Introduction
Most parents are curious about their new baby's perceptions - what their newborn can feel, smell, taste, see, and hear. There's been a lot of fascinating research into this in recent years, and what follows is a slap-dash summary of our current understanding of how babies experience their world.

Touch
- Touch is one of the newborn's most advanced senses, and touch experience has been shown to be a foundation of cognitive and emotional development.
- Touch is the first sense to emerge - 5 week embryos sense touch to the lips and nose, and this sensitivity rapidly extends to chin, eyes, arms, and down to the rest of the body by 12 weeks. Only the top and back of the head remain insensitive throughout gestation, which must come in handy on the way through the birth canal!
- True awareness of touch on more than a reflex level probably starts towards the end of the 2nd trimester and continues through birth and onwards, during which higher brain connections are made and actually shaped by touch stimuli. Rich stimuli have been shown to create more developed brain cortices in rats.
- Babies are best able to feel with their mouths, which is no surprise considering this is how infants (and toddlers!) tend to explore everything. Incredibly, 1 month old's are even able to form an abstract mental image of things they've sucked on - picking out images of pacifiers they've just mouthed (crossmodal transfer). They can't do that with their hands at this point, though - not yet as sensitive.
- Girls tend to be more sensitive to touch than boys, a difference that persists through life. Boys do develop an lateralized increased sensitivity to touch on their nondominant side (left, usually) - hmm.
- Pain - yes, newborns do feel pain, even the youngest preterm babies, and seem to grow progressively more aware of it over the first few days of life (mom's anesthesia? or baby's own endorphins?). Researchers believe that babies don't have conscious memory of pain, but it also seems that early experiences of pain may amplify later painful experiences.
- Babies also respond to temperature differences, often modifying their activity - alert and active when cool, sleepy and extended/relaxed when warm.
- Severe deprivation of early touch leaves both animals and humans stunted in every way - emotionally, physically, cognitively, even immunologically. Preterm babies have been shown to benefit from therapies like "kangaroo care" and infant massage, and the benefit of social touch applies to term babies, infants, children ... and grownups.

Balance and Motion - "the sixth sense"
- It's no secret that from birth onwards, children find delight and comfort in the sensation of motion - rocking, being carried, bouncing, jiggling (just no shaking, please!). This makes sense, as they're born with a highly developed vestibular system, the part of the inner ear which perceives movement and balance. This sense functions largely on an unconscious level, but is crucial for coordinating our actions, as well as early brain development.
- This vestibular apparatus forms starting as early as five weeks of gestation, and is full size by 5 months; after touch, it's the next most precocious sensory skill. By twelve weeks the eyes move in response to head movements, and by the 3rd trimester, maternal movements can activate a baby's Moro (startle) reflex in the womb! Because of this early development, these vestibular organs, especially the hair cells (which includes the hearing organs), are especially vulnerable to early prenatal insults like certain antibiotics like aminoglycosides (the "-mycins"), infections like rubella and CMV, as well as very low birth weight, hypothyroidism, and hereditary factors.
- This system allows babies to sense their orientation, and to turn head down before birth - babies with vestibular problems have a much greater chance of being born breech.
• This sense underlies the tonic neck reflex, or "fencer's pose" - a reflex where turning an infant's head to one side causes the arm and leg on that side to extend, while the other side flexes. This reflex may help babies develop hand-eye coordination by having them reach towards the side they're looking at.
• Since the vestibular system is one of the earliest to mature, along with touch, it is thought to provide a large share of a baby's earliest sensory experiences - experiences which play quite an important role in mental and neurological development. A large proportion of children with deficient nystagmus response (a sign of vestibular function) have been shown to be delayed in motor development, which seems natural, but we also frequently find vestibular defects in children with problems in "higher" functions like language, attention, learning, and emotional problems.
• The opposite may also be true - one fascinating study showed that babies exposed to a month of regular, short sessions of chair spinning in researcher's laps (which they loved, by the way), showed more advanced reflex and motor skills, especially sitting, crawling, standing, and walking! Please exercise restraint here, folks.
• Vestibular stimulation is also one of the best ways to soothe very young infants, helping babies showing "disorganized" flailing, tensing and crying to quiet and become alert. Which is interesting, because this alert state is when babies do their best learning. Continued vestibular stimulation seems to makes babies sleepy, and sleep is when the brain does a lot of its growing.

Smell
• Smell is a primordial sense that is closely tied into the more primitive parts of our brain (the limbic system), with powerful and often unconscious effects on our behavior.
• Olfactory neurons are the only ones known to be continually generated throughout life. This regeneration depends on the presence of healthy precursor cells, which tend to degenerate as early as mid-childhood, often as a result of infections, smoking, and exposure to pollutants and other toxins.
• Between 2 and 6 months of gestation, the nasal cavity is filled by a plug of tissue, so ability to smell begins around 28 weeks of gestation. Olfaction may even be helped by being immersed in amniotic fluid, and the fetus probably smells most anything mom eats or inhales! Not only that but babies seem to 'remember', or imprint on, these familiar odors. Brand-new babies prefer to nurse on breasts moistened with amniotic fluid, and cry less when exposed to it's odor.
• Moms may also imprint on familiar smells - most moms can identify their newborns on smell alone, even just 10 minutes after birth!
• The odor of a lactating breast is intrinsically attractive to newborns, who can also, by just 6 days of age, reliably distinguish Mom's breast pad from another woman's, as well as her neck and underarm odor. This olfactory recognition depends on the amount of close contact, especially nose-to-skin, and bottle-feeding parents may be able to enhance this by holding babies close to their skin while feeding. Which can be nice, as this familiarity with mom's scent has a calming effect. You may also want to avoid using artificially scented products, which may interfere with this olfactory bonding.
• However, these effects are seen more in girl babies than boys, and in fact, females of all ages are more sensitive to odors than males. This seems to be due to sex hormones - testosterone decreases, and estrogen increases smell sensitivity. That's why women are so sensitive to smell during pregnancy, and midway through their menstrual cycle. More bad news for the menfolk - babies aren't so quick to recognize Dad's scent. Doh!
• True appreciation of the goodness or badness of a smell requires several years - toddlers barely react when "bad" odors, even nasty poo smells, are secretly wafted into their play areas ... and this isn't from some innate poo appreciation, as much as it may appear otherwise.
• Smells, both parental and their own - the familiar olfactory environment, are an important part of finding comfort. This may explain why toddlers grow so attached to one (stanky, to us) comfort object as they spend more time away from their parents, and become upset when we wash these snot-encrusted blankets ...

Taste
• Like smell, taste is another "chemical" sense that emerges early in development. As well it should, considering how important nutrition is early on.
In fact, the womb's amniotic fluid is rich in tastes - sugars, acids, salts, strong flavors from Mom's diet, and the fetus's own urination (ummm). Apple juice amniotic injections (in rats, that is) cause a greater preference for apple juice after birth, and more concerningly, so does in utero alcohol exposure. These tastes do affect neurologic development - rats whose mothers were deprived of sodium are forever deficient on their salt-tasting ability.

Newborns love sweetness - in fact, the more the better. Table sugar (sucrose) is preferred over fructose, over glucose, over lactose (the type in breast milk, although this is no reason to switch to sugar water!). Females and heavier babies show a stronger preference for sweeter mixes than do boys and smaller babies.

Sour and bitter tastes provoke strong reactions in newborns, but they seem remarkably indifferent to salt. It's hard to know how much conscious awareness babies have of taste, since these reactions can be controlled by lower reflex circuits alone.

Salt appreciation develops at 4 months, when an infant will choose sodium solutions over water. This may be related to the fact that young infants are unable to use sodium to concentrate their urine, and thus have less need to consume it - human milk is very low in sodium.

Why do kids love sweets? It seems hard-wired - even before the sucrose hits the belly, sweet receptors in the mouth send signals to the brain's pleasure centers, the ones that release the body's own opiates. This may explain why sugar water has been shown to reduce babies' sensitivity to pain (circumcision, etc.), and why babies withdrawing from heroin or methadone find little comfort from sweet solutions.

Why are we made this way? Well, sweet foods are an important early nutritional source, and some of the safest foods in nature. It's just too bad we had to go and invent refined sugars ...

In case you're wondering, tastes from foods you eat can vary the taste of your breast milk, like garlic (all the rage with the suckling set) and many other distinctive flavors. But don't worry, few infants decrease their feeding in response to this. Since we tend to be initially averse to new flavors, a varied maternal diet may in fact help infants be less picky eaters! A varied early childhood diet can also help influence later eating patterns - just please avoid the low-fat trend, as infants and toddlers need more fat than we do, to help build nerves during the brain's growth spurt in the first two years.

Vision

The sense of vision is still primitive at the time of birth, compared to the other senses we've explored. But newborns arrive with what they need, and in fact, since vision is so complex, and needs so much processing territory in the brain, it's no wonder that it waits to develop until after birth for the big brain growth spurt, when outside world sights can influence the development of the brain's visual centers.

A newborn has a visual acuity of about 20/600, which means she can only really focus on things between 7 and 30 inches away, preferring objects about 8-12 inches away ... like your face while nursing, and her hands. These, after all, are the most useful things for her to see at this stage in her development. She'll likely reach adult 20/20 vision by about 1 year of life.

A newborn can see some color, but not really the full spectrum; as color perception develops by 3-4 months, older babies show preference for "purer" primary colors. Newborns view things best at the periphery of their vision, and prefer dim light. They're drawn to movement and bold contrasts - and compelled to look at novel objects.

A nice surprise is that babies can recognize Mom's face, even at one day of age - something Moms always knew but scientists used to doubt. Dad may get some recognition too, provided the baby gets a reasonable amount of contact with him. In general, babies prefer faces and face-like shapes to other objects, even kids less than an hour old! One day olds have even been seen to successfully imitate an interesting facial display, but this really requires a quiet alert state.

Watch your baby's reaction to interesting objects - he may initially startle slightly, but then shut down body movements to focus on the display, and his face may develop a bright, softened look. He will often track slowly moving objects, as well.

As the higher visual cortex starts taking over control of vision from the lower brain centers, it inhibits the "restless" eye movements towards the periphery, and this sets the stage for "obligatory
looking”, where a 2 month old fixates on a stationary object, even for 30 minutes or more - this can be a nice time for parent-baby googlefests.

- In the first two months, babies seem to scan around until they find the edge of something, and examine that edge. But between 2 and 3 months, the focus shifts on finding where things are - scanning all over an object, and noticing much more detail.

- Visual development occurs in such a well-defined order that it's crucial to find and correct problems like strabismus (eye misalignment) and poor acuity (cataracts, etc.) in time for the surges in visual center growth that depend on these abilities. Let us know if you notice a consistently “wandering” or “crossed” eye if your baby is more than 3-4 months old.

Hearing

- While children's hearing improves up through adolescence (where it often seems to become quite selective!), it functions fairly well at birth. In fact, a newborn has already has about 12 weeks listening experience, and even has some definite preferences about what she'd like to hear. Mom's voice is at the top of the charts, especially “motherese” - high-pitched, highly modulated speech. Babies also prefer other complex, intonated sounds like music, lullabies, and nursery rhymes.

- Not only do babies prefers songs, stories and rhymes they heard in the womb, they prefer their mother’s voice to other women’s. Mom's heartbeat also a big hit. Even soap opera theme songs have been shown to have calming effects on babies who experienced them in utero. Sorry Dad, but the newborn doesn't seem to show a preference to your voice until they've known you for a few weeks.

- Even though fluid can persist in the middle ear for days after birth, a term newborn can fully respond to sound cues, although with a slightly higher threshold. Newborns are not so good with quiet or high frequencies, but this rapidly improves by six months.

- Babies are born sensitive to the melody and intonation of spoken language, and to differences between sounds in foreign languages that to older children and adults sound the same. This universal language ability is lost by 12 months through a process of neural “pruning” as the baby grows accustomed to the native language. Quite early on, as well, infants can distinguish their native language from foreign languages.

- Arguments have been made for universal hearing screening in newborns/young infants, as we have found that hearing impaired children may benefit from interventions as early as six months or younger; our ability (as parents and docs) to identify hearing loss at this age without special testing is poor. Hearing testing later in life can also be important, as persistent fluid from chronic ear infections may temporarily decrease hearing enough to slow language development to some degree.

In conclusion ...

I hope this has helped you to appreciate how fully equipped the newborn is to interact with you and the world around, to participate actively in his or her relationship with you. They're hardly the helpless reflexive creatures we once thought they were. It also underlines the importance of rich stimulation for all of the senses, but it's important not to go overboard! Remember that learning takes place best when a baby is quietly alert, and that sleep is important too. Most preterm kids and many sensitive term babies are easily overwhelmed by stimuli, especially involving multiple senses. If your baby starts to look away, look distressed, fuss, or yawn - it's not that they don't like you, they're just likely to be over stimulated. Try just giving the baby your face, or your voice, or your touch - one at a time. Soon you'll learn to read your baby's signals for how much stimulation is enough.

Have fun discovering your new baby!!! Let me know what you find ... you'll soon be the expert of your son or daughter's abilities.

This information was shamelessly cribbed from three great books:

