CVI NOW
Perkins School for the Blind

The science behind visual fatigue and CVI

Research shows there is a neurological and physiological reason why individuals with CVI become so easily fatigued.

[(http://www.facebook.com/sharer.php?u=https://www.perkins.org/cvi-now/understanding-cvi/the-science-behind-visual-fatigue-and-cvi?fbclid=IwAR38TLxSHrfpQX6ID0FDR_SDUimxon2EjbG-VTnsbx-XFC7O0X8iDoRTK4s)]

[(https://twitter.com/intent/tweet?text=The science behind visual fatigue and CVI%20https://www.perkins.org/cvi-now/understanding-cvi/the-science-behind-visual-fatigue-and-cvi?fbclid=IwAR38TLxSHrfpQX6ID0FDR_SDUimxon2EjbG-VTnsbx-XFC7O0X8iDoRTK4s%20via%20@PerkinsVision)] [(https://linkedin.com/sharing/share-offsite/?url=https://www.perkins.org/cvi-now/understanding-cvi/the-science-behind-visual-fatigue-and-cvi?fbclid=IwAR38TLxSHrfpQX6ID0FDR_SDUimxon2EjbG-VTnsbx-XFC7O0X8iDoRTK4s)

(mailto:?subject=Look%20what%20I%20found%20on%20Perkins:%20The science behind visual fatigue and CVI&body=Check%20out%20what%20I%20found%20on%20Perkins.org:%20https://www.perkins.org/cvi-now/understanding-cvi/the-science-behind-visual-fatigue-and-cvi?fbclid=IwAR38TLxSHrfpQX6ID0FDR_SDUimxon2EjbG-VTnsbx-XFC7O0X8iDoRTK4s)

Families deal with the fatigue that overcomes their child with CVI daily. Visual fatigue is often one of the most common shared experiences amo

individuals with CVI. Scientific research is beginning to support what parents see every day and explain why our kids with CVI experience chronic fatigue.

As parents, we've heard it all about our kids: not available for learning, task avoider, inattentive, lazy, doesn't show any interest, easily distracted, always angry and frustrate has a severe behavior problem, can't sit still, can't follow directions, and unfortunately t list goes on. All words that blame the child, rather than seeing fatigue as a key contribu to visual difficulties associated with CVI.

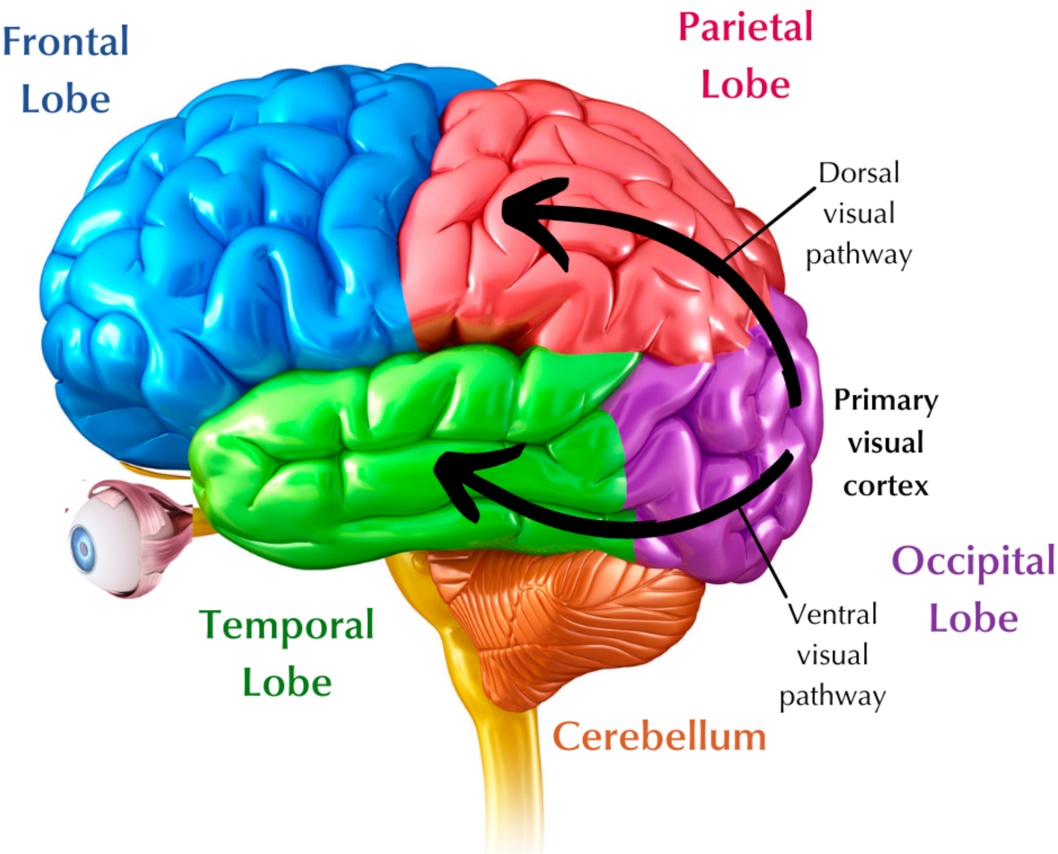
Behavior is communication. There is a neurological and physiological reason why individuals with CVI become so easily fatigued. And each individual with CVI shows this visual fatigue in their unique way. Some examples include resting head in hands, pushi all items out of view, running away, looking away, closing eyes, falling asleep, putting th head down, talking, singing, or telling jokes to change the interaction to an auditory event, yelling, or other outward behaviors.

To understand why individuals with CVI become so easily visually fatigued, we need to start with how the brain processes the visual world.

Visual processing requires the connection and integration of many areas in the brain. David Eagleman, neuroscientist and author of *Livewired: The Inside Story of the Ever-Changing Brain*, described that we have hundreds of trillions of connections between neurons, and it's the continuous altering of this circuitry to "match the demands of the environment" that make up the "dynamic system" of the brain. Connectivity of the early visual pathway (eye to the primary cortex in the occipital lobe) and higher visual pathw (dorsal stream: occipital to parietal lobe and ventral stream: occipital to temporal lobe) enables us to survey an environment, locate and recognize a target of interest, and then choose a plan of action.

Our visual system is highly efficient at processing every aspect of our visual world. Generally, our life experiences feed our visual memory, which then shapes perception, a allow us to come up with a plan of action. Lotfi Merabet, a clinician-scientist at the [Laboratory for Visual Neuroplasticity (https://scholar.harvard.edu/merabetlab)](https://scholar.harvard.edu/merabetlab) at Massachusetts Eye and Ear and Harvard Medical School, notes, "The way we see the wo is heavily influenced by what we expect to see." For example, think about how your perception of a visual illusion can change, even though the image itself doesn't change We have a visual template that we are consistently using to match what we see.

Dr. Josef Zihl and Dr. Gordon Dutton describe that our visual system allows us to visuall search for targets among competing distractors, attend to this target while ignoring otl stimuli, and then match the target to our visual library to support the speed and efficiei of recognition. It's also important to realize that when searching for an object, it's not ju about where to look, but also where not to look. In other words, the brain has to keep track of what it's looking for and ignore information that is not relevant. As far as the vis brain is concerned, this is a delicate balancing act.



From his team's ongoing research and study of CVI, Dr. Merabet finds that the neural network of a CVI brain is "fundamentally different."

Research shows that many individuals with CVI have difficulty with visual attention and visual search (see references below). Individuals with CVI typically engage in **serial processing**—that is "scrutinizing" one piece of information at a time—when there is m sensory information to take in. Serial processing is a less efficient form of visual search. This is opposed to parallel processing, where many elements of a visual scene can be processed at the same time.

It also appears that the threshold to be able to process multiple items at once in CVI is much lower. Individuals with CVI have to work much harder when attempting the same visual tasks as their sighted peers. And often these tasks have to be adapted for individuals with CVI to have full visual access. According to Dr. Merabet, "With an increased visual load, individuals with CVI have to grind it out, as opposed to having th instantaneous capture of information we see with a really efficient visual system."

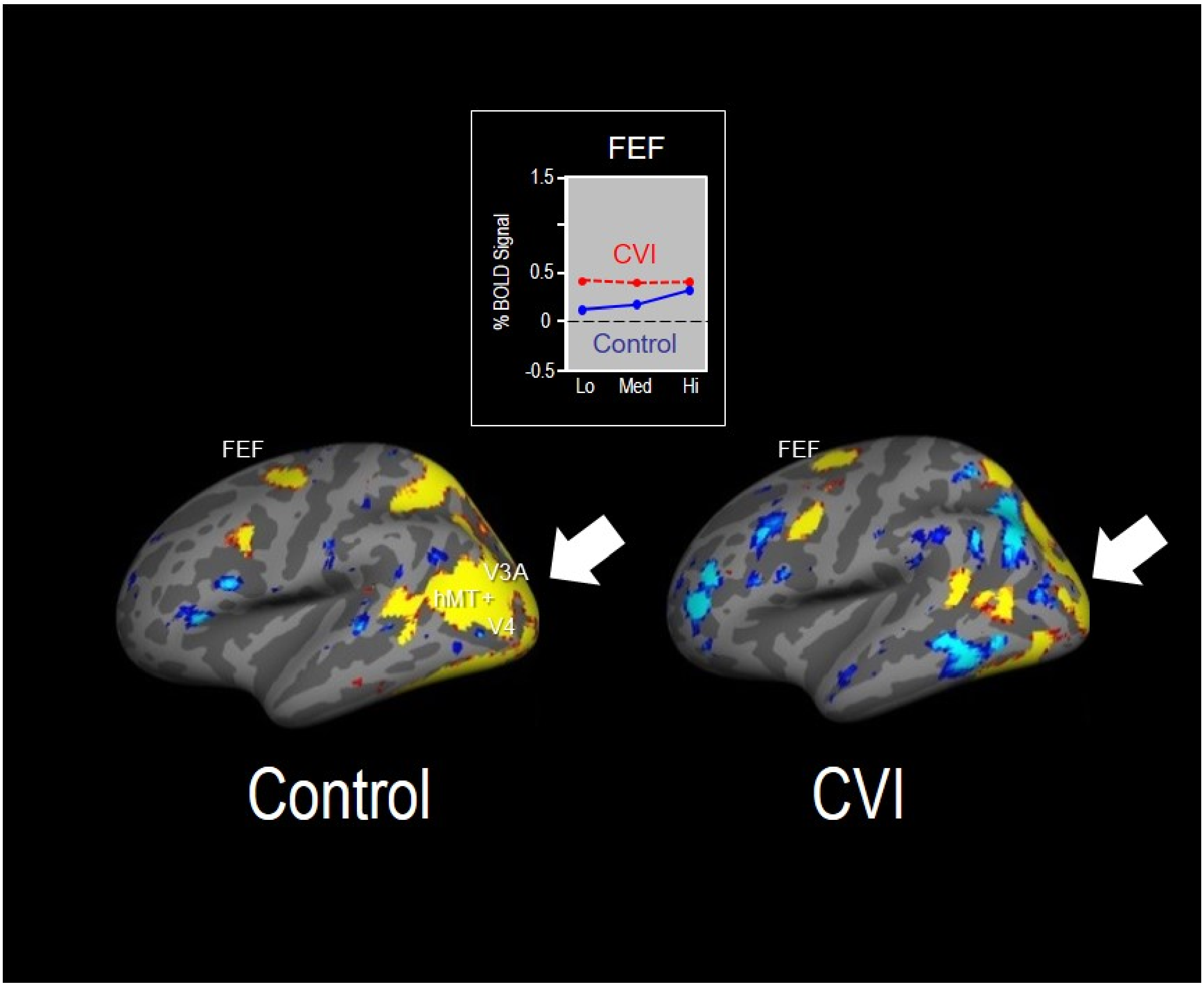
An efficient visual system knows what to ignore in order to visually search and attend. D Merabet states that individuals with CVI can have difficulty knowing where to look and where not to look: "The more you have to ignore and rule out, the narrower your scope the more you have to search. These knock-off effects are what eventually leads to this frustration and anxiety of not finding the target your classmates have found quickly, fo example, which perpetuates throughout each day causing this vicious cycle of frustrati and fatigue."

Dr. Merabet's team at the Laboratory for Visual Neuroplasticity uses virtual reality to stu the CVI brain, including visual search patterns. For the virtual toy box (https://vimeo.com/224532739) task, the individual has to locate a specific toy. The more distractors (other toys and clutter) inside the box, the more time is needed to find the target toy, and the visual search pattern is more scattered. For the virtual hallway (https://vimeo.com/224489624) task, the load effect is particularly evident in the kids with CVI. The more people walking in the corridor, the harder it is for the child with CVI to fin the target person, lock on and pursue it. This is a much more demanding task than the box because not only do you have to find the moving target, you have to lock on and b able to track it for a period of time.

A working hypothesis based on early research from Dr. Merabet's team is that the fronta eye field (FEF) in the frontal lobe, which controls eye movement and visual attention, is more active with the presence of CVI.

> "It seems that the frontal cortex has to work harder to make up for the fact that early visual areas are not doing their part, so to speak, in visual processing. And this may be related to why kids with CVI are so much more fatigued with increased attention demands. So if the early and higher-order visual areas are nc processing visual information as easily, the frontal cortex has to take on the load and work harder. And because the frontal cortex is also interconnected with mar other areas in the brain, including attention and emotion, things can break dow easily with excessive fatigue. A lot of kids with CVI we work with tell us about the frustration they experience, the sensitivity to clutter, and how exhausted they ar at the end of the day. We think this is because their visual system is not as efficie as it should be—the brains of individuals with CVI have to work harder to carry out tasks that may be very simple to someone else." -Dr. Lotfi Merabet

Take a look at the fMRI image below. The arrow indicates activation in early visual processing areas (less activation in CVI overall). Notice that the frontal eye field (FEF) is active in both the control and CVI subjects, but if you look at activation as a function of task demand (line graph figure), you notice that the control shows a graded effect, whil the CVI subject has sustained activation ("working harder") across all task demand level This is a working hypothesis as part of ongoing research to see if this trend is present in larger number of individuals with CVI.



Visual fatigue is a condition of CVI that must be carefully assessed and supported. Furthermore, this is not something that is typically assessed in a routine eye exam.

Explore the next two articles in this series about CVI and visual fatigue. Learn more about the [signs of visual fatigue (https://www.perkins.org/cvi-now/parenting/parents-share-how-their-children-with-cvi-show-visual-fatigue)](https://www.perkins.org/cvi-now/parenting/parents-share-how-their-children-with-cvi-show-visual-fatigue) and [supports that help to reduce visual fatigue (https://www.perkins.org/cvi-now/parenting/6-big-ideas-to-help-to-reduce-visual-fatigue-in-children-with-cvi)](https://www.perkins.org/cvi-now/parenting/6-big-ideas-to-help-to-reduce-visual-fatigue-in-children-with-cvi).

Further resources to explore:

- Learn more about the research projects (https://scholar.harvard.edu/merabetlab/research) at the Laboratory for Visual Neuroplasticity at Massachusetts Eye and Ear and Harvard Medical School
- CVI Scotland created simulations (https://cviscotland.org/mem_portal.php?article=267 based on how individuals with CVI reported their unique vision. The simulations show their theory that the more objects in an environment, the more the spotlig of visual attention narrows—it's as if the visual field shrinks.
- In discussions with optometrists, Dr. Nicole Ross (https://www.perkins.org/cvi-now/understanding-cvi/medical-expert-qa-diagnosing-cvi) and Dr. Barry Kran (https://www.perkins.org/cvi-now/understanding-cvi/no-patient-is-untestable-cvi-qa-witl dr-barry-kran), both shared how they need to consider this fatigue in their low visi evaluation. Providing visual breaks and supports is a vital part of gathering information about patients' functional vision.

References:

Bennett C.R., Bailin E.S., Gottlieb T.K., Bauer C.M., Bex P.J., Merabet L.B. (2018) Virtual Rea Based Assessment of Static Object Visual Search in Ocular Compared to Cerebral Visual Impairment. In: Antona M., Stephanidis C. (eds) Universal Access in Human-Computer Interaction: Virtual, Augmented, and Intelligent Environments. UAHCI 2018. Lecture No in Computer Science, vol 10908. Springer, Cham.

Bennett, C.R., Bauer, C.M., Bailin, E.S., Merabet, L.B (2018). Neuroplasticity in cerebral visu impairment (CVI): Assessing functional vision and the neurophysiological correlates of dorsal stream dysfunction. *Neuroscience & Biobehavioral Reviews*, Volume 108: 171-181. https://doi.org/10.1016/j.neubiorev.2019.10.011

Das, M., Bennett, D. M., & Dutton, G. N. (2007). Visual attention as an important visual function: an outline of manifestations, diagnosis and management of impaired visual attention. *The British journal of ophthalmology*, 91(11), 1556–1560. https://doi.org/10.1136/bjo.2006.104844

Eagleman, D. (2020). *Livewired: The Inside Story of the Ever-Changing Brain*. New York: Pantheon Press.

Philip, S.S. and Dutton, G.N. (2014), Cerebral visual impairment in children: a review. *Clir Exp Optom*, 97: 196-208. https://doi.org/10.1111/cxo.12155

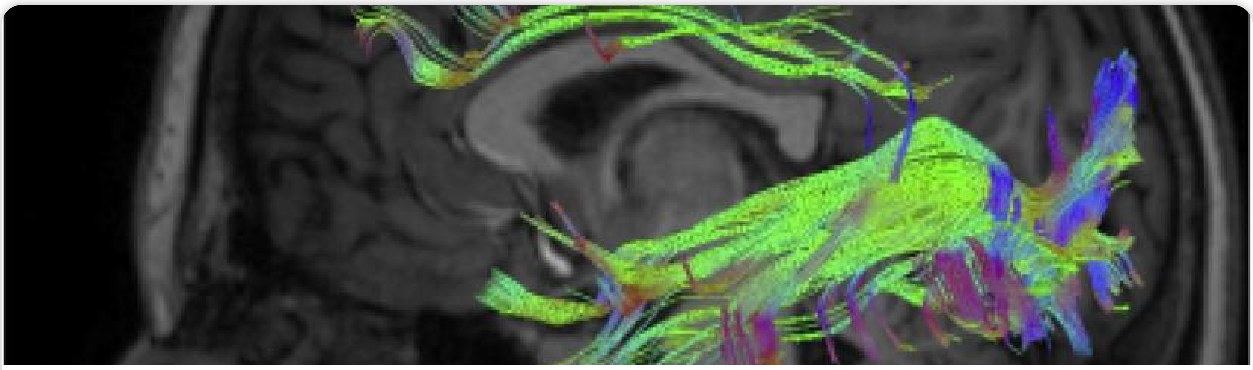
Roman-Lantzy, C. (2018). *Cortical Visual Impairment: An Approach to Assessment and Intervention*. 2nd ed., New York, NY: AFB Press.

Tietjen, Matthew. (2019). The "What's the Complexity?" Framework. In Roman-Lantzy, C *Cortical Visual Impairment: Advanced Principles* (pp. 92-150). Louisville, KY: APH Press.

Related Stories

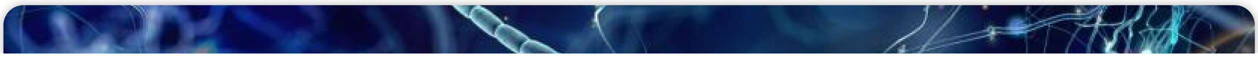
Understanding visual behaviors and CVI characteristics

Children with CVI tend to display key visual behaviors. Understanding how to address the following tendencies can go a long way in supporting your child.



Cortical Visual Impairment vs. Cerebral Visual Impairment

By now you've probably heard CVI referred to as both Cortical Visual Impairment and Cerebral Visual Impairment. What does each name mean?



CVI and the brain: Q&A with Dr. Lotfi Merabet

A talk with Dr. Lotfi Merabet, a clinician-scientist conducting research on CVI and brain-based visual impairments, for some straightforward explanations