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VISUAL COMPETENCE

Vision is the primary sensation on which most people rely for information as they go through their days, learning, playing, working, driving, shopping, and relating to loved ones. The number of neurons that interact with our visual system, and the amount of territory it occupies in the brain is testament to the importance of vision for humans. It is said that two thirds or 60+% of the brain has functions related to vision, however only 20% of the brain has 'vision only' functions. The remaining 40% of visual nerves coordinate vision with movement, vision with touch, vision with attention, vision with spatial navigation, even vision with 'meaning'. So, as the brain matures, a great deal of functionality is dependent upon the full maturation of vision skills.

Despite its importance, vision is very primitive in the infant and must mature through several stages of integration before we experience the kind of vision we experience as adults.

Stage I – Medulla/Spinal Cord Level: Pupillary Reflex and Primitive Color Awareness

At birth, the infant has very poor focus, with an ability to focus that only extends to 8 – 10 inches - the approximate distance from the baby's eyes to the nursing mother's eyes.

Pupillary reflex is the skill that we test at that level. Pupillary reflex is seen when a bright pen light is presented and the pupils contract, then expand again when the light is removed. This is a reflex that should be equal in both pupils.

A 'blown pupil' is the common term referring to a pupil that expands but will not contract in the presence of light. This may be the result of a brain injury or the sign of a stroke or other brain catastrophe and should be referred immediately to a physician.

At this stage of development, the retina is not mature and does not see the full color spectrum. In fact, the infant primarily sees high contrasts and black and white. The first color to become visible to this infant after black and white is red. You will notice that some toys created for the neonate are made of black, white, and red fabrics, as they will best draw the neonate's attention. The full range of colors will become available by the age of four months but may not be as discreet as those of the older child.

On rare occasion, a client will complain about being sensitive to or 'allergic' to a particular color. Almost invariably that color is red. This indicates a very immature visual system that may be decompensating under stress. In these cases, the more agitated or dysregulated they are, the more the color red, and even more rarely, orange, will be an irritant and further their agitation.

Stage II – Pons Level: Outline Perception, Facial Awareness and Horizontal Eye Movement

Between approximately 2.5 – 7 months, when the dominant brain is the pons, the infant has a greater, but still limited range of visual focus. The most compelling visual interest for this infant is the human face.

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The immature visual system sees more in outline than detail, and they are drawn to the two eyes, nose, and mouth arranged as a human face.

Psychologists have done experiments in which the infant is presented with 'features', including a slash for the mouth, two dots for the eyes, and a blob for the nose. When arranged to look like a human face, the infant will stare for a long time, but if those 'features' are rearranged, the infant will look away, uninterested. Such is the draw of the human face in the first months of life.

At this point, the infant is not able to discriminate one face from another. And even though they decidedly know who their mother is, based on smell, sound, and body rhythm, this infant will smile broadly at any human face. This is the infant in the grocery store cart who will make engaging eye contact with you, even if s/he has never seen you before.

Engaging with the human face causes the infant brain to release oxytocin, the love and snuggle hormone that triggers bonding. When the infant releases oxytocin as they gaze into your eyes, the adult releases oxytocin as well, thus the baby and mother 'fall in love' with each other.

The disturbing tendency of young mothers to have their eyes fixated on a phone while nursing or holding their baby can erode the beautiful process of bonding that is so critical for normal infant development.

At this stage, the infant will also develop horizontal eye tracking. This is a smooth movement of the eyes, that at its mature stage, will be independent of head movement and with no skips anywhere in the journey from left to right and back. Initially, this is a way of keeping track of a caregiver. Since the pons level brain is concerned primarily with survival, it is reasonable that the infant is concerned with knowing the location of the person who will meet their needs.

Ultimately, of course, the skill of horizontal eye tracking will be used for tracking words across the page. So, in effect, reading begins during the pons level stage of development, when one of the primary triggers for this skill is crawling on the belly. Crawling serves as stimulation to this entire brain area, setting the stage for and prompting horizontal eye tracking. Competent crawling thus creates the foundation for important factors in our eye tracking skills and reading.

One additional visual factor is to be considered at the pons level of brain development. During the pons level/crawling phase, the baby is stimulating the nerves that go to the muscles that pull the eyes outward. An eye that does not have the proper signal may over-converge and you get what is known as a 'cross eyed' child. One or both of the eyes might over-converge.

Stage III – Midbrain/Mid Cerebrum Level: Appreciation of Detail, Vertical Eye Movement and Convergence

At this stage of development, between 7 and 12 months, visual acuity has improved in the infant. This child still enjoys looking at the human face best, but knows one person from another. So, the baby who was, up until this time, flirting with strangers in public, will now be wary of unfamiliar faces. The infant is looking for familiar faces and may seem to develop 'stranger anxiety'. The truth is that this child did not realize there were any strangers before this developmental stage.

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A baby at this developmental stage is now fascinated with detail and will become the child who creeps on hands and knees across the floor to pick up a dust fuzzy or a toy and examine it closely, just a millisecond before popping said object into its mouth.

This is the same detail appreciation that we carry with us as we grow. It allows us to see details against a background of other visual information, to find a word on a page, to notice where you have dropped your keys, to locate a checkbook on your desk amid a pile of papers.

Later in life, the child develops categorizing abilities that are related to vision. Cleaning a room involves seeing the category of things that are 'Legos', and putting them away, then the category of 'books', putting THEM away, the category of dirty clothes, the category of toy cars, all going in their proper place quickly. This is possible because the eye can see the detail and group those items visually regardless of the chaos of the background visual information.

As well, at this stage, we begin to mature our ability to filter out excess and unnecessary information. At this level, the thalamus modulates the magnitude of response to the input so that we can, for instance, tolerate a reasonable level of light or be outdoors in the sun without discomfort.

Vertical tracking, the smooth movement of the eyes up and down, is developed at this level of visual integration. Reading is deeply dependent upon not only the horizontal tracking skills that were developed earlier, but also vertical tracking skills. This skill allows us to read down line by line without losing our place in the previous line of words. Students without this skill will, for instance, pick up a word from a line above or below and insert them inappropriately into the sentence.

You will frequently find students, both children and adults, with this problem holding a flat edge or ruler under the lines of words so that they don't get any interruption of information from above or below. They will then pull the ruler down to the next line when they are ready for it, without going back to the beginning of the line they just read.

Vertical eye tracking is also needed to cope with columns of numbers, or data of any kind that is put into a column. Additionally, when a student looks up to a screen or board at the front of the class and back down to a paper in front of them, poor vertical tracking can cause them to lose information during the short course of this visual journey.

A major visual skill that develops during this period, a skill strengthened by hands and knees creeping, is bringing the eyes into convergence. And while convergence is often not completed until the time the child begins to develop cortical brain functions, the activities of the midbrain are the prompts and support for the brain to create this critical skill.

To read with ease we must have two eyes that look at the same thing at the same time. And if one examines the brain structure, it is evident that the nerves that go to the muscles that pull the eyes IN, go through the midbrain. The more the child creeps on hands and knees, the stronger the visual convergence and the better preparation this child has for reading.

Children whose eyes do not track or converge have multiple and varied challenges with reading. This is the child who may read a line of words but not understand their meaning. In this case, the dominant eye

may have wandered away from the letters and even though the eyes are tracking the words, poor convergence is creating a double, blurred, or moving image that cannot take information to the brain.

Students whose eyes do not converge will often talk about the letters 'wiggling' on the page. Perhaps they even describe words that wiggle off of the page altogether! Some students, whose eyes diverge intermittently, experience the letters switching from grey to black, grey to black, as they go from two fuzzy images to one solid image.

It is important to realize that the vision an individual has is the vision they are used to and they cannot imagine seeing in a way other than the way they see now. As a result, most clients cannot tell you that they see double because this is the way the world has always looked. Additionally, the brain cannot make sense of a double image and will compensate by creating the impression of a blur, or movement, or the brain may start to shut down the image coming from the other eye.

Good visual convergence is also critical in helping us move through the world. When we have three-dimensional vision, which is the result of good eye convergence, we know exactly where things are around us, which prevents us from bumping into doorframes or misjudging the step down from a curb.

Convergence is also critical for sports activities, such as catching, hitting, or kicking a ball accurately, being able to know where a target is in space, etc.

The child who is going through the full range of developmental activities that occur during the midbrain phase of growth will integrate good convergence when they are creeping on hands and knees, because the nerves that pull the eyes into alignment from a divergent position go through the midbrain and are stimulated by midbrain activities.

As well, we note that the vestibular system is closely associated with the ocular nerves in the brain. And we note that high levels of vestibular activity - spinning, rolling, being tossed in the air - as so many daddies do with their babies, all stimulate the vestibular system, which strengthens the visual system.

Children and adults with poor visual convergence may compensate in a wide range of ways to feel safe in a world in which their vision does not work. They may walk close to a wall, or need to touch things as they go, to reinforce where they are in space. They may be cautious crossing a street because they cannot judge the distance to the other side. You might see this individual bumping into walls and furniture, or you may notice bruising from frequent mishaps.

In our work we have seen anxiety disorders, even agoraphobia, arise from these vision issues. If we cannot see the world as it is, we might see buildings appear to move, we might not know exactly how far we are from a moving car, or how to move our body through a crowd of people. The world can appear fraught with danger if your eyes do not work together.

Visual convergence is a strong indicator of good learning and one of the signs of a healthy midbrain.

When we consider learning disabilities, we want to look with great care at any abnormal functioning in visual competence. Reading problems are, almost universally, not cognitively based, but are perceptual problems that, if corrected, open the door to reading. All students who are being tutored in reading

should have a full visual competence screening before beginning any program that assumes that they can see the words, but simply are not understanding what they are seeing.

Stages IV – VII – Cortex Level: Cortical Visual Competence

Once the child begins to integrate their cortex, we witness the emergence of a new stage of visual skills. This child is very likely to be able to identify simple geographic shapes arranged to represent a boat, a house, a tree. It is an amazing brain that can take very simple shapes, such as a triangle on top of a narrow tall rectangle and understand that represents a tree. But as amazing as this leap is, it happens in very young children and is the basis for reading.

If a child can see that simple geographic shapes and lines represent a cat, for instance, then it will not be long before the child understands that 'c' makes a sound that starts the word 'cat', and that c-a-t is the way we represent the word 'cat'. Once this discovery is made, the child will, in the absence of any of the above-mentioned visual-motor problems, gain an ever-greater reading vocabulary.

If this skill is not emerging, it is critical to check either visual acuity (the field of Ophthalmology) or look at visual tracking and alignment issues that are the purview of developmental specialists.

Once convergence is established in the cortex as the result of lower brain level integration, the last skill to emerge is lateralization. A well-lateralized brain is informed by a neurological system that is right- eyed, right-eared, right-handed and right-footed, or one can be lateralized all on the left. The important consideration is whether we are consistent. A well-lateralized brain sends dominant hemisphere information to one side of the brain, and the "big picture", emotional, non-dominant hemisphere information to the other side of the brain. We do NOT want to encourage bi-lateral or mixed dominance. Mixed dominance compromises learning, memory, and processing speed, and is often found in learning-disabled students.

Mixed laterality is problematic because it causes us to store information in multiple areas of the brain, rather than consolidating the material efficiently, making it difficult to retrieve stored information. Thus, laterality affects reading comprehension, as well as the way we take in and store information. A brain that is informed by mixed laterality can be inefficient, and memory and learning can be random rather than consistently effective.

Laterality is a marker of good brain function that is often overlooked, but its acquisition can be critical in the establishment of a brain functioning at the highest possible level. The book *Neurological Organization and Reading*, by Carl Delcato, is a brilliant exploration of the importance of laterality in the original development of spoken and written language in the human species. Laterality is critical to cortical brilliance, and this work, published in 1966, has been unfortunately overlooked and could be explored again when we consider the learning challenges of our children.

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Testing

Tools needed: a pen light and a translucent/plastic 'finger puppet' to put over the light to dampen the intensity of the light and give the client an object on which to focus.

Stage I – Medulla/Spinal Cord Level: Pupillary Reflex

Test process:

- Shine the light at the bridge of the nose, equidistant from both pupils for 5 seconds, then take it away.
- Wait for at least 10 seconds and repeat, until you can see the pupillary response.
- Both pupils should contract equally when the light is presented and dilate equally when the light is taken away.

What to note on your chart:

- Do both pupils contract when light is presented and begin to dilate when taken away? If no, note on chart.
- Do pupils respond equally? If no, note on chart.

Stage II – Pons Level: Outline Perception and Horizontal Eye Tracking

Test process:

- Shine the light at the bridge of the nose, at about 8 to 10 inches distance.
- Instruct the client to 'keep your eyes on the puppet'.
- Move the light across the visual field from right to left and back slowly and steadily, forming a horizontal arch.
- Make sure the light maintains the same distance from the nose, as if a string connects the light to the bridge of the nose, thus forming the 'arch'.
- If the client moves their head, place your finger lightly on the chin as a hint to remind them that they don't need to move the head, in case this is just a habit and not a visual motor deficit. Do NOT tell them and do not allow parents to tell them to 'keep their head still'. In a school setting, no teacher will support the child by holding their head still while they move their eyes independently. We want this skill to be automatic when the child reads. In the testing, we need to see their natural response.
- If the client asks, "Can I move my head?" respond with "Do whatever feels right." Again, we want their natural, uninformed response.

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- The eyes should track smoothly, independent of head movement, without any skips, jumps, bounces or stutters. Note particularly any skips at the midline.
- If the tracking is initially smooth, continue tracking to see if stress will cause their eyes to skip in any way. This helps us understand how prolonged reading may stress the client's eyes.
- Note if the tracking may be restricted in its range and the eyes stop tracking before they reach the outer corner of the eye.

Interesting note: Asperger's clients may have many visual motor issues that would seem to imply that they would be poor readers. However, they are often excellent readers, even reading far above their grade level. This is due to the fact that even though their general visual world is overwhelming, a book stays at a fixed distance from the eyes and they can 'set' their eyes for that distance and stay there. However, if you ask them to attend elsewhere, they may have a great deal of difficulty pulling themselves out of the book.

What to note on your chart:

Outline perception (information taken from the interview with parents or caregiver).

- Are they drawn to the human face? If not, note on chart.
- Is the patient considered 'cortically blind'? If yes, note on chart.

Horizontal Eye Movement

- Does horizontal eye tracking involve the head, or head and upper body? If yes, note.
- Are there restrictions in how far they can track before they either use their head, or completely stop tracking? If yes, note.
- Do the eyes roll, skip, or jump as they move horizontally? If yes, note.
- Does the problem show up only to one side? If yes, note which side.
- Do they have a skip at the exact middle of the visual field? If yes, note.

Stage III – Midbrain Level: Appreciation of Detail, Vertical Eye Movement and Convergence

Test process:

Vertical Eye Tracking

- Shine the light at the bridge of the nose, at about 8 to 10 inches distance.
- Instruct the client to 'keep your eyes on the puppet'.
- Move the light slowly across the visual field from up to down and back up several times.
- Always keep the light the same distance from the bridge of the nose.
- Use the same instructions given for 'horizontal tracking' if you see any head movement.

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- The eyes should track smoothly, independent of head movement, without any skips, jumps, bounces, or stutters. Note particularly any rolling out to the side of one or both pupils as the eyes go up and down.
- If the tracking is initially smooth, continue tracking to see if stress will cause their eyes to deviate in any way.
- Note if they cannot go all the way up or all the way down without head movement.

What to note on your chart:

- Does vertical eye tracking involve the head, or head and upper body? If yes, note.
- Are there restrictions in how far they can track up or down before they either use their head, or completely stop tracking? If yes, note.
- Do the eyes, roll, skip, or jump as they move vertically? If yes, note.
- Does the problem show up only going up or only going down? If yes, note.

Test process:

Convergence

Convergence is the ability of the two eyes to work together so that both eyes look at the same thing at the same time, preventing double or blurry vision. The blurry vision that arises from poor convergence is not an issue of visual acuity (near sightedness, far sightedness, astigmatism), but are, rather, developmental issues.

- Begin about two feet away and slowly move the light in, pointing at the bridge of the client's nose.
- Tell the client to keep watching the light as it comes towards them.
- Note where the light reflects in the pupil, using a dot on the circles that represent right and left pupils.
- Envision that the client's eyes look like the drawing below, in four quadrants.

Right eye Left eye

Seeing whether the eyes converge, or if they cannot converge, turning either in or out, gives us information about the level of development that needs to be addressed.

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Convergent strabismus, a pons level issue:

Eyes that over converge or look 'crossed', as the result of damage or an immaturity at the pons level of the brain and crawling, is one of the triggers that can support the eyes being pulled outward and into position. You will be noting whether the eyes turn in and if so, whether it is one or both eyes.

Below is a representation of a bilateral convergent strabismus with the light shining in the outer half of the pupil.

Divergent Strabismus, a Midbrain Level Issue:

Eyes that diverge or look 'wall eyed' reveal an injury or immaturity at the midbrain. Creeping on hands and knees is one of the most important triggers to support the eyes being pulled back in to alignment. You will note whether the eyes turn out, and if so, whether it is one or both eyes.

**note-overexaggerated for understanding.*

Remember: Convergence is one of the last visual functions to fall into place and arises as the cortex comes on board, but it is the pons and midbrain level activities that support the development of this skill.

What to note on your chart:

- Use the visual aid on your chart, drawing a dot where you see the light reflecting in the pupil.
- If the light moves from the center of the pupil to a divergent or convergent position (see above for definition) due to the stress of looking at the light, note that.

Stage IV – VII – Cortex Level: Laterality at Far Point and Near Point

Far point test process:

- Client stands approximately six feet away from consultant.
- Consultant closes one eye and states 'point to my open eye' (demonstrate if necessary).

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- Note which eye is covered up by the client's pointing finger. You will see it either over the left eye, in which case the left eye is dominating, or the right eye, in which case the right eye is dominating.
- You may not see the finger over the eye, but between the eyes or above or below the eyes, in which case you will ask the client if they are seeing two fingers. If they are, tell them to 'Choose one of those two fingers to point at my eye'.

What to note on your chart:

- If the finger covers up one of the eyes, note which eye.
- If the finger is above, below, or to one side of the eye, note that.

Near point test process:

- Client will sit up to a table or desk with pen/pencil and paper in front of them with the writing tool placed at their midline.
- Ask the client to write a sentence or their name. If they are not yet writing, but are more than six years old, ask them to make circles across the paper.
- If they are using the right hand, note that, if left hand, note that.
- The dominant eye will be tipped up or elevated, leaving the head at an angle.
- The angle of the spine and head of a client who has the same dominant eye as hand will, when viewed from behind, make a 'C' shape. This is what we hope to see.
- If the head tips one way, then the other, as the client writes, or if the head remains in the middle, they do not have a consistent dominant eye. The writing often changes when the client switches eye dominance.

What to note on your chart:

- If the right hand is writing and the right eye is elevated, they are right dominant. Note both eye and hand dominance.
- If the left hand is writing and the left eye is elevated, they are left dominant. Note both eye and hand dominance.
- If hand and eye dominance differ (Ex: right-handed, but left eye elevated, or left-handed, but right eye elevated), note that.
- If the font changes when the head tilt changes, or if they switch back and forth from cursive to printing, note that.