea) are not yet mature and their sensitivity to contrast and detail is still developing. 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), especially for small-detailed patterns. However, they can see colored patterns as long as the patterns are not too small and have enough contrast (difference in color or brightness).

Are Large Black and White Patterns Important For Visual Stimulation?

Many stores and websites that sell clothing, toys and accessories for infants and children promote items decorated with large, geometrical black and white patterns. Often, these products are promoted with claims that they are important to stimulate normal visual development. The rationale given is that infants have no (or little) color vision (incorrect!) and that they can only see high-contrast patterns (also wrong).



Of course, all parents want their infants to develop and thrive. A thoughtful and concerned parent might reasonably infer that not using these kinds of products might risk a kind of visual deprivation for their baby. Some resource materials for parents even say this explicitly. But the actual science does not support the idea that large, high-contrast black-and-white patterns are needed to promote normal visual development. (Think of this: more than 7 million years of evolution has given us extremely keen eyesight; primate and humans have survived and thrived without black and white, large-pattern toys!)

It is true that infants' visual attention is reflexively drawn to look at patterned stimuli vs unpatterned, homogeneous stimuli (e.g., Fantz, 1964; Teller et al., 1974). The higher the contrast, the more strongly will a pattern draw babies' visual attention and visual orienting (head, eye and body movements). Large black and white patterns present the highest possible contrast (100%) to the eye and thus are the most visible and eye-catching to babies.

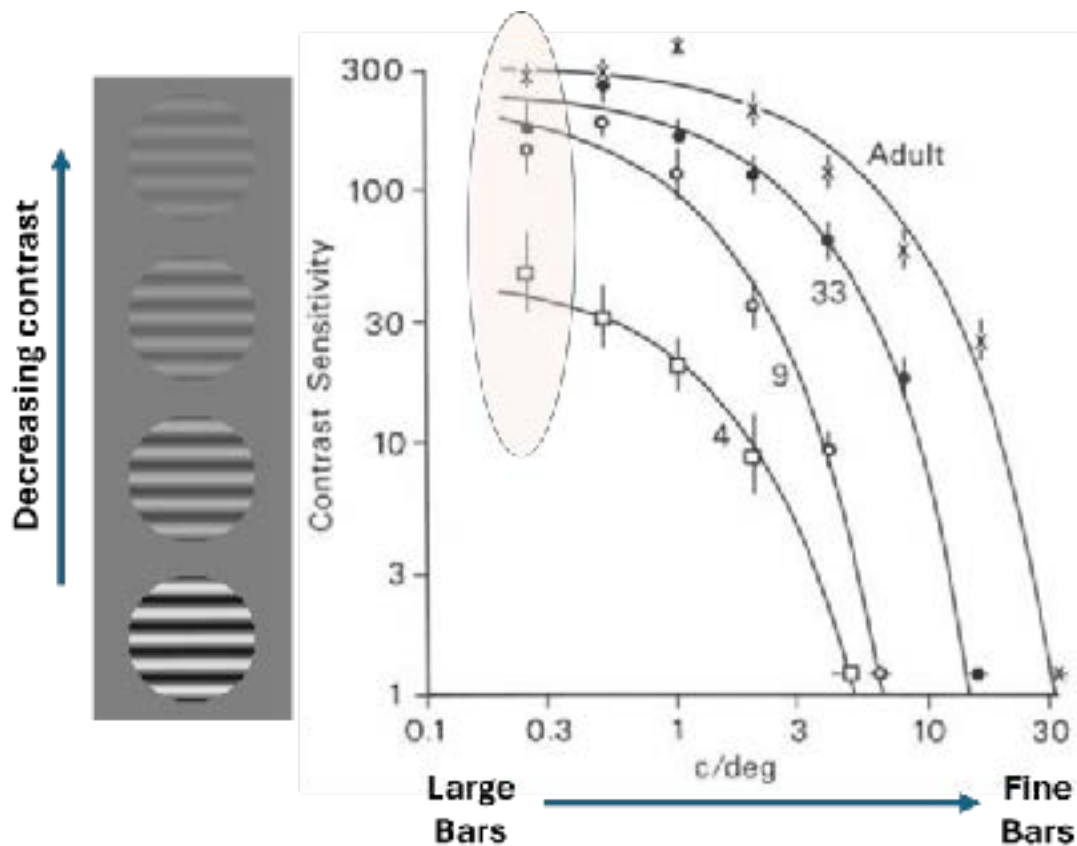
But are high contrast patterns the only things infants can see? It is now known that they can distinguish much subtler shades of gray, especially for relatively large patterns. For example, by the first month, VEP (brainwave) studies have shown that the visual cortex responds reliably to stripe patterns having two shades of gray that differ by only **5 %** in gray level (contrast) (Norcia, Tyler & Hamer, 1988, 1990). As good as that is, by 9 weeks of age, infants' contrast sensitivity becomes 10 times better, so that their visual cortex responds to large patterns that have **less than 0.5 % contrast**.



10% 20% 40% 90% Contrast

Notice that the lowest contrast grating shown in the figure above is about **20 times higher** contrast than the lowest contrast that elicited reliable cortical brain responses in 9-week old infants.

The graph below shows how infants' sensitivity to contrast developed when measured using the VEP (Norcia, Tyler & Hamer, 1990; summarized in Norcia, 2004).



From Fig. 13.3 Norcia (2004). Development of VEP contrast sensitivity (CS). The data inside the oval show how infant sensitivity to bar contrast improved with age when the bar stimuli were large. Between 4 weeks (open squares) and 9 weeks (open circles) of age, contrast sensitivity for the large bars increased dramatically and were only about 2 times less sensitive than adults (“x”) tested with the same stimuli. The 9-week olds’ CS was about 200 which corresponds to bars differing in contrast by only 0.5%!

Note that when tested with large patterns (large bars; data inside the oval), infant VEP contrast sensitivity (CS) increased dramatically, by almost a factor of 10, between 4 weeks (open squares) and 9 weeks of age (open circles). The 9-week-olds’ CS was about 200, close to adults’ sensitivity (300, “x”). A contrast sensitivity of 200 means that their visual system is responding to bars with only 0.5% contrast between the lighter and darker bars!

Being able to see ½% (i.e., 0.5%) contrast gratings is nearly as good as adult contrast sensitivity measured under the same conditions as the infants (adults could see 0.3 %, or 1/3 %). This means that by about 2½ 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.

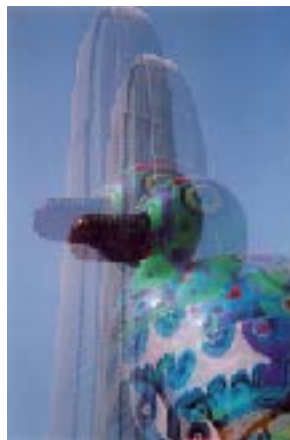
Behavioral measures (FPL) of infant contrast sensitivity are lower: for example, preferential looking studies found that 2-3 month olds’ CS for gratings with large bars was about 20, meaning they reliably responded to gratings with bar contrasts of about 5% (Bosworth & Dobkins, 2009). Although this is about 10 times worse than the VEP measurements cited above, 5% it is still a

very low contrast! And it shows that these young infants can reliably see extremely subtle shadings of light and dark.

So what about those black and white toys and clothing and accessories? Well, all the research described so far suggests that a normal visual environment, with or without black and white toys, is quite rich and stimulating to your baby. Remember, the developmental mechanisms, biological mechanisms, that control the maturation to adult vision have evolved over millions of years without the help of black-and-white toys and wallpaper: we do not need to “teach” the visual system how to develop, and one would have to work very hard to design an environment sufficiently visually impoverished to pose a risk of impeding normal visual development. This means that virtually any normal varied environment will do; 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.¹ 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', Don't Seem To Follow Objects Well. Is That Normal?

We all know eye movements are a very basic part of the process of seeing. 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".



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.

¹ There is one important exception: if your baby were to have some visual problem, like cataracts for example, high-contrast toys might help promote visual development. The degree to which such stimuli might help vision would depend on many factors, like the specific nature of the vision problem and its degree of severity. These kinds of questions would be best addressed by the ophthalmologist or other eye care specialist following the infant.

In addition to acuity, contrast vision and color vision, infants' eye movements and eye coordination are also maturing over the first months of life. These are important for developing eye-hand coordination, and for the development of binocular vision for good depth perception.

For the first 1 - 2 months of life, infants' eyes are not fully 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 (3 months or more) if you notice an eye wander continually or turn in or out for long periods of time, consult your eye care specialist: a wandering eye can impede normal visual development. 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.

Eye tracking. Even newborn infants will follow (track) an object with their eyes if the object is large enough, has enough contrast, and is moving at just the right speed (not too fast or too slow). However, newborn's eyes will tend to track with "jerky" motions. And you may not always see them track, especially if they are in a room with lots of activity, or if there are other things to look at. One simple "following" test is to turn out all the lights and have someone shine a flashlight on a small object while you move it slowly from left to right, up and down, in front of your baby. When there are no other visual distractions, your baby will likely follow the object as long as you don't move it too fast. By 3 months of age, infants' eyes are usually very well coordinated and they are able to follow an object with smooth eye motions (again, as long it is not moving too fast).

Can my baby see the world in 3-D?

We are probably not born with depth perception (3D-perception). The image of the world that is focused on the retina is flat, 2-dimensional. Our rich 3-D view of the world requires that the brain interpret the neural signals generated by these 2-D images to create the perception of depth (the 3rd dimension). Full adult 3-D vision thus requires visual experience, physical exploration of objects in the baby's environment (including his/her own hands, feet etc), good muscle coordination of the two eyes, and sufficient maturity of the nerve cells in the eye and brain.

Stereovision. Infants first develop fine, close-range binocular depth perception, called *stereopsis*, around 3 to 5 months of age (Birch et al., 1982, 1985; Birch & Petrig, 1996). Stereopsis requires brain mechanisms to process visual information (the neural "images") coming from both eyes simultaneously, and to compare the two neural images to "calculate" depth. We use our stereovision to see the striking depth effects in 3-D films.

But full robust depth perception also requires that we learn to interpret many monocular depth and distance cues such as: occlusion (when one object is in front of another, closer to you); size

(farther objects appear smaller); linear perspective (parallel lines appear to converge as they recede into the distance), gradients of texture (the visible details, texture, of a scene become finer the further they are from us); motion parallax (closer objects appear to move more compared to farther objects when you move your head or body). Interpreting these cues in order to perceive depth and distance requires learning and experience, exploring the world both visually and physically, reaching, touching, listening, and moving in our environment to “calibrate” our perception of distance, “calibrate our brains”.

When Can My Baby Recognize My Face?

Faces are a very special kind of visual pattern: recognition of faces and interpretation of facial expressions are of fundamental importance in human communication and social interaction and cohesion. We even have a special area in the brain that seems to be devoted to face perception called the fusiform face area (Sergent et al., 1992; Kanwisher et al., 1997).



Here is an animated GIF of an accurate drawing of the fusiform face area (red).

(If it does not appear animated in this document, see <https://commons.wikimedia.org/w/index.php?curid=9646801>)

Newborns may be able to imitate basic facial expressions!

Ingenious experiments at the University of Washington showed in the 1970s and 80s indicated that infants as young as 3 days old can imitate some basic facial expressions of adults (Meltzoff & Moore, 1977, 1983).



Their results were surprising: how can a baby imitate an expression? How does its brain “know” which muscles to use to do this – (s)he has never seen him/herself! But the results were statistically reliable! One idea is that we seem to have so-called “mirror neurons” in our brain, so that when we view someone doing an action, these “mirror neurons” respond and get the same muscles “primed” and ready for action (Jellema et al., 2000). This “built-in” imitation network in the brain might be “built in” at birth, and it would obviously be important when infants and children are learning to walk and do all the other complicated activities that they acquire during childhood. Another appealing possibility is that newborns already have function “mirror neurons” in the so-called action-imitation brain network (AIN). Brain networks “primed” to “understand” and imitate movements of others have been discovered in both primates (Rizzolati & Craighero, 2004) and humans (Mukamel et al., 2010).

Newborns seem to be able to detect “normal” vs “weird” arrangements of facial features

Experiments in a neuroscience lab in Italy showed that 3-day old infants could perceive second-order features of faces (Leo & Simion, 2009). A first-order feature is the location of the features relative to each other and to the boundary of the face. A second-order feature would be the orientation of a feature in its proper (first-order) location. A classic example is the so-called “Thatcher Illusion” illustrated below.



In the bottom two photographs of Margaret Thatcher, the first-order features (placement of mouth, nose, eyes, eyebrows) are the same. But the photo on the bottom right has some second-order features – orientation of the mouth, eyes and eyebrows - inverted, but in their correct

(first-order) locations. Three-day old infants could discriminate photos of faces like these (Leo & Simion, 2009).

The top pair of photos look somewhat different to adults, but the “Thatcherized” top photo on the right does not look particularly bizarre, and most adults have to study the upside-down faces for a while to figure out which is the “weird” one. In the Leo & Simion study, infants could not tell the difference between normal and “Thatcherized” faces when they were upside-down (like adults). This showed that they were sensitive to the second-order (internal) features of faces. The results suggest that, for both newborns and adults, the fusiform face area (the module in the brain thought to be specialized for recognizing faces) is quite specific in the way it processes facial features and has difficulty in facial recognition when faces, and the first-order features, are inverted.

It is worth noting that the results of the Leo & Simion study do not mean that newborns recognize faces as accurately as adults. Adult accuracy in identification/recognition of faces does not fully mature until adolescence (Carey et al., 1980; O’Hearn et al., 2010; Mondloch et al., 2002, all cited in McKone et al., 2013 review).

**Young Infants Can Learn to Recognize Monkey Faces:
*but then they grow out of it!***

Another remarkable finding is that 6 – 9 month old infants could be trained to recognize a specific monkey’s face out of a group of monkeys. After 9 months of age, infants lose this ability, and even adults fail this task (Pascalis et al., 2005).



What about *your* face?

It appears that infants can distinguish a mother’s face from a stranger’s face by 4 days after birth (Pascalis et al., 1995).



However, certain features of the face seem to be important for this ability: 4-day olds could not distinguish mother's face from a stranger's if they were wearing scarves that blocked the hairline. Recent brain imaging studies have also discovered that distinct patterns in the brain response, occurring in different locations, are evoked when 6 – 9 month olds look at their mother's face rather than the faces of strangers (Carlsson et al., 2008; Nakato et al., 2011).

Overall 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 ½ % 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 subtle 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, depth perception 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 an intense period of development, involving many complex neural and physical changes necessary to create the rich experience of vision.

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