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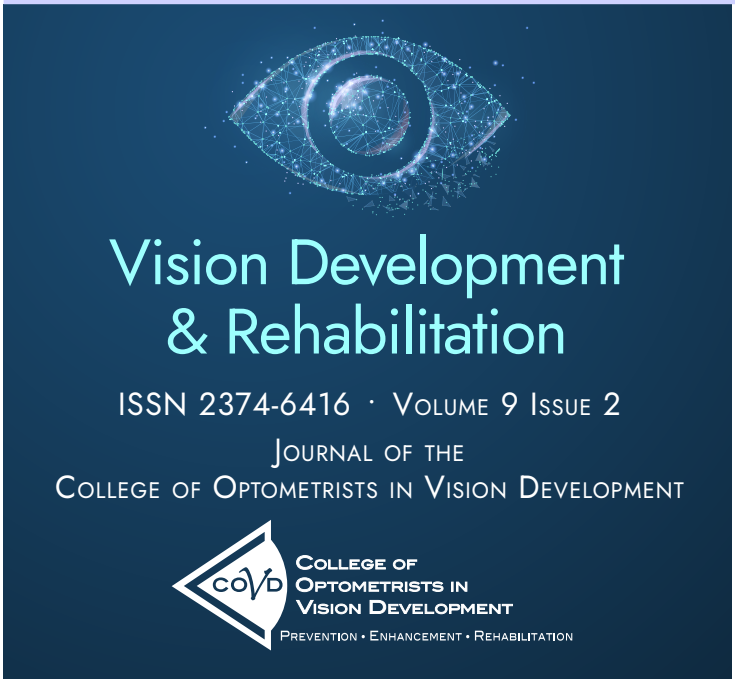

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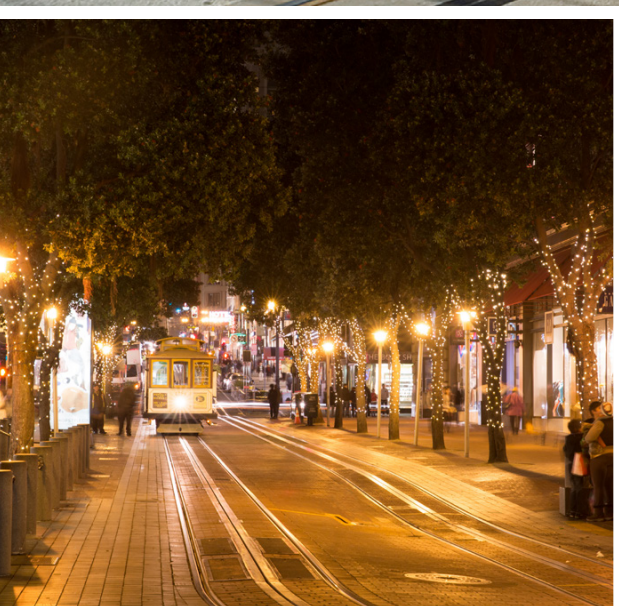


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EDITORIAL

The Ghost of Skeffington Past

Leonard J. Press, OD, FAAO, FCOVD,
Editor-in-Chief

The Ghost of Christmas Past looms large in Charles Dickens' *A Christmas Carol*, visiting Ebenezer Scrooge to conjure scenes from his past. Dickens' work is a classic rendering of memory and interpretation. He is an iconic figure in large measure owing to his character "Scrooge" persisting as part of the English lexicon. I'd like to suggest that in some ways Skeffington emerged to become a similarly larger-than-life figure in our field.

For many years it was commonplace for lecturers on the continuing education circuit, and for authors writing about developmental and behavioral vision, to parse information through a Skeffingtonian filter. In particular, Skeffington's four circle model was frequently referenced, with the concept that vision was an emergent process of four overlapping Venn-like circles: Centering, Identification, Anti-Gravity, and Auditory-Speech/Language.

Centering and identification foreshadowed the cognitive elements of accommodation and convergence, perhaps best understood in the framework of embodied cognition. Skeffington no doubt would have been intrigued by many aspects of cognitive neuroscience. Anti-gravity anticipated how vision would factor heavily into the disciplines of occupational and physical therapy, and auditory-speech language to a lesser extent into speech-language pathology. A. Jean Ayres, an innovator in these domains, readily modeled developmental optometrists who were following Skeffington's lead.

While Skeff's four circle model was the historical antecedent of intersensory integration, his notion of vision as an emergent process was equally if not more prescient. Emergence has become part of contemporary scientific lexicon as representing any process that is greater than the sum of its components. It is the flip-side of reductionism, which tends to isolate components of a system for study and treatment, and runs counter to the nature of holism. Having remained dormant for many years, emergence is a concept that is emerging as mainstream in various circles of research and clinical care.

Yet ironically, Optometry at large has never seemed comfortable with incorporating Skeffington's concepts into the framework of research or clinical care. In the early 1990s while putting the finishing touches on a textbook on Pediatric Optometry that I co-authored with Bruce Moore, Marty Birnbaum and I spent many hours in the SUNY library discussing this as he was putting his finishing touches on his textbook, "Optometric Management of Nearpoint Vision Disorders". He wrote an entire chapter that addressed this divide, but opted to leave it out because it was too controversial.

Every now and then a journal editor is privileged with the good fortune of receiving a manuscript that reads as a gift, its special nature evident with the turn of each page. Such was the case when Dr. David Cook submitted his manuscript addressing in part what we might consider to be "The Ghost of Skeffington Past". Many of you know David

from his pithy comments on the VTOD listserve, where he has a knack of putting challenging concepts into tidy philosophical boxes. (Or not.) In his Perspective piece in this issue,[1] using familiar Skeffingtonian filters at the outset, Dr. Cook deftly guides us through interpretations of the CITT-ART study in a way its authors may have been reticent to undertake.

Before citing a couple of key comments from Dr. Cook's perspective, it is important to note that the CITT-ART study in all of its phases was a monumental undertaking. Anyone involved in research design or implementation can appreciate the incredible skill and effort that was poured into this venture.[2] Any post hoc analysis is bound to sound like back-seat driving to some extent. You may recall that Dr. Mitchell Scheiman, principal investigator of the CITT-ART, did a presentation on the implications of the study during the virtual CE meeting of COVD in 2021. That prompted me to write a blog about it titled "There's a Beautiful Baby in That Bathwater",[3] with Dr. Cook chiming in about the placebo effect, and those chimes became the basis for his Perspective piece.

There are many thought-provoking observations that Dr. Cook offers here, but among them two stand out in my mind, the first being deceptively simple and the second being deceptively complex:

1. *The investigators' conclusion seems to say: we should be equally concerned whether the findings get better and the patient does not or the patient gets better and the findings do not.*
2. *Fusion is the simultaneous uniting of the four circles in agreement. Centering, value (including feelings), body, and language all must simultaneously agree on the unification. Images are not really "fused" if the feelings or words in the mind of the patient suggest the images are not really united. Images are not really fused if the hands and the body disagree with the union. Images are not really fused if they have not been simultaneously selected for value or action. From this viewpoint, classical vision therapy is merely one approach to coherence of the four circles, the only difference being that in the classical model all non-vergence/accommodative inspired improvement in performance (body movement/colored filters/yoked prisms/magnifying lenses/language directed novel seeing) are dismissed as "placebo," not being specified by the limitations of the vergence/accommodative paradigm.*

If Dr. Cook had limited himself by filtering his polemic about the CITT-ART entirely or even largely through the Skeffingtonian model, we would have witnessed another constraint of the ghost of Skeffington past. But he goes well beyond that and, I daresay, exhibits the type of critical thinking crucial to the ongoing evolution and maturation of our field.

Permit me to leave you with Dr. Cook's concluding sentences which, I trust, will inspire you to read his Perspective in its entirety:

As we connect with patients in novel worlds, they are remade. We are remade. Still our art is intimately bound to the real science that has changed the world. Lenses, prisms, computers, vectograms, liquid crystal, virtual reality, augmented reality—none would exist without science. At its best, science inspires new opportunities for action. The real contribution of the CITT-ART is not as a weapon to restrict creativity, but as a tool of freedom from the tyranny of the classical paradigm. The CITT-ART frees us to understand our art as not limited by numbers but only by our ingenuity in arranging worlds of lighted opportunities for novel action and value.

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Dr. Leonard Press is Editor-in-Chief of *Vision Development & Rehabilitation,* the official journal of COVD. He is also an associate editor of *Elsevier's Practice Update Eyecare,* a weekly online review of scholarly papers in the ophthalmic field. Author of the widely acclaimed *"Applied Concepts in Vision Therapy",* he recently completed a 2.0 edition with Drs. Taub and Schnell and a cadre of optometric authors. Dr. Press maintains a private consulting practice in Lakewood, New Jersey, specializing in the treatment of vision-based reading and learning difficulties. He is a Past-President of COVD, and of the New Jersey Society of Optometric Physicians (NJSOP). A recipient of COVD's Skeffington and Getman Awards, he has also received the NJSOP's Scientific Achievement Award on two occasions and its Lifetime Achievement Award.

PERSPECTIVE

Even Professional Baseball Players Need a Hitting Coach: Why Every VTOD Should Consider a Consultant

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> *Mark Twain said "The two most important days in your life are the day you're born and the day you found out why."*

As a baseball fan I have wondered on occasion what sage advice a hitting coach gives to a major league batter. Likely the hitter has been hitting a small ball with a bat for many years. Also, likely this batter is good at it. However, he may be struggling in the moment, not for lack of knowledge, not for strength, but simply from lack of awareness. Perhaps he's changed his stance a bit, perhaps he's moved his hands down the barrel of the bat unintentionally. Either way every major league baseball team has a coach designated to give feedback about one of the most fundamental aspects of the game of baseball. Business is hard, the business of optometry is hard and specific. The business of running an optometric practice that is solely vision therapy oriented or a significant portion of the income is from vision therapy services presents itself with its own unique challenges. We as optometrists are smart individuals; however, we are not without fault. In recent years social psychology as taught us a lot about our propensity for making mistakes and rationalizing them as well as our unawareness to our unawareness. For some owners of a vision therapy practice the struggles can be very apparent. Some problems can include lack cash flow, or even lack of cash, all of our free time devoted to the business, or difficulties with employee management. Business acumen can come easily to some, but for others the lack of business knowledge hurts productivity as well as the personal reward associated with ownership. I have personally experienced both the highs and lows of business ownership and a mistake I feel I made in hindsight was not getting professional advice sooner. I needed to pay someone to tell me how to do fundamental aspects and things I thought I had been doing for many years, and I think many of us should as well. After twelve years of ownership, I decided to hire my first consultant. A few years later I hired another, and a few years later yet I hired a third. By the time I sold my practice after twenty years my vision therapy practice went from averaging twelve patients a week to over sixty. My revenue from vision therapy services had tripled, and I was spending more time with my family. Even so ownership was still with challenges, and things were far from perfect. The insight however, to create systems and solve problems was invaluable. Consider the idea that if you own an optometric practice that offers vision therapy you might be terrible at the business aspect of it. Paying for an outside opinion may be your best option for success.

Optometrists complete a rigorous undergraduate course load which includes biology, chemistry, physiology, and physics. The graduate programs in

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optometry school are arduous and challenging. It is easy to characterize an optometrist as intelligent. My experience is most, if not all of the ODs who are interested in vision therapy also demonstrate a high level of caring, compassion and empathy. Many of these doctors (VTODs), understand the rigidity of optics, the semantics of glaucoma meds, but also are curious, observant and can think outside the box. What is more likely is many VTODs don't finish nearly a decade of post high school education learning about business.

We are wrong a lot. I don't have any statistics on this but it is common knowledge to err is to be human. Long before Descartes told us we are because we think St. Augustine made the statement "fallor ergo sum," I err, therefore I am. Unfortunately, when we make mistakes we deny them, respond as if we hadn't made them, ignore them, downplay them, or blame them on someone else. We know to be human is to err, yet we fail to see our own faults. In contrast, we excel at acknowledging other people's errors. Many times, I made errors in undervaluing what I did, undercharging, poor communication with patients, or staff, failed to market, failed to see the need to market, the list goes on. Many of these mistakes or errors I didn't feel "wrong" about. I could rationalize my theories and methods, my "reasons' for doing what I did. I imagine many business owners do this, and make many of the same mistakes. I don't think it's easy to admit fault. The reality is being wrong or making a mistake doesn't feel any different than being right. It is only when we discover we are wrong that we feel something different. A consultant can bring our errors to the forefront, help de-rationalize the mistakes and attack them head on.

In social psychology, naïve realism is the human tendency to believe that we see the world around us objectively, and that people who disagree with us must be uninformed, irrational, or biased. We assume the patient knows everything that we do. We make assumptions that the things we know, perceive and deduct are the same things others know, perceive and deduct. It is important to then get outside views. It is essential for an objective evaluation of your practice from your management skills to your marketing. We are blind to our blindness and need an outsider's view.

It took me a long time to accept the idea of hiring a consultant. After residency I joined the practice that I had initially been shadowing at during undergrad with the goal of ownership. Within a few years, I was the practice owner of a primary care office with vision therapy. My perception was my mentor at the time had a general distaste for consulting. Around this time, the book "House of Lies" was now the basis of a television show. The title of the book includes "How Management Consultants Steal Your Watch and Then Tell You the Time." I navigated practice growth with the Field of Dreams mantra, "If you build it, they will come". The idea if one does the training; has the equipment and staff; patients will just automatically come. At the time I had no formal training in management or marketing, just plenty of free advice from others. My perception was that hiring a consultant seemed to be a bad idea, a high-cost low reward endeavor. However, after years with limited growth, I decided to hire one. The drive for me, as I'm sure with many, was more time for myself and financial growth. I was a new parent, and finances were about to change dramatically, I also wanted the flexibility to be a parent who was present and available for his children. I wanted to be able to take a weeknight off to attend a piano recital, or have a Saturday to go to a soccer tournament.

My first venture into consulting was a large group of consultants who primarily dealt with general optometric practices. At the time my revenue from the therapy portion of my office was approximately 25 percent. I was told this group had an individual who could offer consulting for vision therapy as well as my optical and medical aspect of my office. The insight offered was immense. Everything from data collection, marketing, creating value, and management was covered over the calendar year. The contract ended with an onsite visit with the consultant. My revenue had nearly doubled in my optical portion of my office, my leadership skills had grown, and most importantly I learned the metrics to review to evaluate the health of the office. Even with these positive changes I still hadn't

learned how to grow my therapy services. Some principles are ubiquitous in any business such as creating value, employee management, community engagement. However, vision therapy is unique to our profession. Even within the profession relatively few individuals practice this aspect of optometry. I wanted to grow my therapy services and I felt I needed more insight.

I was under the false assumption that if I put the academic work in, I learn as much as I can doing the best therapy I can then people will just come. An example of my approach before consulting and after hiring a vision therapy consultant is evident in my presentation format. I loved talking about VT with other professionals and have for many years presented to local occupational therapists and physical therapists. My intention was to strictly educate. What I failed to do was actually market myself. I was also failing to listen to audience members who weren't just there to learn about vision therapy but were there because of a someone close to them who might be suffering from a vision related learning problem. Likely many were looking to find a practitioner to send friends, family and patients to. What I failed to learn in all of my pre-consulting years the most powerful education is that which is personal and specific. When you can evoke an emotional response and develop an emotional connection with an audience member you often develop trust. Instead of general terms and ideas I began openly discussing with mothers or fathers of struggling children the link between vision and learning. I would then demonstrate in a way that the parents could experience what these problems felt like, or impacted performance. This was powerful to not only the parent but to many of the audience members who knew a child, or lived with a child in the same situation.

It is likely the first two things a consultant is going to do is help you as the doctor see your value and establish value in what you do as well as identify your "why." I have reviewed several case reports ranging from fellowship reports to journal submissions. A surprisingly high amount of these case reviews will include a statement that treatment was not initiated or discontinued due to financial concerns from the family or patient. As a mentor for fellowship or reviewer for a journal, I often will not comment on this. However on social media I will share my thoughts on what consulting taught me. These thought boil down to simply: many optometrists, including VTODs, undervalue the time and commitment they've invested to be knowledgeable in their specialty and the value of what we provide is priceless; it is worth way more than a few thousand dollars we charge. As I was reaffirming the value of the service, I was providing I was also reaffirming my why.

The first vision therapy consultant I hired spent several hours on our first day establishing vision therapy's profound impact on quality of life. It seemed quite strange as if he was "preaching to the choir." Over and over, we discussed cases that we had changed a child's life. We all cried over sharing stories of traumatic brain injured patients being able to go back to the grocery store or Target and not feeling overwhelmed. The consultant shared several anecdotes and stories of lives that were without a doubt considerably better than before vision therapy. Every single person in the room left that day understanding that what we did was of the utmost importance.

The consultant did this is because every single team member MUST see the value in what we do. The mission statement must be shared, and there should be no hesitation in feeling good about what we do. It also provides a uniformity in stories and anecdotes. The third and most important idea we established is that every single team member was essential in the success of each one of these cases. We all played an important role in the lives that we changed.

Vision therapy can come at a cost. It also involves time and energy. I recognize that for some there is the choice of paying for vision therapy and paying for essentials including food, rent, clothes, etc. Many patients and parents are making discretionary income choices, where I practiced, in the suburbs of Chicago. In other words, we must make a stronger effort to help patients understand from an emotional level what we do. If cost, time, and money were barriers to

spending money, then Disney theme parks would fail. According to **mousehacking.com**, a baseline Disney World vacation cost for a family of four is $6,320.[1] I was shocked to learn that the parents of an intermediate player for a local travel hockey organization were paying $7000 for ice-time and equipment on an annual basis. Reading programs at well-known chains across the country will also cost parents thousands of dollars. For example, a short summer program at a reading center might cost a parent $2500.

Not only are we subject to naïve realism in context of how our business is running but we also run the risk that of assuming that every parent knows just how much a life can change with vision therapy. We assume the patient knows everything that we do. Without a full understanding of the value of what we do, not a single employee, including the doctor, at the practice should discuss cost. Cost is not value and value is not cost. Value can be defined as the extent to which people perceive what we do is good. Value is not real; it is perceived. The patient sees the world through their own eyes, and people have their own level of knowledge, formulate their own perceptions and make their own deductions. People don't know what they don't know.

Parents or a spouse must truly understand the value of the services. They cannot just be told the cost. Your office needs a system in place ensuring each and every patient or parent is educated in the experience that his or her child, or partner are experiencing. This is how you create value. Vision therapy changes lives. What is the cost of a bright child feeling stupid? What is the cost of income post college graduation as opposed to a high school drop out? If the visual system is interfering with reading, learning, or paying attention this might very well be the case. My staff and I were taught methods of listening and relating the impact of visual dysfunction to day-to-day struggles. We rehearsed phone calls, we rehearsed workshop scenarios, we all discussed our success cases with each other.

Patients are expecting and you should deliver quality care and thoroughness. Everyone at your office should be able to offer a complete explanation of what is happening and why it is done a certain way. Every staff member needs to have a sincere interest in a parent or patient's concerns and outcomes. The office should have timely communication, a follow up system, and meaningful interactions with the doctor. These are likely givens at your office.

If you already deliver exceptional care, then you already know it comes at a cost. To provide the best care, you will have to spend money. Parents understand that children come with a hefty price tag. How and what parents spend their money on is not a value judgment one should make for the parents as providers. It took many years for me to understand that caring for the patient does not mean caring for their parents' pocket book. I am not a financial advisor. Consultants help practitioners understand this, and feel comfortable with this. Create the value and give your families choices on treatments. Neither of my offices took insurance for therapy. Insurance discussions are just simply discussions of cost vs. value.

A second area we may be unaware of is marketing. All of the consultants I worked with emphasized marketing. After we had established what we did was valuable, next we have to tell people. Marketing, as it relates to a vision therapy practice, is anything we do to increase the perception of value, increase patient retention, increase revenue per-patient, or increase new patients.

Marketing includes the service we provide and the way you and your staff greet a patient. It also includes the initial phone inquiry, what is said during the pre-test, all of the doctor evaluation, and conferences. Marketing includes the way we schedule patients, office decor, attire, fee system, community activity, newsletters, advertising and so much more. Some important rules of marketing I was taught include:

1. you must know yourself to market yourself
2. if you want people to know something, tell them
3. if you want people to do something, ask them
4. maximize interest in what you do

A consultant will go into depth with each one of these. If you want to be successful with a vision therapy practice, you must know what your mission is and have confidence in what you do.

As previously mentioned, a mission statement is a good place to start in "knowing yourself." Many of us have a comprehensive understanding but knowing your own "why" is important in marketing yourself. We began as a staff by writing down key phrases and elements about our office, about each other, and about our practice. My why began some twenty-five years prior. I fell in love with vision therapy in my junior year of undergrad. I was a student in a shadowing program designed for future health care providers. I knew I wanted to be an optometrist, but until I stepped into a vision therapy room, I didn't know what I wanted to do with my life. Watching a ten-year-old boy struggle with reading develop into an excellent reader over a three-month period was amazing. That boy would become my patient for over twenty years.

After careful deliberation using words such as caring, compassion, understanding, and excellence we are able to form our own unique mission statement. This exercise also reaffirmed my own personal insight, what kind of practitioner I was and wanted to be. Not only do we need a mission statement but you must know what you want. If you want to be a part of direct care with each patient, or have a therapist driven practice it is essential to work this out internally before any marketing platform is created. As with the mission statement it is helpful to workshop this. Sometimes we think we know what we want, but insight from others and open dialogue can help us formulate goals and personal expectations. A consultant can help with this, even if ultimately you are learning about yourself. We finalized our statement as "At West Suburban Vision Therapy it is our mission to provide our patients with a welcoming and distinctive vision experience, giving great care to each individual patient and their unique needs. Our doctors and clinical staff provide notable value through thorough care to protect our patients' gift of sight, as well as optimize visual performance."

Many of us know the profound impact that vision therapy has on a patient's life. I do not believe that a majority of the public has this awareness and understanding. If you want people to know something, you must tell them. There are multiple ways to let people know what we do. Some doctors provide in-house workshops, others provide external presentations. Some practitioners offer free screenings while others have professional meetings to discuss specific cases. If you are a practitioner interested in growth and expansion, you must continuously be alert to opportunities to discuss what you do.

Another fundamental rule of marketing is if you want people to do something, you must ask them. Perhaps most pertinent to referring friends and family, but also applicable to other aspects of marketing. If you are constantly alert to speaking engagements, then every teacher, coach, or therapist you interact with in life should get a specific invitation to a workshop or some other learning engagement. A personal experience that comes to mind is a patient my mentor had been seeing for years. The patient was a teacher who came for annual eye exams. After hiring a consultant, we started doing workshops. I often would show her the flyer and passively invite her. For many years I never specifically genuinely asked her to come. Finally, at one annual exam I did. She was so interested and fascinated. However, she had retired and wasn't sure of why she should come. I insisted anyway. During the workshop, I became aware of a change in her disposition. I stopped what I was talking about and asked about this change. She said the symptoms I was discussing reminded her of her grandson. After a short discussion, she decided to make an appointment for him. Not only is he one of our most successful graduates of therapy, his sister also benefited from therapy. My patient regretted not coming to a workshop sooner as she could think of countless children that may have benefited from a functional vision evaluation. The regret, however, was also mine to have. Had I given a specific invitation with strong intention given her profession, I am sure she would have come years prior.

Maximizing interest in what you do is often best done with demonstrations. Many VTODs can discuss phorias, vergences, and accommodation with ease. To pique interest, one has to relate to symptoms and more importantly demonstrate the experience that a patient might have. Consultants have learned how to teach this. Although discussing findings with a parent in the office seems more academic in nature, it is marketing. Internal marketing, creating value, and discussing impact are essential to running a successful vision therapy practice.

Marketing should never have an end point. Internal marketing is everything that happens in the office. Every aspect of patient interaction should be creating and sustaining value in what you do. External marketing is everything that happens outside your office. Both are essential for growth. Consultants can help every practitioner take a practical look at both facets.

A third and essential aspect of hiring a consultant is dealing with your organization. Organizational systems are important in keeping any business running well. Practice management is mentioned but not taught in optometry school. Oftentimes in small practices the doctor/owner is doctor, therapist, HR person, IT person, scheduler, etc. A trap I fell into for many years was since we were a small office that every employee should understand and be able to perform multiple duties and responsibilities. The problem I faced, as I suspect many offices face, is there isn't a written organization chart. What are the specific responsibilities of every role and who is in that role? Scenarios such as when something breaks, when a patient needs attention, or when a parent has insurance questions are likely to arise. It is helpful to have a hierarchy clearly written out and discussed in advance with all staff who will handle each issue. Keeping this chart up to date is important.

Organizational systems also include meeting with key staff members. Every week staff members would meet with each other. I would then meet separately with key staff members. The main Vision Therapy Administrator would report on administrative staff, concerns, and ideas of development among other things. My lead therapist would discuss staff education, therapists meeting information, and other facets of the clinical arm of our organizational chart.

My own bias is apparent. The outside perspective that a consultant provides is of immense value. I can still remember the sticker shock I had when I considered my first consultant. As mentioned, I perceived the value enough to hire two more. A doctor should be prepared for a quote in the tens of thousands for a consultant. Personally, the cost of each consultant was earned back within three months. Consultants are not a cure all, and you as the provider must do the work, follow up, continuously work on systems, but the insight is immense. The Dunning-Kruger effect is a cognitive bias in which people with limited knowledge or competence in a given intellectual or social domain greatly overestimate their own knowledge or competence in that domain relative to objective criteria or to the performance of their peers or of people in general. The reality is that we all suffer from the Dunning-Kruger effect. We are unaware of our unawareness. We are not taught business models in optometry school; we are given the didactics of care but don't have much personal experience to convey to patients. For many years I was disinterested in the services provided by a consultant. I needed my own hitting coach and hired a consultant. However, hiring vision therapy consultants was one of the best professional decisions I had made. I think we all need some sage advice from a relative outside to bring attention to our faults, offer insights in value, marketing, and business organization, and of course the occasional pep talk.

For full transparency eventually I did sell my practices and move to a different state. My reasons were family related. I however was able to sell both of my practices. I'm proud I was able to develop an office that was a vision therapy only center. My associate who purchased the practice still maintains an ongoing relationship with a vision therapy consultant. She has continued to grow and I have a great sense of pride that I chose her and she chose me.

Some other anecdotes I've heard over the last few years from consultants that made me think (or laugh) and are worth repeating:

1. Don't tell people you meet socially what you are, instead tell them what you do.
2. How does a McDonalds in Chicago make the same hamburger as one in San Francisco, London, and Dubai? Easy... systems.
3. If it's good for the patient, it's good for the practice
4. There are two types of people: patients and future patients
5. Big decisions are never made because of reasons. Big choices are made from emotions/feelings. It is only after we make a choice that we rationalize it and find the reasons for this choice.
6. We have two ears, and one mouth. The best way to help patients is to use that ratio when we listen and speak.

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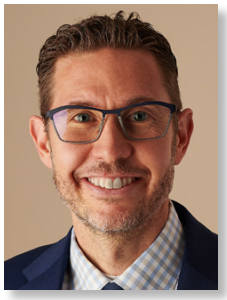

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ARTICLE

The CITT-ART and the Art of Vision Therapy

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Knowledge … is not a series of self-consistent theories that converges towards an ideal view; it is not a gradual approach to the truth. It is rather an ever increasing ocean of mutually incompatible alternatives, *each single theory, each fairy-tale, each myth that is part of the collection forcing the others into greater articulation and all of them contributing, via this process of competition, to the development of our consciousness. Nothing is ever settled, no view can ever be omitted from a comprehensive account.*

—Paul Feyerabend, *Against Method*

ABSTRACT

As optometrists we practice at the interface between two worlds: mind and matter. The Convergence Insufficiency Treatment Trial— Attention and Reading Trial (CITT-ART) was designed to explore this interface. Predicting symptoms from signs, however, is always a challenge, no less for science than the clinician. In this perspective piece, I will argue that practicing evidence-based care requires the art of separating evidence from interpretation. I will also argue that there are two primary vision therapy paradigms, the "classical" and "behavioral," and that both—along with the concept of placebo—must at least be superficially understood to investigate the evidence of the CITT-ART and what those trials tell the clinician about both the efficacy and art of vision therapy.

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INTRODUCTION: THE TWO WORLDS

The Feel of Seeing

What is vision? Imagine mountain peaks silhouetted by twilight fire or leaves dappled into flames by the chill of autumn sunlight. Imagine the sight of a baby's fingers massaging your smile or a lover's eyes igniting your heart. Imagine headlight beams sweeping away the mystery of a midnight road or a million stars constellating the heavens with transcendence. Fire, love, mystery, transcendence—welcome to the miracle of vision, that transformation of light into action pursuing value, that consummation of the love affair between light and life.

Is our opening paragraph overstatement or understatement?

From the first time we opened our eyes for food, affection or both, our seeing has been intimately bound to emotion. A standing ovation, a homerun, a bride or groom kissed, a toe stubbed, the red, round, juicy, fragrant, tangy, crunch of biting into an apple—all revolve around feelings. In professional school, we are indoctrinated to confuse twenty feet with infinity. What is close enough for physiological optics, however, somehow overlooks the glories peeking out from behind the Snellen chart. There the real infinity beckons from the bounds of a cosmos no less vast and inspiring than our combined imaginations. By eviscerating the emotion from seeing, the plain prose of our professional journals runs the risk of failing any patient who sees from the heart.

Vision brings light to life. As optometrists that is what we do for a living; we help bring light to the life sitting in our exam chairs or moving in our therapy rooms. Working with that phenomenon known as vision—a phenomenon no less psychobiologic than life itself, we stand at the threshold of two worlds commonly described as the "physical" and "mental" or the worlds of physics and experience. The optometrist's contact with the two worlds is intimate because the inner world of emotion, scaffolded by the fight or flight of the autonomic nervous system, meets in the eye with the outer world of light and movement.

Our most basic exams are divided into "subjective tests" and "objective tests" depending on whether the patient or the clinician is doing the guessing. When it comes to hobnobbing with the better letters on the acuity chart, it is one thing to know the autorefractor data; it is often quite another to know if "one" *feels* better than "two" or, for that matter, if the letters correctly identified on a chart will predict which patients will return raving about their new glasses—one way or the other.

Perhaps nowhere in optometry does the task of correlating the two worlds become more challenging than in the art of vision therapy. It is one thing to measure accommodation and vergence; it is quite another to predict which patients will complain of blur, diplopia, asthenopia or abbreviated reading endurance and comprehension. With that in mind, we will examine the most meticulous and extensive vision therapy clinical trials ever designed and executed, the Convergence Insufficiency Treatment Trial—Attention and Reading Trial (CITT- ART) and see what is the very best that behavioral science has to offer concerning our efficacy and art in bridging that gap between light and life.

We will divide our approach to the subject into five parts:

1) The CITT-ART Dilemma: What does the CITT-ART, as interpreted, suggest about the efficacy of vision therapy to improve reading, attention, and symptoms?
2) Paradigms and Placebos: What must the clinician understand about the classical vision therapy paradigm, the behavioral vision therapy paradigm, and the placebo effect to interpret the CITT-ART.
3) "Abstract" Reasoning: How well do the published abstracts and the published evidence of the CITT-ART agree? Are there possible biases?
4) The Elephant in the Room: What are the CITT-ART abstracts not discussing?
5) Conclusions and Discussion: What are some plausible alternative conclusions for the CITT-ART and what do they tell the clinician about the efficacy and art of vision therapy.

Part 1: The CITT-ART Dilemma

Our currently organized attempt to view vision therapy through the lens of science traces back to the mid-nineteenth century but began in earnest at least as early as 1996 when the Convergence Insufficiency and Reading (CIRS) group had already composed a manual for assessing convergence function[1]. By 2005, the CITT Study Group, including researchers from six optometry schools, compared in-office vergence/accommodative vision therapy to pencil pushups in the treatment of "symptomatic convergence insufficiency."[2]

To gain information on the mental world, the world of symptoms, the researchers required the participants to fill out the "Convergence Insufficiency Symptom Survey" (CISS), both before and after intervention. The survey included fifteen questions: When reading or doing close work do—1) your eyes feel tired, 2) your eyes feel uncomfortable), 3) you have headaches, 4) you feel sleepy, 5) you lose concentration, 6) you have trouble remembering what you read, 7) you have double vision, 8) you see the words move, jump, swim, or appear to float on the page, 9) you feel like your read slowly, 10) your eyes ever hurt, 11) your eyes ever feel sore, 12) you feel a "pulling" feeling around your eyes, 13) you notice words blurring or coming in and out of focus, 14) you lose your place, 15) you have to re-read the same line of words. The subjects rated each question on a five-point, never (0) to always (4) scale, with

a total score of 16 or above being designated as "symptomatic."

The participants were divided into three treatment groups. One group was asked to move a pencil toward the nose and watch its approach, not letting the pencil double. This was to be done for three sets of twenty pencil pushups five days a week for 12 weeks. The second group had in-office and home therapy using various lenses, prisms, and instruments to work amplitudes of accommodation and convergence, facility of relative accommodation and convergence, and the kinesthetic awareness to allow voluntary convergence. The third group received a non-vergence/non-accommodative vision therapy. Because this therapy was devised to avoid directly working amplitudes of accommodation or convergence or positive and negative relative accommodation and convergence or voluntary convergence, the non-vergence/accommodative therapy was hypothesized to be inert for the treatment of convergence insufficiency (CI) and interpretated in the study as "placebo vision therapy."

The three therapies were worked for 12 weeks. The study's conclusion: "In this pilot study, vision therapy … was more effective than pencil push-ups or placebo vision therapy … in reducing symptoms and improving signs of convergence insufficiency…."[3] The strength of the study was that it suggested that training relative accommodation and convergence was more effective in reducing symptoms than either non-vergence/accommodative vision therapy or largely unmonitored pencil push-ups. And most importantly, unlike many studies of CI, this study highlighted the change of subjective symptoms with objective gains in the ability to converge compared to non-vergence/accommodative therapy.

Whatever this study told us about the efficacy of pencil pushups versus in-office vision therapy/orthoptics, it told us even more about the confusion between evidence-based versus interpretation-based medicine. No one is more aware of this confusion than those who fully understand how evidence-based medicine works—at least when it addresses behavior rather than merely physical changes. The 2005 preliminary study NEI-fundedand-reviewed study was examined and dismissed or at least critically questioned in an accompanying editorial[4] by Burton Kushner, M.D, founding editor of the journal of the *American Association for Pediatric Ophthalmology and Strabismus*.

Kushner commented, "Like all scientific studies, this one can only answer the specific questions it asks … I believe the authors may not have asked the correct questions."[5] Kushner argued that the investigators' home-based pencil pushup protocol did not mirror Kushner's personal experience using a different home-based orthoptic training protocol, which he imagined was representative of whatever miniscule percent of ophthalmologists who not only specialize in pediatrics but employ the services of orthoptic technicians. To support his own experience and interpretation, Kushner even offered a retrospective review of 20 of his own charts. Kushner was, however, pleased with the study's placebo group, which he believed "should dispel the beliefs of those naysayers who believe that CI is not a real entity and that all perceived benefit of treatment is a result of a placebo effect."[6] He nevertheless admitted his own fears:

> *Given how the lay media and professional tabloids hype sensationalist 1-line quotations from the abstracts of scientific articles, I fear this study will herald the belief that an office-based treatment program is superior to a home-based program, per se. That would be a serious misrepresentation of this study.*[7]

The implications of Kushner's words—published as they were in a reputable clinical science journal with a venerable 150-year history—suggest that what we get from evidence depends as much on the questions we ask as on the evidence itself and that a clinician's interpretation of evidence need not agree with that of the investigators. Indeed, as Nobel Laureate Richard Feynman has written, "Science is the belief in the ignorance of experts."[8] We will keep Kushner's words carefully in mind and return to them as needed when we analyze the results of the actual CITT-ART.

In 2008, the study group—now also including researchers from Mayo Clinic, Bascom Palmer Eye Institute and two other medical centers—performed a second, larger, multi-center randomized, placebo controlled, twelve-week study, this time with 221 subjects instead of forty-seven. In this study, some of Kushner's criticisms were addressed and the pencil push-up group was better organized and monitored to encourage the actual performance of the activities (unlike in the first study in which, as in actual clinical practice, patients were handed a pencil and told to go for it). A fourth group was added as well. This group, at home and often unwatched, not only did pencil push-ups but used a random-dot stereo computer program to work PFC—an approach that more nearly mirrored Kushner's own orthoptic approach.

Again, the conclusion was that twelve weeks of office-based positive and negative relative accommodation and convergence therapy and voluntary convergence vision therapy both reduced symptoms and met predetermined criteria for near point of convergence (NPC) and PFC success better than in any of the other groups (73 percent compared to 43 percent for pencil pushups, 35 percent for non-vergence/non-accommodative vision therapy and 33 percent for the home computer program). Interestingly, the non-vergence/non- accommodative therapy, despite not altering convergence to the same degree as the vergence/accommodative therapy group, fared better at reducing symptoms than the pencil pushup group, which worked nothing but absolute convergence ability in following a pencil on the z-axis.

The vergence/accommodative therapy group's average CISS score dropped (less is more) to 15.1, which was outside the agreed-upon range of symptomatic CI. Both the non- vergence/non-accommodative and push-up groups remained symptomatic, but the CISS score for the non-vergence/non-accommodative group was lower (better) than that for the push-up group (21.9 compared to 24.7 despite 35 percent versus 43 percent success at improving convergence). This was an early sign that the conflict between the two worlds in which we practice may not have been fully resolved.

The 2008 CITT had, nevertheless, provided *statistical* evidence that 12 weeks of vergence/accommodative vision therapy could not only train convergence but reduce symptoms compared to 12 weeks of non-vergence/non-accommodative therapy.

It was next reasoned that the symptoms of CI could adversely affect reading and attention so the investigators expanded the clinical trials to study the effect of vergence/accommodative vision therapy on reading and attention in the CITT-ART. This third trial now included three hundred and eleven subjects. Vergence/accommodative therapy was once more compared with non-vergence/non-accommodative therapy, both therapies now taking sixteen weeks instead of twelve. Fewer treatment groups combined with more patients resulted in far larger groups for comparison over a 25 percent longer period of time. The study results were published in three separate articles, one reporting on convergence measures and CISS scores;[9] one, before-and-after therapy standardized reading scores;[10] and one, before-and-after standardized attention scores.[11]

So, after almost a quarter century of painstaking and meticulous preparation and scientifically rigorous, placebo-controlled, randomized treatment trials, what has an evidence-based approach to vision therapy told us about the objective and subjective worlds and that portal between them known as vision? As it turned out, 16 weeks of office and home vergence/accommodative therapy was superior to 16 weeks of office and home non-vergence/non-accommodative therapy in improving PFC and NPC. There was, however, *no statistical difference* between the two types of vision therapy improving CISS scores, attention, and the primary measure of reading performance, the Reading Comprehension subtest of the Wechsler Individual Achievement Test, 3rd edition.

Should we be surprised that the CITT-ART failed to replicate the link between the physical and mental worlds found in the 2008 CITT? Hardly. The

Open Science Collaboration has previously found that of 100 behavioral science experiments—97 percent with statistically significant results—*only 36 percent could be replicated*.[12] Physical science requires repeatable observations, but since we cannot observe much less repeat the observations of another's mind, behavioral science depends on the study of groups. While no physical scientist would suggest that knowing the half-life of uranium allows us to predict the fateful decay of individual particles, we use the group statistics of behavioral science to predict that very thing: the fate of individuals. The variable results of the process speak for themselves.

This disparity between the behavioral and physical/life sciences tempts many of us, myself included, to treat vision therapy as more of an art than a science. We draw from a wide variety of theories, procedures, and perceptions resting—like vision perception in general—on previously successful and failed actions of self and culture including mentors, colleagues, and science. Favoring our own clinical interpretations over others' interpretations of scientific evidence, however, is not without hazard, especially when it comes to increasing intraprofessional and interprofessional acceptance of vision therapy. In the multi-billion-dollar medical industry, the label "Evidence Based" legitimizes insurance-reimbursed healthcare as surely as in other cultures "Kosher" and "Organic" legitimize diet. To fail to embrace this week's version of science, whatever its limitations, is to fail to communicate with many holding the purse-strings in today's world.

That said, Kushner was hardly wrong on his prediction of "how the lay media and professional tabloids hype sensationalist, 1-line quotations from the abstracts of scientific articles."[13] Before the CITT-ART appeared in the November issue of *Optometry and Vision Science,* the professional tabloid *Science Daily* had already offered a sensationalist headline on October 23, 2019: "Treatment for common vision disorder does not improve children's reading skills: Therapy for convergence insufficiency is no better at improving reading than placebo." Apparently, no time had been lost in distributing press releases.

What does the CITT-ART offer the clinician? Clinical scientists, I would argue, are like the rest of us in that they see what they value and are blind to what they do not. For instance, before Ignaz Semmelweis hypothesized that puerperal fever was caused by doctors not washing their hands after performing autopsies or between patients—and for many years afterwards—scientists neither valued nor saw clean hands as evidence when considering the death of women during hospital child birth.[14]

Our blindness aside, however, the strength of the scientific method is that it inspires us to reflect on our approaches.[15] Even more importantly, meticulous records are kept of what scientists imagine they see and do. Such records allow clinicians, like Kushner, who are more interested in evidence-based medicine than second-hand expert-biased interpretation of evidence, to interpret the data for themselves. So, what does the CITT-ART tell us about the efficacy and art of vision therapy in improving human performance? Before reviewing the CITT-ART's conclusions in more detail and considering a number of possible alternative interpretations, a wide detour is required. In Part II, we will first explore the topic of paradigms and their use in explaining away unpredicted healthcare improvements.

Part 2: Paradigms and Placebos

The word paradigm was coined by Thomas S. Kuhn, one of the most influential philosophers of science of the twentieth century—not that true believers of today's realities are pleased with Kuhn's relativistic perspective.[16] Of paradigms, Kuhn wrote, "These I take to be universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners."[17]

A paradigm is thus a principal story being told by scientists during a period of history, a story that everyone—at least on review boards—believes is the only story worth telling. For example, if the story "Little Red Riding Hood" were the paradigm, then

science would study scheming wolves, forest paths, and naïve but tasty granddaughters. If absolute time and space were the principal story, science would use Newtonian physics. If relative time and space were the story, then scientists would explore the possibilities hypothesized by Einstein. In normal circumstances, science does not look outside the main story for answers. In Little Red Riding Hood, there is no talk of beanstalks or golden harps influencing Little Red's tastiness or credulity.

In vision therapy, there are essentially two basic paradigms: the classical and the behavioral, neither of which possessing precisely drawn boundaries. One could ask, why is it necessary to consider both paradigms to understand the CITT-ART? The answer is simple. The CITT-ART did not consider vision therapy. Instead, it considered and tested only one model of vision therapy. The study completely neglected the other model, dismissing as "placebo" a goodly portion of what goes by the name of "vision therapy" across much of the nation and world. While the study was completely forthright in documenting the exact form of the vision therapies performed, readers were left entirely unaware of the possible behavioral significance of the supposed "placebo" therapy. This oversight could compromise readers' understanding and interpretation of the study. With this possibility in mind, we will consider *both* paradigms before returning to the study itself.

Classical Vision Therapy Paradigm

The classical story has been told since near the inception of modern ophthalmology. In 1862, von Graefe's[18] "On Muscular Asthenopia" appeared in the journal he founded: *Archives of Ophthalmology*. The "founder of modern ophthalmology"[19] prescribed prism exercises for eye strain accompanying "insufficiency of the internal rectus muscles."

In 1893 Maddox's second edition of his *The Clinical Use of Prisms and Decentering of Lenses*[20] appeared. Maddox hypothesized—based on clinical observation and speculation rather than formal experimentation[21]—that four components added together to comprise convergence: tonic, accommodative, voluntary, and reflexive (my order not Maddox's).

Tonic convergence is the difference in your distance phoria between when you are alive and dead. (And you thought dilation could be a hassle). Lest death be too proud or optometry in your state has not legislated the use of execution, "sleep … drowsiness … drunkenness … [or] chloroform"[22] will all suffice to reduce tonic convergence just as wearing "adducting prism … for ten minutes"[23] or "prolonged use of the eyes for near work"[24] will increase tonic convergence. Barring such interference, when tonic convergence is not too hot or cold but just right (the thinking goes) the distance phoria is ortho. In Maddox's words: "Latent divergence in distance vision indicates a deficiency and latent convergence an excess of *tonic convergence*."[25]

A second component of convergence is *accommodative convergence,* "due chiefly to sympathy with accommodation but also to the habit of converging."[26] Enough said—for now.

The third component is *voluntary convergence*: "Convergence due to 'knowledge of nearness' or in other words, 'Voluntary convergence,' for we cannot, without special practice, converge the eyes voluntarily, under ordinary conditions, without doing so by thinking of near.[27]" We will return to voluntary convergence later. For now, where the "habit" in accommodative convergence ends and the "knowledge" in voluntary convergence begins is not entirely clear, but both add together with tonic convergence to align the eyes at near. Or not. And this is where the fourth component—the most important for the classical paradigm—becomes important.

Reflex convergence—which Maddox also calls[28] "fusion convergence"— has to prevent double vision whenever tonic, voluntary, and accommodative vergence fail to keep the two eyes' images together. In Maddox's words:[29]

> *[To maintain single vision] the joint sensations in the brain must all the while be bearing between them the message of continually impending (yet quickly averted) double vision, by threats of double images, so slight and frequent, that they*

produce the required effect without our being conscious of their existence …

Maddox continues:

An action so complex must necessarily be more tiring than the mere overflow of one impulse into another. If, therefore, there be an undue proportion of reflex convergence, there is a waste of co-ordinating nervous energy. In many cases … [which] may give rise to the so-called "muscular asthenopia" of V. Graefe, which, however, is really in many instances a central asthenopia …

And so, we have further explanation about the nature of the fusion that von Graefe expanded by prism training. Although Maddox claimed no experience in prism training, he did describe and evaluate a contemporary 2.5 to 15 diopter abduction and adduction prism facility program promoted by one of his contemporaries, a Dr. Dyer:

Dr Dyer's so called "invigorant plan" of treating latent deviations … does not, if my belief be correct, 'invigorate the muscles," but simply trains the efforts of accommodation and convergence to assume broader relations to each other in their work…. If these exercises strengthen anything, it is the visual reflex, the amplitude of which they increase, and by so doing increase the relative range of convergence.[30]

In speculating on fusion, or what he called "reflex convergence" and what today may be called fusional or disparity vergence, Maddox fleshed out the classical paradigm with relative convergence and divergence, the stretching of convergence away from accommodation, which is also trained in the CITT-ART.

A third important step in the classical vision therapy paradigm came from British ophthalmologist Claude Worth as described in his 1903 book *SQUINT: Its Causes, Pathology, and Treatment.*[31] The model problem involved a "defect of the fusion faculty,"[32] which Worth surmised to be a common cause of convergent strabismus. To overcome this problem, Worth devised an adjustable stereoscope or "amblyoscope" to align dichoptic images with the visual axes to overcome suppression and encourage fusion. Worth went on to write: "After a time it is found that the angle of convergence of the instrument may be varied slightly without the fused picture coming apart."[33] Next, Worth increased the amplitude of fusion until "a considerable range of vergence eye movements becomes possible, fusion being still maintained. This 'amplitude of fusion' may … be taken as a measure of the extent to which the fusion faculty has been developed."[34] Thus, the solution to the model problem of failed fusion was extending the range of convergence and divergence over which the images would stay together.

Worth made the assumption that a patient's ability to diverge and converge the eyes in alignment with the tubes of the instrument was a measure of the strength of fusion—the larger the ranges, the better the fusion. He did not limit his approach to crossed eyes. He wrote, "*Heterophoria* is the name given to the condition of imperfect oculomotor balance.

There is here a *tendency* for the eyes to deviate from their normal relative directions. Ordinarily, however, this tendency is kept in check by the fusion sense, so that there is no squint."[35] And how did the fusion sense relate to symptoms?

Occasionally, however, one meets with a patient who complains of pain and discomfort in the eyes, and whose refraction has been repeatedly examined, and who has for years worn glasses to correct some unimportant refractive error, without any relief to his suffering. Such a patient usually has a heterophoria, the correction of which immediately and permanently removes his trouble.[36]

More support for this better-ranges-better-comfort paradigm was contributed by two names that I was introduced to in optometry school: Percival and Sheard. In 1892, we find Percival's hypothesis about "the area of comfort":

I think we may assume tentatively as a working hypothesis that the area of comfort *occupies*

about the middle third of the relative range of convergence … I have defined the limits in this way from a careful examination of my notes and charts, assuming that when a prism gives relief it brings the … [vergence demand] within the area of comfort.[37]

Based on examining his patient records, Percival made an assumption, a tentative hypothesis, to use prism to put the phoria in the middle third of the prism range. Thus, if a patient had 1 diopter of exophoria, and the prism range was from 2 base in to 3 base out, the middle third of the range would fall from ortho to 1 base in. Thus, according to Percival's assumption, the patient with the collapsed base in and base out ranges should be comfortable, one of the drawbacks of a model being that it tends to ignore the size of the area of comfort.

Sheard made a different "assumption" based on his own practical experience:

"Never correct unless the symptoms call for it." This statement I believe is to be called into question seriously. Symptoms alone do not constitute a sufficient basis on which to judge the necessity for prismatic assistance. I believe that the law of supply and demand is just as applicable to ocular functions as to the functions of financial institutions and business in general. With low liabilities and high assets, logic would lead one to conclude that no assistance was necessary. If the ratio between assets and liabilities, however, in the matter of relative convergence functions is less than 3 : 1 or, as a limit, 2 : 1, I believe that assistance should be given in order economically and efficiently to co-ordinate the function of accommodation and convergence.

The possibility of discomfort is not the only consideration; decided exophoria or esophoria may exist with no complaints on the part of the person examined for the reason that binocular single vision does not exist.[38]

Sheard pioneered one of the basic assumptions of classically-oriented practice: theories and numbers are more important than what patients are telling us. Moreover, Sheard's experience-based, analogy-reasoned assumption rose to a criterion over the years: to ensure there is no run on the bank of oculomotor coordination, positive relative convergence should be no less than twice the patient's exophoria; that is, the patient's "compensating fusional range" should be at least twice the phoria. If it were good enough for banking, it's close enough for science.

Again, the size of the area of comfort is not stressed. To use an analogy of my own, living on a quarter-acre desert island is as good as living in Manhattan. (Whether the assumption is true or false, who can say?) According to Sheard's criterion, if a patient has 2 prism diopters of exophoria at near and the patient's compensatory base out range is 4 prism diopters, all should be well. The patient's base-in range is immaterial. More practically, the criterion tells us that the patient with 15 diopters of exophoria should have voluntary control of a full range of convergence—not a bad rule of thumb. In my experience, however, patients trained with cover-uncover-recover procedures to maintain alignment even with one eye covered, or patients with a large volume of spatial awareness and good central peripheral integration may not necessarily need mammoth prism ranges.

How good is Sheard's criteria? A randomized clinical trial assessing prism glasses for the treatment of convergence insufficiency[39] suggested that the criterion was no better at relieving symptoms than placebo (more accurately—as we will shortly discuss—that reading glasses often reduce symptoms but not for the reasons specified by Sheard). Despite the evidence-based failure of Sheard's criteria, however, the CITT-ART included the model in their criteria in analysing their own data. Not that this is surprising. As Kuhn suggests, falsification hardly leads to the demise of a paradigm unless there is something better to offer.

Thus, the larger-ranges-fewer-symptoms paradigm of von Graefe, Maddox, Worth, Percival, Sheard, and others came to dominate classical

thinking. To relieve asthenopia, fusion could be increased to align eyes or reduce symptoms by strengthening the fusion faculty or fusion sense through increasing the amplitude of the fusion ranges—or, per Maddox and Sheard, relative convergence and divergence. Such ranges could be quantified. As such they were convenient for scientific study.

This classical vision therapy paradigm is typically introduced in the classrooms and textbooks of our schools of optometry. As Kuhn notes, "But science students accept theories on the authority of teacher and text, not because of evidence … The applications given in texts are not there as evidence but because learning them is part of learning the paradigm at the base of current practice."[40] Thus the failure of Sheard's criteria to pass the rigors of evidence-based practice hardly dismisses his ideas from the classical model. Classically-oriented clinicians are happy to join Sheard in flying by the seat of his biases.

Behavioral Vision Therapy Paradigm

In addition to the classical vergence-accommodative approach to vision therapy, there is also what might be called a behavioral approach to vision therapy (although, in truth, most optometrists borrow from both approaches). While the classical paradigm is largely about treating physical disease by the numbers, the behavioral approach is more about improving visual performance by enhancing the "what" and "where" of seeing. Such performance is seen as not necessarily being predicted by the numbers or limited to the treatment of disease.

An example of improving performance rather than fixing a broken vision system might be to work with a child whose testing reveals above-average visual memory. Enhancing that child's imagery ability by teaching the child to use it for spelling sentences forwards and backwards to the rhythm of bunting a Marsden ball could make dramatic improvements in spelling performance, especially if the child was previously an unsuccessful phonemic speller. The disease model would have dismissed this normally performing child as a candidate for vision therapy.

As did Sheard, most classically-oriented optometrists place numbers ahead of symptoms. During therapy, improvement is judged by comparing numbers. More behaviorally-oriented doctors listen to the patient to see if there are goals that can be helped by the doctor's tools; such doctors do not necessarily need a diagnosis to justify treatment, nor do they necessarily look at numbers to see if the patient's performance can be improved, the goal being superior performance, not normal numbers. Numbers may or may not be used as clues about the best approach to improving performance. Personally, I would treat a patient with a base-in range of 2 and a base-out range of 30, differently than I would treat a patient with a base-out range of 2 and a base-in range of 30. Others might approach both patients the same.

Sheard once wrote, "I venture to say that there are almost as many opinions regarding ocular exercises, their character, their frequency, their modus operandi, and so forth, as there are individuals who hold any opinions on these matters."[41] Little has changed. When we look at vision therapy as it is practiced in offices around the nation and world, there are probably as many models of vision as there are practitioners. Each of us develops our own art of doing vision therapy by selecting from theories and procedures based on our abilities and experiences gained through life, education, patients, mentors, colleagues, and the clinical and scientific literature. The experiences of no two vision therapy practitioners are the same.

The scope of how vision therapy is currently practiced is hinted at in *Applied Concepts in Vision Therapy: 2.0*.[42] The book touches on everything from perspectives on basic eye movements to the development of fusion in constant strabismus, everything from basic accommodative and vergence therapy to primitive reflexes, multisensory integration, and optometric photo therapy. The book also presents perspective on special concerns about sports, visual information processing, neuro-optometric rehabilitation and special populations.

Chapter 2, "Principles of Vision Therapy," by Harris[43] offers a more extensive and thoughtful summary of what I would call behavioral approaches to vision therapy. Such approaches are also captured in the papers and library of the Optometric Extension Program Foundation. While again, behavioral approaches vary greatly, most of them (not to mention most classical approaches) seem to fall under what we will call Skeffington's Four Circles.

Skeffington's Four Circles

According to optometric lore, Skeffington drew four circles on a napkin, creating a Venn diagram. I will describe the four circles, not because I or any other practitioner necessarily uses them to organize vision therapy ("This procedure works this circle; that procedure, that circle!") but because the circles appear to capture the bare minimum a paradigm would need to specify if we are going to sort out what is specific and nonspecific in a vision therapy program.

Figure 1. Requires polaroid glasses for fusion.

Figure 1 shows the four circles. Roughly speaking, *Centering* answers the question, "Where is it?" *Identification* answers, "What is it?" *Antigravity,* "Where am I?" *Speech Auditory,* "What is important and why?"

We will consider each of the circles in more detail.

Centering

In 1948, Skeffington used the terms centering and identification as synonyms for convergence and accommodation.[44] In 1959, Skeffington wrote, "Centering has been defined as the slowly learned, covert, patterned ability to know precisely where a thing is in spatial relation to other things.... It is not to be confused with alignment."[45] And again, in 1961, he elaborated, "Centering—Choosing a region of concern out of the whole of the forces in the terrain ... It picks out the region of value at the moment to the viewing person."[46]

While convergence is one tool of centering, centering is much more. Consider a viewer aligning eyes on a raven perched on a tree branch fifty yards in the distance. About a quarter million miles behind that raven, the moon is rising. Despite physiological optics telling us that our viewer's convergence does not significantly change between raven and moon, centering on the raven is vastly different than centering on the moon. So, what is the viewer's region of concern or value for action—the raven, the moon, the space between them? To our naked eyes, however, the convergence of the viewer's eyes is unchanging. The viewer's centering is, therefore, "covert."

One seer simultaneously locates the broad side of a barn, using a single glance; another seer—lost in the stories of the details—takes one hundred sequential glances to evaluate window panes, door hinges, individual planks and floodlights. The simultaneous style is more efficient for localizing the barn; the sequential style, for estimating renovation costs. Just as Gilbert and Sullivan insist in *Mikado* that "the punishment fit the crime," so should perception fit the action at hand.

Elsewhere I have discussed this selection of a volume of space for value and action, calling it both the "sphere of attention,"[47] or the "zone of simultaneous awareness (ZOSA).[48,49,50] In vision therapy, we are also interested not only in the size of the zone but in central-peripheral integration, the ability to select a large enough ZOSA while simultaneously processing the most minute acuity demands—for the efficiency of the task at hand. When we see both big and little simultaneously,

we are seeing more than if we just see big or just see little.

As patients become more adept at processing a larger ZOSA, they also become more accurate in their reporting on the relative changes in size and distance of objects in a field from their viewing position. Unlike real objects, which take up more of a viewer's visual field as they loom closer, dichoptic images are perceived to be smaller and closer with increased convergence and larger and farther away with increased divergence. This is referred to as "SILO," a shorthand for "smaller-in/larger-out." SILO is an indication that a patient is localizing these visual phenomena accurately, rather than using logic of their experiences with looming objects to guess at the location of projected dichoptic images.

Relative convergence and accommodation could be viewed as one possible measure of such central-peripheral integration. A better example might be reading street signs while driving on a winding road in a starless night. Here the driver would benefit from integrating central sequential processing with simultaneous x-y-and-z-axis egocentric depth perception—something probably better predicted by integrating SILO with the processing of central detail than by relative convergence ranges. The same might be said of comfortably viewing a 3-D movie.

As I have described,[51] the ability to see 20 arc seconds of stereopsis says little about the egocentric depth perception, the ability to see the space between self and target simultaneously. Rather than comparing the relative position of an approaching car's side and rearview mirrors, the driver centers on the approaching car's *position* compared to self.

To experience sequential versus simultaneous seeing, examine the words of this paragraph to see if they are all clear. Next, while maintaining fixation on a single letter of the paragraph, reexamine its words. How many are still legible?

Initially, when all the words appeared clear, you were likely using vision sequentially, your eyes dancing about the page. Unaware of your sequential style, you created the perception of a simultaneously clear paragraph on a simultaneously clear page in a simultaneously clear world. Reading requires such sequential seeing. Some viewers, however, read the world the same way that they read a book—selecting tiny areas to see sequentially. Upon entering a room, they see details in a room rather than a room with details; they see clocks, upholstery patterns and light switches rather than the vastness of space separating the particulars. In a forest, they are more interested in the leaves than the trees, the trees than the forest. If asked, however, if they see a tree all at once, they will generally say yes, even as their eyes dance about constructing a tree sequentially.

They perform not unlike those with esotropia who alternate in major amblyoscopes and yet insist they perceive the suppression controls in both tubes simultaneously. Brock,[52] for instance, reported on a forty-two-year-old, congenital esotrope who claimed to see targets simultaneously even when they were presented sequentially a number of seconds apart. This confusion between sequential and simultaneous processing was noted by Lancaster, an orthoptic technician, almost seventy years ago:

> *The word "two" in the English language may mean two simultaneously, which is relationship in space, or two consecutively, which is relationship in time … Many failures in orthoptic training are due to the use of the word interchangeably to indicate both time and space relationship. If I mean simultaneous perception when I use the word "two" and the patient means alternation, we are as far apart as the poles in interpreting how the patient sees.*[53]

To experience simultaneous processing, read the current paragraph sequentially but become aware of the space between your face and the screen. Don't mentally calculate the feet and inches of the distance but try to see the air between yourself and the words on the screen. If you can, open your vision further, not only seeing the distance between yourself and the screen, but the distance between the screen and the wall behind it until, without removing your eyes from the screen, you

are aware of the position of the screen between yourself and the wall.

If you are not able to open your periphery enough simultaneously to read the print and see the screen edge and its position in the room, then use your phone instead and determine if you can open up your vision enough to see simultaneously the screen and the position of the phone hanging in space between your face and the floor.

There is more to fusion than building ranges. While Worth suggested building ranges to strengthen fusion, he also strengthened fusion by working simultaneous perception at the angle of turn. Similarly, at least in my imagination, the size of the ZOSA often relates to strength of fusion. Patients with expanded ZOSA's typically perceive SILO. They use simultaneous vision to compare the illusional vectogram float with the general world rather than alternating attention between the actual vectogram on the wall and the surrounding room. Those habituated into sequential processing of small rather than large ZOSAs typically do not perceive SILO unless the therapist places a hand or pointer next to where the patient's converged eyes are pointing, allowing a simultaneous comparison of target and pointer position without having to expand the ZOSA.

Nor am I the only one to imagine that the size of the area fused is related to the strength of the fusion. Burian mismatched central fusion with peripheral fusion and found that peripheral fusion was enough to override central fusion.[54] Similarly, Brock, wary of creating the diplopia necessary for measuring breaks and recoveries of fusion ranges, suggested that peripheral stereo or SILO was better than ranges in assessing fusion in constant strabismus.[55]

To experience the effect of periphery on fusion, fuse the Bernell Acuity-Suppression Vectogram # 9 (see Figure 2) in which both eyes see the peripheral stereo rings and lines 1-3, 5 and 7 while only the right eye sees line 6 and only the left eye sees line 4. Using a prism bar, slowly introduce base in prism. As fusion fails just enough for a fixation disparity to occur, lines four and six will begin to slide slightly to the sides, lines four, five, and six

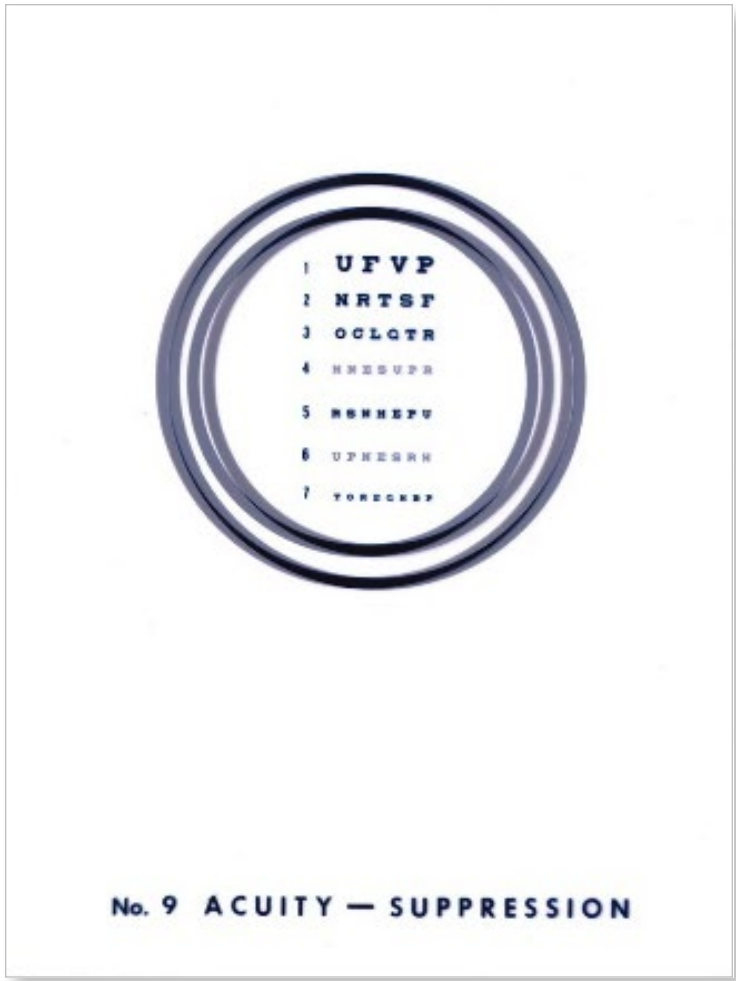

Figure 2. Polaroid glasses required to obtain peripheral stereo.

no longer directly aligning vertically. Instead of concentrating on the lines, open your periphery and concentrate on the two rings surrounding the lines of letters. See how far you can get the rings to separate on the z-axis behind and in front of the vectogram. *The displaced lines four and six will often realign and the fixation disparity vanish as you expand the ZOSA*.

The same can be true with the Brock string. Instead of coaching the patient with an eso or exo response and intermittent suppression to perform the parlor trick of crossing or diverging the eyes, the therapist merely coaches the patient to see the bead's location by becoming simultaneously aware of a larger lateral area of space, or perhaps seeing simultaneously the z-axis space between the bead and the patient's nose. When the ZOSA is expanded to allow the patient to see simultaneously the bead's position relative to patient and room, the strength of fusion often increases, both aligning the eyes and reducing suppression.

Thus centering, in Skeffington's above words, is the ability "to know precisely where a thing is in spatial relation to other things". When performed simultaneously this selection defines the ZOSA. Centering could also be called the selection of a volume of space for the purpose of value and action. Again, in Skeffington's above words, "[Centering] picks out the region of value at the moment to the viewing person." Thus, appropriate centering can allow to see simultaneously the "what" and "where" of an object. This mention of value brings us to our second circle.

Identification

In 1958, Skeffington wrote, "identification is perhaps farther away from any real explanation of its mechanisms (accommodation) than any other process of the body. … Identification is the process whereby one knows what things are."[56] In 1963, Skeffington defined the identification process as "scanning by the organism for certain experiences within the stream of consciousness, that let it meet the demands of the immediate environment."[57] Whether those successful (or unsuccessful) previous actions are floating in the stream of consciousness or unconsciousness or both is another matter, but identification revolves around positive and negative survival value, around recognizing the opportunities for and hazards of action in the physical or cultural world. In this light, the actual accuracy of accommodation is more critical for identifying an ant than an elephant.

A principal figure in the "embodied cognition" movement, psychologist James J. Gibson, writing a decade after Skeffington lived, hypothesized "that the 'values' and 'meanings' of things in the environment can be directly perceived."[58] In Gibson's model, to perceive things is "to perceive what they afford."[59] "*The affordances* of an environment are what it *offers* the animal, what it *provides or furnishes,* either for good or ill."[60] In Gibson's words:

> *"Orthodox psychology asserts that we* perceive these objects insofar as we discriminate their properties or qualities. … *I now suggest that what we perceive when we look at objects are their affordances, not their qualities. We can discriminate the dimensions of difference if required to do so in an experiment, but what the object affords us is what we normally pay attention to."*[61]

With Gibson and Skeffington in mind, we can imagine that a hungry child values an apple for eating and identifies a snack. A naughty child values an apple for throwing and identifies a weapon. An artist identifies the shades and contours of an apple for drawing. William Tell identified an apple as a target for cross-bowing; Eve, as an opportunity for knowledge. Depending on anticipated action, we could value and identify a cliff as an opportunity for hang-gliding, sightseeing, or falling.

We value opportunities for action, whether physical or cultural. A noun is just a verb waiting to happen. A pilot identifies Brazil on a map for the physical action of flying there. A student identifies Brazil on a map for the cultural action of passing a geography exam. A status seeker identifies Brazil on a map for the cultural action of communicating sophistication. Similarly, playing with two-dimensional designs may help a child to value opportunities for action in the two-dimensional world of culture. The designs may not only help the child describe the three-dimensional world with two-dimensional symbols but even teach the child to explore, which could well spill over into exploring in the three-dimensional world.

Past actions determine perception. A drycleaner might see minute stains to which a football player would be blind. A patient might identify a phoropter as complex gadget to sit behind during an eye exam while an optometrist identifies the same instrument as an opportunity for any number of complex examination actions. We see what we value and what we value paves the way to opportunities for action, be it sports, philosophy, or Facebook battles. And when it comes to value not only diamonds can be our best friends. A dog turd has value in that it either guides our steps or follows them.

Vision converts light to action, and like in most conversion scenarios, emotion plays its part.

Our valuing opportunities for action, is bound to the emotions of past actions, successful or unsuccessful, such as climbing a tree or falling out of one. A kiss, a tightrope walk, a smile, dance or philosophical argument—none would be worth our time without emotion. Skeffington imagined centering to be skeletal; identification, visceral. He noted, "Today one speaks of 'centering' and 'identification.' The one is skeletal and the other visceral."[62] In the Oxford English Dictionary we find visceral defined: "1a. Affecting the viscera or bowels regarded as the seat of emotion; pertaining to, or touching deeply, inward feelings. *Obsolete* after 17th cent. and revived in the 20th."[63]

To remove emotion and feelings from visceral is to eviscerate the word. The autonomic nervous system on which accommodation rests is unconscious and aligned with such basic survival emotions as fight (rage) and flight (fear). Other emotions in a taxonomy that Panksepp based on deep brain simulation studies[64] include lust, seeking, panic/grief, care, and play. If vision is not "seeking," what is it? To neglect emotion in a model of vision is to ignore what it means to see.

If value is emotion unleaded, then belief is emotional rocket fuel. Emotion transforms understanding and misunderstanding into belief, and seeing is, indeed, believing. To insist to someone without binocularity that their hands are not telling the truth, that the quoit floats off the silver screen, that one string is two, that two pictures in a stereoscope are one is to stir emotion, whether anger at you or fear of failed perception. If there is any doubt about the role of emotion in seeing, show a picture of Donald Trump to a heterogeneous group.

When it comes to valuing opportunities for action, we rely as much on our hearts as our eyes. Any model of seeing that neglects, dismisses, or denies emotion is an incomplete model of seeing. Vision converts light into action—often on a wave of emotion: love that sunset, those eyes, that baseball sailing over the fence and into the stands. In a model of vision in which seeing is believing, there is no way to tell where belief ends and seeing begins. They are the same thing.

Antigravity

The antigravity, the where-am-I circle, could also be viewed as the being-or-getting- there circle. It tells us where we are and where we will be. It is the circle of the body and its fight against gravity. It is the circle of physical action.

The antigravity is essential for absolute localization. Without it, where would the ego be in egocentric? The antigravity could be developed through motor planning, through the banishment of retained primitive reflexes, through the development of the vestibular, proprioceptive, bilateral, and/ kinesthetic systems. Angels in the snow, walking rails, chalkboard circles, moving named right or left body parts, simultaneous movement of contralateral body parts or any number of other full-body coordination activities could help to increase the accuracy of the antigravity. Such procedures could also stress simultaneity, which might easily transfer to simultaneous rather than sequential processing of space, simultaneous perception of dichoptic targets or simultaneous integration and coherence of all four circles. Having seen such transfers of performance, some therapists even see the antigravity as the primary circle, supporting and sewing together the others.

Such full-body locomotion appears helpful in developing the antigravity. But is full- body locomotion necessary? Quadriplegics enjoy a form of visual perception and apparently an antigravity circle (although the relative quality of such perception or circularity of the circle could be disputed). Fortunately, the eyes are also a part of the body. We sometimes overlook eye movements in the development of the antigravity despite their use in locating objects compared to self and self compared to objects. The dance of our eyes can reveal our positions in space. Lest we forget the role of eye movements in perception, Berthoz has provided a fuller perspective by calling eye movements "stationary locomotion."[65]

Personally, I imagine the power of eye movements to develop the antigravity is often underrated by those prioritizing full body movements just as those prioritizing vergence eye movements often underate full-body movement in

their therapies. This ongoing argument, however, will not be settled here. I'll leave the disputants to count the neurons and paint the fMRIs associated with their approaches. In the meantime, perhaps it's all good; perhaps the more therapy tools at our disposal, the better.

Finally, the antigravity circle sews action to value, preparing us to see the opportunities for action that will develop into value. We have fully seen neither the forest nor the trees until we have traversed one and climbed the other. The nursing infant illustrates the antigravity's role in the creation of value even as the where-is-it, where-am-I positions of mouth and nipple are coordinated. In the four circles, body action and antigravity should coordinate with not only the actions of the inner and outer eye muscles, but the moving of the tongue and lips—which brings us to our final circle.

Speech-Auditory

Typically, clinicians pay only lip service to the speech-auditory system, imagining that adding a metronome to therapy is all that is needed to address the circle. Except when signing for hearing impaired patients, however, conducting a vision therapy session without speech can be difficult. Every word coming out of a therapist's mouth depends on the speech- auditory circle for its effect on seeing. Our words help emphasize and reinforce the value of opportunities for action no less than the beat of a metronome, the screech of tires, or the roar of a lion. Sound alerts us that some light energy may be more important than others, not to mention surround sound in a movie theater reinforcing the illusion of action on the screen.

As for language, Skeffington wrote: "The child who does not acquire the intricacies of the language, lacks the bridging from the primary visual experience to the vicarious, and will be permanently prevented from achieving complete development of the visual process."[66] Thus, language helps bridge the gap between the primary and vicarious visual processes, allowing us to imagine the fantasy worlds of novels, news stories and, rarely, abstracts from clinical trials. Where there is a hole in language there is a hole in perception. We see what we value. Words emphasize value. When vocabulary is missing, potential value is lost. When asked to point to the cats in a picture, the child with undeveloped language may point to the yellow tabby and the Siamese but overlook the lion and tiger.

In vision therapy, we use words to transfer our values to the patient. If the therapist values development, so may the patient. If the therapist values the flexibility elicited by base-in with minus lenses and base-out with plus lenses, so may the patient. If the therapist values exploration, or seeing volumes of space between objects in the world, or fixating a bead, or converging voluntarily without a target, or finding the where and what of an object, or acknowledging the power of light devoid of certain wavelengths or creating voluntary movement to override or extinguish reflex, so may the patient. Similarly, if the therapist values the patient having fewer symptoms or better performance in the classroom, so may the patient—especially if the patient and therapist are in good communication and the patient has been conditioned by faithfully following thousands of the therapist's commands and constantly seeing improved performance. Improved health may be as simple as following one more command: feel better.

Words can also pervert what we see. In a figure-ground puzzle, the command "Find the three cats in the picture" as opposed to "Find all the cats in the picture" can work against our seeing that there are actually four or five cats. Emphasizing value according to symbols, whether words or pictures, is not without its hazards—the words may be selected and rejected, the pictures cropped according to the opportunities for action valued by the editor.

Without the fourth circle, vision would be profoundly different. When we do vision, sound and symbols underscore location and value. When the four circles are in sync, when they cohere, sound, light and action become one. To see how tightly they are bound just try to unravel them with Pepper's modification of "Kirschner's Arrows," a vision therapy procedure in which the patients

demonstrate with full arm and body movements the direction of consecutive arrows, simultaneously calling out directions opposing each arrow. To try to divorce speech from vision is difficult, for the two are typically fused. Whether we collapse vision into language or language into vision, depends on if we are language or vision specialists.

Skeffington's Circles Summarized

Where does one circle end and another begin? An image floating in the sky is more likely a cloud than a camel; thus, "where" and "what" cannot really be separated. In Skeffington's words, "It might be said that identification is a function of centering and then they become functions of each other."[67] Value revolves around the opportunity for action; action, the pursuit of value. It's not the boundaries of the four circles that are important, but rather that their overlap emerges as vision. Nor do I imagine that one circle is holier than the others.

Any hierarchy, I reason, rests more in our imaginations than in our successful and unsuccessful therapies. We are all tempted to believe that our successes and failures prove our theories rather than merely failing to disprove them. We typically ignore the infinite number of alternative explanations lurking about the universe. As a result, one therapist concentrates on simultaneous, integrated body movement with the hope of highlighting the location of self. Another therapist uses vectograms in the hopes of addressing centering and identification (or maybe, as Skeffington once supposed, convergence and accommodation). Another therapist expands the areas used for value and action by generating aftereffects with colored filters. Another teaches opportunities for action (learning to draw a triangle for instance) to expand identification and value in two-dimensional space. Some use words, as I earlier did (see the space between you and the page) to expand the ZOSA.

In therapy, every fixation of a bead has self at one end, centering in between and value at the other—all waiting to be emphasized by words. Simply asking, "How do your eyes feel?" can expand seeing toward the where of the patient in space. Asking questions about the distance between patient and bead can expand centering to include awareness of patient, space, and bead. Asking about the bead itself can alter the opportunities for action valued (the patient can identify images in bead-reflected light, what it would take to touch, feel or even draw the bead's shape).

The four circles remain largely inseparable. Enhancing any circle could well transfer to all circles to emerge as vision. Arguments of my-favorite-circle-or-part-of-a-circle-is-better- than-yours variety are probably less helpful than arguments supporting approaches that better integrate the four circles, using words to emphasize self (body, including eyes), space, and value.

Before moving on, we will consider one more aspect of the four circles: coherence. The four circles will ideally cohere or agree. The person who feels one peach, sees two, and insists that there are three is likely to have a problematic snack, maybe even a headache. While Donders[68] connected asthenopia with anomalies of refractions and accommodation and von Graefe blamed an "insufficiency of the internal rectus muscles," Skeffington saw past accommodation and convergence to the root of the four circles: the person "doing" the vision, "the organism as a whole":

> *The reason for ocular discomfort has been a baffling search for many optometrists. They sought it in muscle, in anatomical failures, in differences in image size and in a score of anatomical and input hypothesized causes. In all probability … [S. Howard Bartley, Ph.D., psychologist (Psychosomatic Medicine, April 1942] said it better than it has ever been said before, 'Evidence suggests that the localized discomfort is a function of the* organism as a whole, *becoming thus localized when visual achievement becomes, for any reason, unsatisfactory.' [Emphasis added]*[69]

Thus, a deficit in any of the circles, their simultaneous integration, or their coherence could result in symptoms. Difficulties with accommodation and convergence could be but two of these issues.

Another psychologist interested in developing fusion in strabismus, Samuel McLaughlin, provides a perspective that agrees with the four circles:

> *Evidently, in normal binocular vision, the two images are drawn toward one another, not because they resemble each other in visual characteristics, but because they are both interpreted as having the same nonvisual qualities.... Because the two are interpreted in this fashion, the appropriate oculomotor reflexes are called into play, the eyes are positioned so as to superimpose the two images, and the two are seen as one. An observer would hardly be credited with normal binocular vision if he were to superimpose two images which did not appear to him to represent the same object.*[70]

To understand McLaughlin's words, suppose that you have a recent right lateral rectus palsy and your right eye deviates inward. You would likely see double, a second image to your right side. In time the extra image would lose its "nonvisual qualities." If you were to tap a pen on the table, you would not hear the second image. You would not feel the second image with your pen-tapping hand. In time, you might no longer even speak of the second image. Along with the loss of nonvisual qualities, the second image would become unreal. You would no longer try to fuse it with the real image. Some might even strive to equalize the performance of the two eyes in order to reestablish fusion.

We can imagine that neither the "reflex" fusion referred to by Maddox and McLaughlin, the asthenopia referred to by von Graefe and Worth, nor the comfort referred to by Percival and Sheard can be reduced to mere accommodation and convergence. It involves not only the simultaneous union of information from the two eyes, but the simultaneous union or coherence of the four circles. Working simultaneity in any of the four circles might have the potential to strengthen the fusion, whether we built fusion ranges, insisted on keeping things clear and single, or worked on simultaneous instead of sequential visual processing with one or both eyes.

Classical versus Behavioral Vision Therapy

In classical vision therapy, we might say that the clinician primarily uses lenses, prisms, instruments and novel actions (fixation inside the NPC, for instance) to introduce incoherence in the areas of vergence and accommodation; the patient then uses action to regain coherence. In the behavioral paradigm, we might say that vision therapy uses lenses, prisms, filters, instruments, words, novel actions, and/or novel values to introduce incoherence within the four circles (all capable of expanding centering—the ZOSA); the patient uses action to reestablish coherence in the new world. For instance, base out prisms cause the incoherence of diplopia. The action of fusion allows the patient to reestablish coherence. Base right yoked prisms cause the incoherence of walking into the left wall; the patient uses the action of exploring the new relationship between eyes and body to reestablish coherence.

In the meantime, the exploration of novel visual worlds could expand the ZOSA and with it, the strength of fusion (simultaneous use of the four circles). While the behavioral four- circle model explains most all results from the classical approach, the classical approach fails to explain many of the behavioral results. For instance, while the behavioral approach explains both base out and yoked prisms, the classical model falls short when explaining the 1) exploration, 2)expansion of the ZOSA, and 3)strengthening of fusion related to yoked prisms. When enhanced performance or health is not explained by a model, the gains are often attributed to "placebo" as we will explore in the next two sections.

When Paradigms Fall Short

Paradigms seldom come without problems. In Kuhn's words, "There are always difficulties somewhere in the paradigm-nature fit,"[71] and if "any and every failure were ground for theory rejection, all theories ought to be rejected at all times."[72] Similarly, Paul Feyerabend wrote that "there is not a single interesting theory that agrees with all the known facts in its domain."[73]

Kuhn called such plot twists in the favored scientific tales "anomalies" and explained that when a paradigm's defenders are confronted by an anomaly, they "will devise numerous articulations and ad hoc modifications of their theory in order to eliminate any apparent conflict." In other words, reason will be used to hold observation and theory together when they fail to mesh with the expectations of the guiding story or paradigm. If the Little Red Riding Hood story did not explain how Red and Grandmother fit in the wolf's tummy, we could use reason to hypothesize that the wolf previously had tummy-extension surgery. So long as the logic of the ad-hoc tale convinces those with no wish to be unconvinced, it will be sufficient to stretch the paradigm into fitting the unfitting observations.

In Feyerabend's words, "It is very difficult, and perhaps entirely impossible, to combat the effects of brainwashing by argument."[74] When it comes to paradigm expanders, reason is all we need to fit our clinical experience to our story. If, for instance, heterophoria, reduces ranges, and a faulty fusion faculty causes visual symptoms, why do many patients have CI but no symptoms? The ad hoc explanations tumble forth, typically unsubstantiated by actual studies: the patient avoids up close activities such as reading and computer work, or as Sheard above explained why the numbers don't always fit the symptoms: "decided exophoria or esophoria may exist with no complaints on the part of the person examined for the reason that binocular single vision does not exist." In the ad hoc story, the patient has learned to suppress in order to use the two eyes independently thus circumventing stress or strain; etc. Such arguments may not be "brainwashing," but when it comes to rescuing a paradigm they are nonetheless spellbinding.

Such logical ad hoc tales can best be viewed as paradigm expanders. They relieve us from having to expand our most basic assumptions; they flourish especially at that threshold between the mental and physical worlds. There, all symptoms unpredicted by the practitioner's physical paradigm can be blamed on our despicable minds: "Your headache is all in your head." Who can argue? The same goes for unexplained cures unpredicted by the reigning paradigm. These can be rationalized away with the expletive *placebo*.

The Placebo Effect

So, what exactly is placebo? In 1799 it was defined as the "wonderful and powerful influence of the passions of the mind upon the state and disorder of the body"[75] Today, we more often use "placebo effect" to explain why good treatment outcomes happen to our bad professional competitors.

The Oxford English Dictionary's definition of placebo hardly clears things up: "A drug, medicine, therapy, etc., prescribed more for the psychological benefit to the patient being given treatment than for any direct physiological effect; esp. one with no specific therapeutic effect on a patient's condition, but believed by the patient to be therapeutic (and sometimes therefore effective). Also: a substance with no therapeutic effect used as a control in testing new drugs, etc.; a blank sample in a test."

In the definition, placebo, in its own illogical way, is effective while being simultaneously not effective, or rather having "no specific therapeutic effect," "specific" meaning specified by a favored paradigm. In other words, the effect cannot be legitimate unless voted in by the consensus of the dominant group of healers. To get a "psychological benefit" without a "physiological effect" is even more of a trick. It requires a brainless patient if, as many of us currently imagine, mental events depend in some mysterious way on brain events. Indeed, as research advances, placebos have been demonstrated time and again to change actual brain activity,[76] in some cases even producing "endogenous opioids,"[77] which tend to be pretty darn "specific" in their nonspecific way. For some, therefore, the placebo effect refers only to actual physical brain changes associated with patient expectations, for others the placebo effect refers to subjective improvements unaccompanied by the physical changes predicted by a paradigm.

Considering the placebo effect places us solidly and ethereally at the interface of the two worlds:

> *Disease adversely affects the organism; illness adversely affects the person. The body is the locus of both disease and illness; however, the impact on the body is understood differently in these two domains. Disease is understood scientifically in terms of pathophysiology; illness is understood phenomenologically, as lived experience … Commonly for a sick person, illness and disease co-habit in a dynamic and not necessarily stable relationship.*[78]

The placebo effect is more than a concern about healing, it spills over into worldview, our thoughts on the two worlds we introduced earlier. A science priding itself in physical explanations has little use for mental theories. As a result, "placebo" has long been a term of derision for cures not specified and predicted by physical models. The Oxford English Dictionary tells us that in 1811[79] placebo was "an epithet given to any medicine adapted more to please than benefit the patient"—feeling better evidently being of no benefit.

The rocky road that mind-related cures have had to travel in the land of a physically- oriented medical profession is further summarized by Harvard Medical School's Kathryn T. Hall in her 2022 book, *Placebos*.[80] Hall shares that in the fourteenth century the wealthy could afford to pay fake mourners to enliven the funerals of their loved ones with the chant *'Placebo Domino in regione virorum,'* I will please the Lord in the land of the living. Named after the prayer's Latin placebo or "I shall please," the fake mourners were called "Placebos." The term has been associated with fakeness, dishonesty or deception ever since, not to mention mystery. Just as we can't know with certainty if the placebos are more pleasing to the living or the dead, we often don't know if placebos are better characterized by the doctor lying to make the patient feel better or the patient lying to make the doctor feel better.

Doctors are particularly upset when placebos are used by their competitors. In the 1800s, for instance, many well-educated patients began to prefer quacks using placebos to doctors professionally trained in leeching, bleeding, and unanesthetized surgery. No less than today, physicians abhorred the heresy of unorthodox treatments and for good reasons:

> *Regular physicians were not allowed to advertise, and this put them at a tremendous disadvantage in relation to quacks who used flyers, magazines, religious and secular papers, and the press to appeal to sufferers of every ailment imaginable with an offer of a miraculous cure. The rise of medical societies and journals gave the regular physicians a platform from which to take aim at nostrums, quackery, and pseudomedicine.*[81]

Today, even orthodox practitioners have learned from the quacks. LASIK ads now compete for billboard space with personal injury lawyers. Luckily, at the end of the eighteenth century we had Benjamin Franklin. As optometrists we know him as the inventor of the bifocal, but even more impressively, Franklin invented a forerunner of the placebo-controlled study. In the late seventeen hundreds, the Austrian physician Franz Anton Mesmer had captivated Paris elite society, including Marie Antoinette, by using magnets to heal his patients. Fortunately, Ben Franklin was called upon to lead a Royal Commission. For three or four months, in the name of scientific truth, they lied to people, using fake magnets to create the same screaming, retching, and convulsing elicited by Mesmer's cathartic magnets. The commission included such distinguished scientists as Joseph-Ignace-Guillotin, inventor of the guillotine. Ironically, Marie Antoinette may have abandoned better sense when it came to the unscientific Mesmer, but she abandoned her head when it came to the scientific guillotine.

Despite Franklin's brave beginning, nostrums and their placebo effects continued to be patented well into the 20th century. Unfortunately, not all of these cures were inert. Some contained alcohol, while others contained opium, cocaine, or even antifreeze. To save the health of the public—and more importantly the pocketbooks of the

physicians—Congress implemented the Federal Food, Drug, and Cosmetic Act thus initially saving the public from poisons, and eventually from the horrors of pinhole glasses temporarily stealing patients from offices of licensed practitioners. Still, there remains an elephant in the room of placebo-controlled studies:

> *Since Mesmer versus Franklin … we have done an outstanding job separating clinically effective treatments from those that appear to have no benefit beyond that of a placebo. But like Franklin … and the many scientists and clinicians who followed, we have failed to focus on the most important part of the placebo puzzle: the patient. While the determination of safety is paramount and immutable, the determination of efficacy presents a different challenge. If both a placebo and verum pill, injection, or surgery equally reduce patient suffering with no difference in benefit, is it fair and reasonable to withhold both when there is no other option available?*[82]

Common sense would tell us that in the above case the harmless placebo would be a better choice than the potentially dangerous surgery. The passage reminds us that placebo controls are important, not because they prevent the patients of competing practitioners from getting better for the wrong reasons but because they protect our patients from being harmed except for the right reasons. Think: George Washington and bloodletting. Although leeching, bloodletting, and lobotomy have largely passed into the ever-increasing ranks of pseudo-medicine, in the United States medical error is still the third leading cause of death.[83] Placebo-controlled studies save lives; they limit the number of ways that physicians can kill us.

When it comes to placebo-controlled studies, our job as clinicians is different from that of the scientist. The scientist's job is to understand nature. The clinician's job is to benefit the patient. The scientist's job is to understand not only *if,* but *why* a treatment works. The clinician's job is to compare a treatment's benefits to its possible harm. If placebo-controlled studies tell us that opioids offer better pain-relief than the NSAIDs, we remain cautious. Opioids kill more people than vehicle accidents.[84] In its quest for scientific truth, the placebo-controlled study is often more concerned with truth than life.

That said, what exactly is the mechanism of placebo or more properly the placebo effect? We don't really know. Experts[85-89] have proposed expectation, motivation, conditioning, emotion, desire, positive feelings, somatic focus, distorted memory, trust, hope, relationship, imagination, motivation, compassion, and meaning attributed by the patient to the healing ritual, communicated expectation of benefit, clinician-patient encounter, alterations in patient's attention (away from distress), embodied experience, active versus passive healing, interpersonal healing, activated self-healing functions of the organism, language, symbolic significance, social attitudes, interpersonal contact and psychosocial context. Take your pick.

When we consider that "context" can include just about anything you've experienced during your lifetime or anything else in the healing world not specified by group consensus, our explanations haven't exactly narrowed things down. The word *placebo* is little more than a euphemism for a mystery used to explain away a mystery created by an inadequate model of care. Rather than say, "We really don't understand why she got better, we say, "The placebo effect, cured her!" Translation: "We really don't know why she got better. Her cure is not specified by our theory." Clinicians cavalierly tossing about the word placebo to discourage their competitors' patients from improving are merely confessing the failings of their own models. In truth, we understand the mechanism of the placebo effect and how mind and body interact no better than we know how matter presumably got a pay raise to expand into life and visual consciousness.

In clinical practice, the placebo effect is most often mentioned in the service of the healing wars—those battles of interprofessional politics and competition for the dollars and affections

of patients. Clinicians wield placebo-controlled studies as powerful weapons.

Rather than say, "The treatment was successful 60 percent of the time, but our model doesn't explain why," the physician performs the "no-better-than-placebo" chant to create doubt. In the name of science or truth, the resultant nocebo effect helps to stem the publishing of internet testimonials by the patients of competing practitioners.

Some have sought to reduce the derision accompanying "placebo effect" by substituting such euphemisms as "meaning response"[90] or "remembered wellness."[91] I prefer "nonspecific effects,"[92] an innocuous designation meaning simply that the effects of the treatment are not specified by a group's present paradigm. Placebos attest to the limitation of theories limited to the physical and not the mental world.

Philosopher of science Karl Popper has allowed, "Science may be described as the art of systematic over-simplification."[93] This oversimplification is apparent in the classical VT paradigm of the CITT-ART in which centering is reduced to convergence and identification reduced to accommodation. We are left with physical model of vision in which value, language and emotion are banished as "placebo" and the wide variations in the volume of spatial awareness needed to thread a needle versus play basketball are largely ignored as playing any role in fusion.

Finally, the more behaviorally-oriented the optometrist, the less relevant the notion of placebo effect. Placebo is normally applied to disease, not performance. John Wooden led seven UCLA teams to championships. No one questioned whether it was Wooden's motivating, technical, or scouting skills that led to his teams' success any more than we would disqualify a financial empire because its business executive was "charismatic" or "good with people." The placebo effect concerns the limitations of healers' paradigms. Vision therapy can center on disease or performance. Unfortunately, this does not solve our problem of intraprofessional and interprofessional referrals by those firmly rooted in a disease model.

Such practitioners will still depend on scientific studies. And so, we return to the CITT-ART.

Part 3: "Abstract" Reasoning

Having stepped outside the classical version of the vision therapy box, we are now ready to return, comparing evidence-based medicine to abstract-based medicine. Are abstracts superior to news headlines in capturing the stories beneath? Let's compare the CITT-ART abstracts with what they purport to summarize.

Performance Changes Accompanying Vision Therapy (Classical and Behavioral)

First, what changes in reading, attention, and symptoms actually accompanied the 16 weeks of classical vergence/accommodative and behavioral non-vergence/non-accommodative ("placebo"?) vision therapies? Changes in reading and attention scores from before to after therapy were evaluated using Cohen *d* effect sizes, a statistical method assumed to quantify treatment effect for significance. "Using Cohen's taxonomy, an effect size greater than 0.80 represents a large treatment effect; between 0.50 and 0.80, a moderate effect; and less than 0.50, a small effect."[94] For instance, according to the CITT-ART, "Bloom and colleagues reported mean effect sizes ranging from 0.23 to 0.40 for expected reading growth from one grade level to the next (as a result of typical instruction and maturation in grades 3 through 8) based on composite scores of reading proficiency from nationally normed tests."[95]

Standard classroom instruction provided a "small effect," at least when subjected to Cohen d statistical analysis. By contrast to these small one-year school improvements, the effects of the 16-week vision therapy trial measured by the primary outcome measure, the reading comprehension subtest of the Wechsler Individual Achievement Test, 3rd edition (WIAT-III) rose to a moderate effect of 0.70.

The secondary measures of reading comprehension showed more variability. Using a non-Cohen *d* statistical method, the AIM Sweb Curriculum-based measures rose as high as 0.84 on the silent-reading-and-fluency-and comprehension Maze test

and fell as low as -0.18 on the Gates-MacGinitie Reading Test, 4th edition—a multiple-choice type test. Surprisingly, these moderate to large improvements on two out of three standardized reading comprehension measures, not to mention large (1.14) to no (.05) improvements in oral reading fluency, belonged to the behavioral vision therapy that investigators interpreted as the "placebo group." The improvements of the classical vergence/accommodative group, however, were not significantly different from the behavioral non-vergence/non-accommodative group.

In conclusion, the wide variation in secondary measures suggests they may not be measuring the same thing or measuring up to their titles. Caution is, therefore, required in making blanket statements about reading improvement. What remains certain is that the primary standardized reading comprehension measure of the CITT-ART accompanying both styles of vision therapy demonstrated a moderate Cohen *d* effect, an effect nearly twice as large as that accompanying a year of standard classroom instruction. To suggest that improvements in standardized reading testing do not accompany both classical and behavioral vision therapy is to equivocate.

In the attention study, parents saw mainly large effects, but there were some exceptions. On the CITT-ART's primary outcome measure for attention, the Strengths and Weaknesses of Attention-Deficit/Hyperactivity Disorder Symptoms and Normal Behavior (SWAN) parents—who are most likely intimate with their children—reported large effects in "inattention" (1.00-1.04), moderate effects in hyperactivity/impulsivity (.55) while teachers—primarily familiar with children as part of a group—reported, respectively moderate to small effects (which is significant to clinicians, who depend on parents, not teachers for support). On secondary outcome measures for attention, parents reported strong effects on the Swanson, Nolan, and Pelham 4 (SNAP) inattentive report (0.82 – 1.00) and moderate effects on the SNAP hyperactivity/impulsivity report (0.55 to 0.65) On Homework Problems Checklist and the d2 Test of Attention, parents' reports all indicated large effects (1.33 to 1.87), the one exception being a small effect for non-vergence/non-accommodative therapy for children already using ADHD medications. Again, with that same medicated-children exception, *there was no significant difference in improved attention between the vergence/accommodative vision therapy group and the non-vergence/non-accommodative vision therapy group*. Thus, in either type of vision therapy, parents are likely to see large effects in performance and moderate effects on wiggling (which typically reduces with age anyway). Nor were the improvements limited to reading and attention. Visual symptoms also improved dramatically. There were large improvements in symptoms as measured by the CISS. Again, however, the improvements were not significantly different between the classical vergence/accommodative and behavioral non-vergence/accommodative ("placebo") vision therapy groups.

Investigator Bias

Interestingly, even though all three studies showed essentially the same results with both treatment groups demonstrating primarily moderate to large effects in attention, reading, and symptoms, the tone and conclusions of the three articles varies significantly, suggesting possible biases in the investigator group. Examining the three conclusions may provide insight into the possibility of such biases.

The interpretations in the writeup of the attention trial seem to be most neutral in capturing the evidence:

> *These results suggest that vergence/accommodative therapy is no better than placebo therapy in improving attention. Large improvements in inattention, completing homework, and selective and sustained attention were found in each group. However, these improvements cannot be attributed to improvements in vergence and accommodation and are likely due to nonspecific effects of an intensive therapy regimen.*[96]

While the conclusion's introductory "no better than placebo" still offers a nocebo weapon against the patients of practitioners with rival paradigms, the conclusion's second and third sentences do all the necessary work for scientific understanding. A more accurate, less interpretation-heavy way to phrase the first sentence would have been, "Thirty-two hours of home and office classical vergence/accommodative therapy was no better than thirty-two hours of behavioral home and office non-vergence/non-accommodative vision therapy in improving attention." This sentence would have emphasized that both therapies required equal effort rather than that one therapy required effort and the other therapy worked through some sort of effortless magic. My suggested version also does not assume that the behavioral non-vergence/non-accommodative therapy was necessarily inert for the purposes of enhancing vision and attention.

One could easily dismiss my quarrel with the words "no better than placebo" as unfounded, the phrase being standard nomenclature for clinical trials and suggesting that an active substance does not outperform an inert substance. I would respond that while this approach seems to work well for studies on drugs and the far-too-rare studies on surgery, it has been criticized for allowing any definitive conclusions about psychotherapy programs because evidence[97] suggests that in randomized studies the results of psychotherapies are often indistinguishable despite a wide diversity of specified theories guiding the therapies: almost 400 different approaches lead to similar results. Would it be a surprise if two types of vision therapy led to a similar result? In addition, there is another problem with using placebos in therapy studies:

> *The main problem in studying placebo effects in psychotherapy is that it is difficult, maybe impossible, to separate the placebo component from the specific effects of a psychotherapy … The practical problem is that … in pharmacotherapy … all that is needed is to omit the active ingredient from a pill or a solution … to disentangle the psychological component from the overall pharmacological effect. With a psychological treatment, this is not possible, as all of the ingredients are psychological.*[98]

Supporting the "no better than placebo" terminology, one could still argue that vision therapy is not psychotherapy. I would disagree. As we have discussed, vision occurs at the interface between mind and body. In training voluntary convergence, for instance, are we primarily training the oculomotor apparatus or are we training volition to control the oculomotor apparatus? The muscles, we generally agree are already many times stronger than necessary to move the eyes. Furthermore, as we have previously imagined, the mental actions of value, modulated by belief, emotion, and language, also apply. In other words, vision therapy can be as involved with the mind as psychotherapy just as psychotherapy can easily affect body actions. Thus, the pharmacological/placebo approach to evaluating vision therapy may be no more conclusive than the pharmacological/placebo approach to evaluating psychotherapy while the inappropriate "no better than placebo" verbiage wrongly suggests that the same rules apply and, not surprisingly in a culture of "physical" healers, discounts therapy.

Continuing with the vision therapy/attention trials' conclusion, the second sentence is accurate and emphasizes that both therapies were correlated with improved attention (as they should because both therapies are essentially behavioral vision therapy affecting the four circles.) The conclusion's third sentence is similarly helpful, replacing—as we have noted—the pejorative *placebo* with the nonpejorative "nonspecific effects of an intensive therapy program." The phrase communicates that moderate to large effects in attention accompanied both therapies but allows that some part of the process or context not specified by the classical better-ranges-better-fusion-better-comfort paradigm may have contributed. This hardly surprises us when we consider that a complete paradigm would have to account for the four circles, not just parts of two circles.

In the attention study's section on "Significance," prominently displayed in the abstract, the investi-

gator's bias is more apparent. The group writes, "The results of this study suggest that clinicians providing vergence/accommodative therapy for convergence insufficiency in children should not suggest that such treatment will lead to improvements in attention when compared with placebo treatment." The suggestion verges on the absurd. No vision-therapy clinician would suggest any such thing. Clinicians mention placebo only when discussing their rivals' interventions, not their own. How often does a surgeon tell you that any symptoms relieved by a surgery may well be due to a placebo effect rather than the physical changes produced by the surgery? Still, the abstract hardly captures what is plainly stated late in the body of the article:

> *The results of this study suggest that clinicians providing vergence/accommodative therapy for the treatment of convergence insufficiency in children would find moderate to large improvements in measures of inattention (Strengths and Weaknesses of Attention-Deficit/Hyperactivity Disorder Symptoms and Normal Behavior scale), completing homework (Homework Problems Checklist), and selective and sustained attention (d2 Test of Attention). However, these improvements cannot be attributed to improvements in vergence and accommodation.*[99]

This paragraph demonstrates that the investigators were well aware that both vision therapies improved attention but the improvements remain unexplained (unspecified) by the vergence and accommodation paradigm. Why did the investigators, under the supervision of the NEI, bury this admission under "Clinical Implications" at the very end of the body of the article where few would read it? Why tailor-make the more negative interpretation for the convenience of, in Kushner's words, "the lay media and professional tabloids hype sensationalist 1-line quotations from the abstracts of scientific articles"?

While the largely neutral vision therapy and attention article hints at the bias of its investigators or supervising government agency, the conclusion of the vergence/accommodative vision therapy and reading article provides more than a hint:

> *For children aged 9 to 14 years with symptomatic convergence insufficiency, office-based vergence/accommodative therapy was no more effective than office-based placebo therapy for improving reading performance on standardized reading tests after 16 weeks of treatment.*

What is wrong with this conclusion? Why do the words suggest that they were selected by the authors or NEI for their persuasive rather than scientific value?

Consider how real science is done. In April of 1953, Watson and Crick published in *Nature* the most famous biological discovery of the 20th Century. The article is introduced with the characteristic brevity and understatement of science: "WE wish to suggest a structure for the salt of deoxyribose nucleic acid (DNA). This structure has novel features which are of considerable biological interest."[100] What is relevant for our discussion is that despite the importance and ultimate renown of the discovery, the authors do not declare what the structure of DNA "is." They "suggest," the caveat announcing that this is the best they could do for now and that progress might prove them wrong. In real science, a modicum of skepticism is fashionable, providing it's not skepticism about the scientific method itself. The moment the caveats are removed, we can suspect we have abandoned science for the rhetoric needed to fuel politics or sales.

While the conclusion of the attention study was tempered with the caveat "suggest," the reading study abandons the subjunctive to declare "*office-based vergence/accommodative therapy was no more effective than office-based placebo therapy for improving reading performance* … [emphasis added]": the perfect abstract hype for the sensationalist lay press and professional tabloids. Not only does the abstract carefully avoid mentioning the positive results of the primary outcomes' standardized reading test for both therapies, the abstract adds the adjective "office-based" so that the abstract cannot be used to

promote office-based vision therapy over Kushner's preferred home-based orthoptic training.

This abandoning of science for persuasion hearkens back to a pattern begun in 1972[101] when organized ophthalmology and pediatrics, began a string of editorials and political position statements promoting the idea that vision therapy was unrelated to reading or learning gains. The 2011 version, for instance, reiterates the basic premise in its equivocal way: "There is no valid evidence that children who participate in vision therapy are more responsive to educational instruction than children who do not participate."[102] No scientific skepticism here. No *mays, suggests,* or *mights* about it.

Since the article is a political position statement posing as a scientific article, however, no caveats would be expected. Again, however, the abstract fails to agree with the body of the 2011 article where once more we find the following:

> *Symptomatic convergence insufficiency can cause discomfort, eye-strain, blurry vision, diplopia, and headache, which can contribute to limited fluency by interfering with the child's ability to concentrate on print for prolonged periods of time. Symptomatic convergence insufficiency is a treatable condition.*[103]

"No valid evidence"? As we discussed in our example of Semmelweis and handwashing, in science "evidence" is in the eyes of the beholder. Still, a caveat would have been useful because some might question if limited "fluency" and "concentration" bear "no" relation to "educational instruction." Again, we are reminded that the clinician interested in evidence- based medicine should stick to the evidence recorded in the body of scientific articles, not the interpretations found in abstracts and position statements.

The disparity between the reading article's abstract and body is not the only suggestion that the investigators and NEI reviewers may have shifted into position-statement mode for the reading arm of the CITT-ART. The other suggestion is the return[104] to references failing to support the folk-psychology-style contentions of the reading article. For instance, the investigators write, "Robust placebo effects have been shown in studies investigating novel treatments that required a large time commitment from children and their parents."[105] While I hardly doubt the statement is true, the article[106] cited to support the contention was written to assess the feasibility of a sham neuro-biofeedback group, not the efficacy of placebo therapy. The article did not support the contention of the CITT-ART authors any more than most articles in position statements support science as much as they support politics.

The difference in tenor between the attention and reading conclusions despite similar results hardly proves but certainly suggests that bias may be in play in reporting any link between reading and vision therapy. Nor does inconsistency of reporting seem limited to the reading study but extends in the opposite direction in the CITT-ART convergence study:

> *CONCLUSIONS: Our results demonstrate that office-based vergence/accommodative therapy is effective for improving the NPC and PFV in children with symptomatic convergence insufficiency. However, given that both treatment groups had a similar reduction in self-reported symptoms, it may not be prudent to use the CISS alone as a measure of successful treatment.*[107]

Again, unlike in the attention study, no modifying "suggest" tempers the declaration that vision therapy improves NPC and PFV. If the investigators were being consistent with the reading study, however, they would have noted that classical vergence/accommodative vision therapy is no better than behavioral non-vergence/accommodative (placebo) vision therapy in improving scores on the CISS. Instead, any mention of placebo is replaced with "treatment groups." If the bias of the CITT-ART investigators and their NEI reviewers extended to discrediting any connection between reading and vision therapy, the bias reversed itself when questioning any connection between symptoms and vision therapy. Instead, the investigators direct the readers' attention to that mysterious interface between the two worlds that we discussed in the opening section of this paper. The investigators' conclusion seems to say: we should be equally

concerned whether the findings get better and the patient does not or the patient gets better and the findings do not. Personally, I would agree, but those who are unimpressed by the numbers related to convergence might not.

Finally, there is an odd claim in the reading conclusion that seems to highlight the disparity between the three CITT-ART conclusions:

> *For children with convergence insufficiency in this age range, identification and treatment with vergence/accommodative therapy are likely to improve vergence and accommodation function … which could make reading and schoolwork more comfortable.*[108]

This remark is certainly reasonable, but the source cited for this remark is the updated convergence study, which, if we read more than the abstract, essentially seems to support that VT is no better than placebo in improving CISS scores. Is the "placebo effect" of VT on symptoms legitimate while the "placebo effect" on reading illegitimate?

In summary, the inconsistencies between the three conclusions of the gold- standard CITT-ART seem to suggest the biases of the investigators and/or their NEI reviewers. That vision therapy, for the wrong reasons, may affect attention apparently need not be promoted in the abstract but neither must it be buried entirely in the body of the paper. That VT, for the wrong reasons, may affect reading appears to be anathema to the authors and must be not only banned from the abstract but carefully explained away in the body of the paper. That VT, for the wrong reasons, may influence symptoms must also be concealed, otherwise we are coming dangerously close to supporting the naysayers that Kushner was happy to leave behind in his editorial about the pencil-pushup preliminary study in 2005: "This should dispel the beliefs of those naysayers who believe that CI is not a real entity and that all perceived benefit of treatment is a result of a placebo effect."[109]

For those who have a bias against vision therapy, the CITT-ART's stated conclusions and unstated implications should be welcome. For those of us biased in the other direction by countless hours in seeing patients improve with vision therapy (possibly for reasons unsuggested by our models), the conclusion and unstated implications are less comforting. After a quarter of a century of painstaking work, they seem to lead to a dead end. Would there be less disease in the world if we could all cross our eyes even though this new skill affected symptoms, reading, and attention no better than placebo? Fortunately, this question may not require our attention, for the inconsistency of the abstracts and the biases these inconsistencies suggest may be the least of our problems, for there appears to be an elephant in the room of the CITT-ART—an elephant we will next visit.

Part 4: The Elephant in the Room

We find the elephant buried beneath a blanket of caveats italicized in the following quotes from the convergence/symptoms, reading, and attention articles: "Although the improvements in clinical signs were significantly less in the placebo group, *it could be speculated* that the placebo therapy … was not *purely* a sham therapy [emphasis added]."[110] *"It is possible* that both the vergence/accommodative and placebo therapies shared some common element that improved some reading measures in both groups [emphasis added]."[111] *"We cannot rule out* that the unintended improvements in the vergences and accommodation in the placebo therapy *could account for some* of the positive response in this [improved-attention] treatment condition [emphasis added]."[112]

We'll consider some ideas from these quotes one at a time.

"Although the improvement in clinical signs were significantly less in the placebo group..."

Were they? Let's explore.

Returning to the investigators' discussion:

> *After 16 weeks of treatment, office-based vergence/accommodative therapy was found to be significantly more effective than office-based placebo therapy in improving the clinical measures of near point of convergence and positive fusional vergence in 9-to 14-year-*

old children with symptomatic convergence insufficiency.[113]

When first inspected, the evidence certainly supports this conclusion. In the vergence/accommodative group the NPC went from an average of 14.4 cm to a normal 3.9 cm, while in the non-vergence/accommodative group only improved from 14.9 to 8.8, an improvement of approximately 10 cm compared to 6 cm. Similarly, PFV improved from 11.5 to 34.5 prism diopters in the vergence/accommodative group compared to 11.3 to 20 +/- 1.7 in the non-vergence accommodative group. But a question still remains. How much convergence is enough? Perhaps we need to reconsider the results.

The CITT-ART measured convergence in two ways: 1) NPC, in which accommodation, convergence, and the object of regard's spatial position compared to the body are all matched as they are in the habitual world. 2) PFV (actually positive relative convergence (PRV) unless blur is reported) in which prism mismatches convergence with both accommodation and body, creating a new or nonhabitual world.

What do we expect for a normal NPC? Over the years, authorities have typically given estimates between 5 cm and 11 cm.[114] Hayes et al, using an accommodative rule with 20/30 letters, tested 297 children, divided between kindergarten, third grade, and sixth grade students with the following results: "At least 85 % of the subjects in each grade had an NPC break ≤ 6 cm. NPC break values were 3.3 ± 2.6 cm for kindergarteners, 4.1 ± 2.4 cm for third graders, and 4.3 ± 3.4 cm for sixth graders." The CITT-ART investigators used the kindergarten norms, settling upon <6.0 cm as normal even though something between 6.5 to 7.4 cm might have been a better cutoff for a group of 9 to 14-year-olds—at least if we are defining disease as the failure to live up to group norms rather than merely having symptoms.

Averaging the data from the third and sixth graders, we could estimate a standard deviation for NPC breaks at around 2.9 cm, suggesting that the average approximate 6 cm improvement in the non-vergence/non-accommodative vision therapy group was a solid two standard deviations of change, even though the findings, for most patients, fell short of the normal range. Put another way, the non-vergence/non-accommodative group averaged a change of NPC from 14.9 to 8.3 cm or 6.7 to 12.0 meter angles for a total of 5.5 meter angles of convergence increase. If we estimate that most pupillary distances fell between of 5.0 and 6.2 cm for an average of 5.6 cm, then converting meter angles to prism diopters we get 5.3 MA X 5.6 cm pupillary distance = 30.8 prism diopters of convergence. Granted, this is a non- traditional perspective, but perspective is all when we are using what I have described as "rhetorical numbers,"[115] numbers used to persuade rather than predict. Put bluntly, could an over-30-diopter increase in convergence ability, placing patients in the normal range, have been enough to reduce symptoms in the behavioral non-vergence/accommodative vision therapy group?

When considering PFV, the investigators noted that measuring positive fusional convergence can vary naturally by a significant range (although in the study reported the findings were retested after 1 week rather than 4 months so any practice effect would have been different).[116] The investigators selected greater than 10 diopters of convergence improvement as outside this natural-variation range and, therefore, "successful," which is a reasonable premise.

As mentioned above, the behavioral non-vergence/accommodative therapy group improved in PRV or PFV, averaging 11.3 prism diopters before therapy and 20 prism diopters afterward. According to Wesson's prism bar norms of 19 ± 9 prism diopters,[117] the group demonstrated approximately a full standard deviation of change from low normal to slightly above average. According to Morgan's phoropter expecteds (PRC: 17 ± 5)[118] the group began one standard deviation below normal and ended a half of a standard deviation above normal—another large effect.

If these results occurred in a treatment group, and a control group showed significantly less robust findings would we be all that disappointed? The

reason for dismissing the gains of the behavioral therapy group nonspecified by the vergence/accommodative classical model is not that the gains are especially poor but because the changes in the vergence/accommodative therapy group was significantly better. But were they? Again, let's look.

Strength of Reflex Fusion Versus Ability to Voluntarily Converge

What makes the vergence/accommodative group's findings better? Our classical paradigm tells us that larger fusion ranges suggest stronger fusion, which reduces asthenopia and subsequently improves symptoms—that, hypothetically at least, should improve attention, and reading. But is the paradigm correct? Do larger ranges relate to stronger fusion? To answer this question, we'll return to Maddox, who felt that it was the job of "reflex convergence" to overcome vergence demands not met by tonic, psychic, and accommodative convergence. Maddox speculated that it was the inadequacies in "reflex convergence" that caused the symptoms.

So how does this relate to the current study? What do the numbers tell us about the quality of reflex/fusional/disparity-driven convergence? The answer is not as evident as it seems. Practically speaking, the lifesaver card and eccentric circles, when eventually performed without the help of a pointer, demand the creation of voluntary convergence, meaning convergence without the aid of a convergence target. The ability to "cross our eyes." Such voluntary control of convergence can dramatically expand vergence ranges with or without fusion. I can, for instance, voluntarily cross my eyes to combine the pointer finger of my left hand with the thumb of my right hand (chiastopic fusion) without calling into action reflex fusion, my mind hardly being tricked into believing my finger and thumb, though rivaling for attention in the same spatial position, are "one."

Thus, once voluntary vergence is practiced sufficiently, a viewer can control the dissociated position of the eyes, keeping even first degree, dissimilar targets superimposed over extensive ranges with no real reflex alignment of the eyes. The magnitude of the ranges may, but not necessarily, reflect reflex convergence or "good fusion." For this reason, if reflex convergence were responsible for comfort and efficiency and voluntary/psychic convergence could extend the numbers without necessarily adding to reflex convergence, then how much reflex convergence is enough for comfortable seeing?

Are larger ranges beyond an adequate point necessarily better? Do higher numbers necessarily suggest stronger reflex convergence, or do the numbers merely reflect the parlor trick of being able to converge voluntarily? In addition, the classical vergence/accommodative therapy, while not directly working prism-bar ranges, did directly work ranges. *The behavioral non-vergence/non-accommodative vision therapy instead concentrated on equalizing monocular inputs and strengthening simultaneous perception and fusion from the two eyes.* Since the behavioral non-vergence/non-accommodative therapy was not specifically designed to expand the numbers, *which findings are more related to the development of genuine reflex convergence and which findings are more likely to be inflated by more nearly practicing the test?* In other words, was one therapy really superior to the other in strengthening the reflex convergence that Maddox related to asthenopia?

The large specific effect in strengthening reflex convergence suggested by this interpretation of the evidence could go a long way in explaining why both therapy groups showed medium to large effects in the primary outcomes of symptoms, attention, and reading.[119] As we have already quoted, the investigators hardly denied such a possibility, admitting, "We cannot rule out that the unintended improvements in the vergences and accommodation in the placebo therapy could account for some of the positive response in this treatment condition." Whether or not the convergence improvement was intended, the investigators still confined the elephant to the discussion section of the article, as if to avoid creating havoc in the abstracts.

Still, there is another question, was it placebo (mystery) that created the strong effects in reflex convergence or is there a less mysterious

explanation? This question brings us to another caveat-clad speculation of the investigator group.

Both the Vergence/Accommodative and Placebo Therapies Shared Some Common Element

As we have considered, behavioral vision therapy could be viewed as the art of using lenses, prisms, instruments, filters, language, novel actions and novel values to introduce incoherence to the four circles; the therapist then guides the patient to use light-inspired exploration and action to reestablish coherence. If in the past a patient had only walked on sidewalks, guiding that patient to use light to guide walking in deep sand or waist-deep water would alter visual perception. The patient would learn to use light information to predict action in new worlds. In the behavioral model, this could qualify as vision therapy—no accommodative flippers or prism bars necessarily required.

Nor, in the behavioral model, is fusion limited to simultaneously seeing in the same direction of foveal images from the two eyes. Fusion is the simultaneous uniting of the four circles in agreement. Centering, value (including feelings), body, and language all must simultaneously agree on the unification. Images are not really "fused" if the feelings or words in the mind of the patient suggest the images are not really united. Images are not really fused if the hands and the body disagree with the union. Images are not really fused if they have not been simultaneously selected for value or action. From this viewpoint, classical vision therapy is merely one approach to coherence of the four circles, the only difference being that in the classical model all non-vergence/accommodative inspired improvement in performance (body movement/ colored filters/yoked prisms/magnifying lenses/ language- directed novel seeing) are dismissed as "placebo," not being specified by the limitations of the vergence/accommodative paradigm.

Viewed from a behavioral rather than classical viewpoint, the CITT-ART contained no "sham" or "placebo vision therapy. All the vision therapy in the CITT-ART—both vergence/accommodative and non-vergence/non-accommodative—worked simultaneity, unification, and coherence of the four circles. To explore this idea, let's look at the actual therapy in the two vision therapy groups.

CITT-ART Vergence/Accommodative Vision Therapy Protocol

Gross convergence

Brock String
Barrel card

Both provide novel, incoherent worlds encouraging exploration and action in an effort to reestablish coherence. Simultaneous perception of all beads on the string encourages expansion of the ZOSA on the z-axis. Identification is expanded by giving value to the illusion of physiological diplopia and providing a novel opportunity for action of the vergence system. The procedures integrate language and body/eye action possibly to expand flexibility and coherence between the four circles.

Fusional vergence

Clown and quoit vectograms
Computer orthoptics (RDS)
Lifesaver cards
Aperture rule
Eccentric circles

The procedures mismatch light information with the body, encouraging exploration, creation, and coherence from incoherence. All procedures are capable of expanding the ZOSA, especially if the patient perceives SILO. All encourage potential coherence of the four circles.

Accommodative

Monocular loose lens facility
Monocular letter chart facility
Bullseye rock
Lens sorting
Stereoscope biocular facility
Prism dissociation biocular facility
Binocular +/-2.00 flipper facility

Again, all these procedures provide novel worlds mismatching light information with normal actions of the eyes and body. The procedures either work to equalize monocular performance or strengthen simultaneous perception and fusion between the two eyes. The procedures introduce incoherence and demand light-inspired action to reestablish coherence. Any spontaneous SILO could signal expansion of the ZOSA and subsequently strengthened fusion.

CITT-ART "Placebo" (Non-vergence/ Non-Accommodative) Vision Therapy Protocol[120]

To emphasize that the in-name-only "placebo" procedures are not sham, but real vision therapy, I have described and analyzed office procedures 8.5 1-22 individually in Appendix A.

As with the vergence/accommodative procedures, the non-vergence/non- accommodative procedures employed the art of guiding light-inspired value and action in novel worlds possibly to expand the capacity for exploration, creation, and performance. As we will see, the procedures exploited lenses, prisms, instruments, filters, words, novel actions, and or novel values to create incoherence. Learning to overcome such incoherence could easily lead to increased coherence or flexibility between the four circles, which in turn, we might hypothesize, could strengthen fusion.

Worth strengthened fusion with simultaneous perception of macular targets at the angle of deviation before beginning any vergence range extension. It is not unreasonable to speculate that the many dichoptic targets used in the "placebo" therapy, especially the randot-stereo dichoptic targets used both in office and at home, could have worked the same functions as Worth's dichoptic major-amblyoscope targets.

As previously argued, fusion is based on the perception and language-reinforced belief that all four circles and all the body's senses including both eyes' inputs belong to the same perceived object. Equalizing the two eyes' motor inputs with monocular eye movements and equalizing the two eyes' sensory inputs with balanced monocular fixation in a binocular field/simultaneous perception/ anti-suppression/blinking/randot stereopsis training could well account for the strong, approximately standard-deviation size effects on reflex convergence/fusion found in the non-vergence/non-accommodative vision therapy group.

Counting as dichoptic the monocular fixation-in-a-binocular-field procedures and prism disassociation procedures, eleven of the twenty-two office "placebo" procedure were dichoptic. Another 4 procedures were monocular and would be expected to help equalize performance between the two eyes to facilitate fusion. That neither dichoptic therapy nor occlusion therapy occur in normal life suggests that the behavioral therapy can hardly be explained away by comparing it to day-to-day novel activities such as learning to read.

In addition to the work on simultaneous/ equalized performance between the two eyes, the "placebo" therapy required patients to move their eyes, and sometimes their hands—and thus their bodies—in worlds made novel through lens magnification (if the front lens surface was curved), prisms, colored-or-neutral-gray filters, occlusion, and dichoptic presentation. All these procedures used novelty to encourage exploration and creation to reestablish coherence in incoherent environments. The required exploration, in many cases, could have supported the expansion of the ZOSA and the strengthening of fusion.

Based on these considerations, it is not only possible but, I believe, highly probable that what the investigators dismissed as "placebo group" was hardly inert but more accurately an active behavioral vision therapy that simply avoided directly working voluntary convergence.

Why didn't the possibility that the placebo therapy was active make it into the studies' abstracts? A paragraph in the reading study provides a clue. The investigators appear to take pride in the methodological superiority of their placebo-controlled design:

> *Improvements in reading performance … in children with convergence insufficiency after treatment with vision therapy have been reported; however, both studies had methodological*

differences from our study and were conducted without a placebo control group.... We are not aware of any well- designed prospective randomized clinical trials to which we can compare the present study results.[121]

To admit that there is no real placebo group, but rather two treatment groups sans a control group risks demoting the study's standing in the hierarchy of evidence-based medicine. The possibility of such a demotion could have biased the investigators from pursuing any such interpretation. Similarly, discrediting the inert nature of the "placebo" therapy might have potentially called into question a quarter century's hard work. Indeed, the correspondence between physical convergence findings and subjective symptoms found in 2008 was not repeated in the CITT-ART. The mystery at the interface between the mental and physical worlds of vision remains.

Suppose, however, we accept the investigator's no-better-than-placebo conclusions. As vision therapy clinicians, should we be disappointed? Not necessarily, I think. The vergence/accommodative vision therapy was also no less effective than the "placebo therapy." Indeed, the words "placebo effect" tend to conjure up a classical 1955 paper on placebo in which Beecher[122] considered 1082 patients and found an average significant placebo effectiveness of 35.2 ± 2.2 %. Thus, when we think about the concept of placebo, we imagine an effortless cure, a largely costless, easy to administer dummy pill with about a 35 percent effectiveness: the promise of something for nothing. If the placebo therapy is effortless compared to our interventions it is difficult for clinicians to admit that placebo deserves credit even if it is effective.

In the CITT-ART, nothing could be further from the truth. Not all placebos are created equal. Our Beecher description hardly applies to the current study. There was no something for nothing. This "placebo" involved about 32 hours of combined home and in-office therapy. The placebo was no less costly, time-consuming, or effortless than the vergence/accommodative therapy. Despite 17 percent of the "placebo" group correctly suspecting placebo-group placement,[123] 67.3% of the "placebo" group attained a normal NPC or ≥ 4 cm of improvement; 50.0% of the "placebo" group attained normal PFV or improved by ≥ 10 prism diopters; and 58.7% of the placebo group attained normal CISS scores or improved by 10 points. Thus, when comparing Beechers placebo pills to the highly involved CITT-ART "placebo" vision therapy, the therapy effectiveness was almost twice as effective as the pills.

Considering this increased effectiveness, the harmless nature of the procedures, and the fact that the vergence/accommodative therapy has repeatedly been shown to improve faulty convergence, the CITT-ART therapy would still make a good choice for both clinician and patient despite the failure of the theory behind the therapy. When it came to improving symptoms, convergence, and reading, the program results would also likely be higher in private practice. There the therapy would be purchased, individually tailored, extended as necessary, and lacking the doubts engendered by a study with a 50 percent chance of being sham. Whether the improvement in symptoms, attention, and reading are better explained by the failure of the classical model or the success of the behavioral model remains unanswered. In either case, the treatment was no less successful.

Before leaving the topic of placebo, we need to acknowledge that the CITT-ART's vision therapy placebo group may well be the best we can design. How could it be improved and still keep it indistinguishable from active vision therapy? How could we create a vision therapy that is inert on all of Skeffington's four circles—any of which might improve performance? In the centering circle, how can we remove increasing flexibility in manipulating the volume of space that patients select for value and action? In the identification circle, how can we remove the change in value of opportunities for action. Similarly, how could we remove the emotional component of value without removing the patient? In the antigravity circle, how can we remove gravity's interaction with eye and body action? And, in the speech-auditory circle,

how can we remove the possibility of language directing novel visual values?

In other words, if vision is pervasive, how can we delete the vision from vision therapy? It may well be no easier to design a truly inert and undetectable placebo group for vision therapy than it is ethically feasible to design a much-needed placebo-controlled study for strabismus surgery—the angle of strabismus known often to fluctuate with emotions.

Part 5: Conclusions and Discussion

The CITT-ART can probably be interpreted in as many ways as there are interpreters. We'll consider 4 approaches:

1) Following the words of Kushner's editorial in the peer-reviewed, clinical-science journal *Archives of Ophthalmology: a scientific study* "can only answer the specific questions it asks."[124] When confronted with the CITT-ART most clinicians providing vision therapy need only join Kushner and the readers of Archives of Ophthalmology stating, "I follow a different protocol."
2) If we want to use the study as a nocebo to reduce the outcomes of patients receiving vision therapy, we can leave the abstracts in the form approved by the medical influences in the NEI. This allows us to support, in Kushner's previously- cited words, "the hype sensationalist 1-line quotations from the abstracts of scientific articles" that have and will continue to appear in "the lay media and professional tabloids."
3) If we are favorable to vision therapy, as I am, we can remove the placebo word from the abstracts, noting that both classical and behavioral vision therapy are, for non-specified reasons, equally correlated with predominantly moderate to large effect in reflex convergence, CISS scores, and standardized assessments of attention and reading. Although this 16-week study comparing two styles of vision therapy lacked a natural control group, the moderate to large effects in performance accompanying both treatments compared quite favorably against the small effects of an entire year of typical educational instruction and maturation from one grade level to the next.
4) Finally, we can skirt the questions about placebo in two ways: A) Use a behavioral paradigm centered on increasing human performance rather than treating disease—placebo pertains to healing rather than performance. B) Abandon the CITT-ART for fMRI studies that document and persuade with technicolor statistics the neural effect of training convergence ability.

There is, however a problem with approach 4B. Placebo therapy, as previously noted, has been documented to change blood flow in the brain. Thus, to understand what produces the brain changes, we need to compare both treatment and placebo groups to a no-treatment group. Only thus can we rule out changes not predicted by a theory.

Sadly, we have come full circle and are left with questions: If vision is pervasive, how can we create a convincing sham therapy that circumvents the four circles any more than we can create a sighted life that circumvents our love affair with light? Will we ever truly know if it is the process and context of novel therapy or the physical changes suggested by changes in findings that enhance performance? For the clinician, is it the cause or the size of the clinical effect that really matters? Are we more interested in proving our theories or improving the lives of our patients? Until we can answer such questions once and for all, what lessons have we learned from the CITT-ART?

Implications for Clinical Practice

As we have discussed, the CITT-ART provides the clinician with a number of cautions:

1) In an abstract, the absence of mays and suggests can signal the abandonment of the world of science for that of persuasion.
2) Abstracts may prove no more reliable than news headlines in capturing the details of the story beneath.

3) Clinical experience should not necessarily be discarded for a study's evidence-based conclusions so long as caveats and logical objections remain unexplored in other completed studies without caveats of their own.
4) According to the Greek father of history, Herodotus, "Men trust their ears less than their eyes."[125] If we wish to base our clinical practice on evidence, then we should accept Herodotus's wisdom and—as Kushner and the Archives of Ophthalmology did—look at the evidence for ourselves rather than listen to once-removed-from-evidence interpretations presented in abstracts.

The CITT-ART suggests little about the efficacy of vision therapy in the broader sense other than its seemingly direct relationship to changes in convergence. These changes were, however, accompanied by predominantly medium to strong effects on symptoms, attention, and reading for reasons unspecified by the classical larger-prism-ranges-better-vision model. The trials, however, suggest something important about the art of vision therapy: there is no one way to approach Skeffington's four circles. While those practicing "behaviorally" are apt to dismiss the classical model as "just orthoptics" and those practicing "classically" are apt to dismiss the many behavioral approaches as "just placebo," the trials hardly exclude either approach. Whether we prefer our prism bases in, out, up, or down, they introduce new incoherent worlds ripe for developing the exploration and creation needed to make the four circles—not to mention performance in life—cohere. They may even expand the ZOSA and strengthen fusion in the more-limited optical sense.

As optometrists we explore the interface between two worlds: the physical versus the mental. Where one begins and the other ends remains uncertain. Take voluntary convergence: how much of it depends on the physical sensorimotor apparatus, how much on mental volition? While the mind-body problem continues to confound our practice, models, and studies, one thing seems certain: vision therapy remains an art whether or not it follows the vicissitudes of scientific consensus. As contemporary philosopher Alva Noë reminds us:

> *Talking about art doesn't leave things as they are; it changes everything. To look, to think, to say what you see or why you respond as you do—this changes what you see, and it changes your response. The effort and the caring remake us.*[126]

The same applies to the art of vision therapy inviting us, as it does, to discover new opportunities for action waiting to be captured by language. As we connect with patients in novel worlds, they are remade. We are remade. Still our art is intimately bound to the real science that has changed the world. Lens, prisms, computers, vectograms, liquid crystal, virtual reality, augmented reality—none would exist without science. At its best, science inspires new opportunities for action. The real contribution of the CITT-ART is not as a weapon to restrict creativity, but as a tool of freedom from the tyranny of the classical paradigm. The CITT-ART frees us to understand our art as not limited by numbers but only by our ingenuity in arranging worlds of lighted opportunities for novel action and value.

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Procedure 8.5.1 TV Vision Trainer

Viewer watches movies through a novel, colored filter, one side red, the other green. Viewer wears novel gray filtered glasses and is asked to keep screen "clear and single" and to "blink his/her eyes" if the screen appears non-uniform with patches of gray or black. Language is used to stress clarity. The novelty could work precise reflex fusion and accommodative posture if the CI patient has any tendency toward blurred or double vision. Flashing (blinking) could strengthen reflex fusion.

Procedure 8.5.2 VTS Placebo Accommodation

The procedure works monocular fixation in a binocular field (MFBF), both eyes always being able to see the screen, room, and hands, but only one eye at a time alternately being able to see the Landolt Cs in a left-to- right fashion. The Cs are relatively small while the binocular view is large. The instrument records how many correct directionality responses are being made, so the procedure works speed of perception for right, left, up, and down. The patient is similarly required to use saccades to approach the Cs left to right—as when we read. The patient looks through plano lenses, which probably magnify and thus change the light compared to normal body action. Later, yoked prisms are alternated base right and base left, again changing the light compared to the body. The liquid crystal glasses are flashing back and forth between the right and left eyes 60 times per second, possibly reducing any suppression. The patient is directed to keep the targets clear. Classically the procedure is working MFBF, which supports equalization of the speed of performance of the two eyes. Any of the components within this activity (MFBF, alternate flashing, directionality reinforcement, saccades, visual re-orientation through yoked prisms) could help bring coherence to the four circles.

Procedure 8.5.3 Ductions and Versions

Fixation target: penlight. Patient monocularly follows the slowly-moved light in each of the cardinal positions of gaze to about 45 degrees to the side (possibly more), at a viewing distance of 1 foot in front of the patient. Patient holds fixation for 10 seconds in each cardinal position. The procedure is repeated at "2 or 3" feet, thus cutting the angle by at least half, the target now being more central. The procedure is done both monocularly and binocularly. The patient is repeatedly asked about how "the eyes feel." The endpoint of the procedure is achieved when "the participant can look in all positions of gaze and hold fixation for 10 seconds." The patient is getting verbal feedback matched to the felt position of eyes.

The procedure potentially helps to equalize performance in the two eyes. Fixations and pursuits with their necessity to follow the penlight both train visual attention, any daydreaming interfering with performance. In addition, Bruenech's work supports that smooth pursuit eye movements engage the globe-facing portions of the extraocular muscles, and that smooth pursuit training enhances fine oculomotor control, supporting reflexive fixation skills as well as reflexive vergence:

> Sensory input is known to increase neural plasticity and adaptation. Tracking slow-moving objects will stimulate multiply innervated muscle fibers and activate their associated receptors. This will initiate neural activity in a variety of supranuclear structures and may enhance their function.[127]

Bruenech also notes:

> Multiply innervated fibers do not propagate an action potential but produce instead slow-graded contractions. They are fatigue resistant and ideal for facilitating smooth-pursuit eye movements, gaze holding, and prolonged convergence.[128]

> Such skill enhancement can hardly be dismissed as an inert placebo effect, for it possibly has far-reaching benefits in mitigating visual fatigue

and enhancing automaticity of ocular motility when reading.

When done binocularly, procedure 8.5.3 also trains the maintenance of fusion despite variation of gaze, especially at 45 degrees near the edge of the binocular motor fields where diplopia is common—the patient having been conditioned in other procedures to keep things clear and single. The interactions between head and eye movements are complex,[129] but the divorcing of head and eye movements to the side creates a novel action. In addition, our eyes normally explore the room sequentially so that maintaining fixation is both novel and a move toward simultaneous seeing. An expansion of the ZOSA is necessary to see the world beyond the penlight. Questions about how the eyes feel could prompt the patient to explore.

Finally, when we are discussing reading eye movements, *fixations,* not saccades dominate. So, any speculation that the "placebo" therapy did not directly train "reading eye movements" is open to question.

Procedure 8.5.4 Monocular Brock String (Level 1)
Participant monocularly examines Brock String with two beads, one at 5 feet, one at 10 feet. Participant is instructed to look at each bead and asked "what he/she sees" including the string and two single beads and if the string enters and exits both beads. The patient holds fixation on each bead for 10 seconds, going back and forth between the two beads 10 times. Next, the fixations z-axis saccades are repeated with the string repositioned up, down, left, and right. Finally, the end of the string is rotated while fixation is maintained. The procedure is done with each eye. Classically, the procedure works pursuits and fixations, possibly equalizing the two eyes to increase reflex convergence/fusion and attention. Behaviorally, the novel worlds foster exploration. Saccades are most accurate when a patient can see both targets simultaneously. The z-axis technique thus has the potential to open the z-axis ZOSA, which could potentially improve reflex convergence/fusion.

5. Monocular Brock String (Level 2)
   Similar procedure to 8.5.4, but now done in the novel worlds of lenses and prisms creating the exploration to further open the zone of simultaneous awareness as monocular prism saccades further equalize the two eyes' performance.

6. Monocular Brock String (Level 3)
   Similar procedure to 8.5.4-5.) but following a finger between the 5 and 10-foot beads. The z-axis pursuits and z-axis string have the potential to open up the zone of simultaneous awareness and improve reflex convergence/fusion.

7. Computer Aided Vision Therapy (VIPS).
   Much like the TV trainer, but instead of viewing movies, the patient works such identification/value/centering skills as visual closure, visualization, speed of perception, visual figure ground/selective attention, and visual spatial skills. The use of filters or yoked prisms with commands to see if things are clear and single also possibly affect accommodative or vergence posture and integrate the centering and identification circles. This procedure works exploration in a novel setting, with exploration and coached blinking possibly affecting the ZOSA (via flashing targets and selectively emphasizing periphery).

8. Prism Dissociated Bi-ocular Rock
   In the procedure, vertical prism mismatches light and body to dissociate the two eyes while the participant reads left to right and performs saccades between the two eyes' targets. Yoked prisms are also used, further mismatching light and body. Classically, this is an anti-suppression activity which could work simultaneous perception from the two eyes and could improve reflex fusion. Behaviorally, the participant is in a novel environment in which

light and body no longer agree. A larger zone of simultaneous awareness is stressed.

Saccades are worked. Participant is asked to clear targets so that accommodative posture and exploration are worked. As always, the integration of the four circles could strengthen fusion.

9. High/Low Contrast VA

Participant reads acuity charts, one with high contrast letters, the other with low contrast, thus stressing identification and value. The whole-chart acuity approach requires left to right saccades at the thresholds of acuity and contrast. Behaviorally, the environment is novel, inviting exploration.

10. Bernell-O-Scope (Level 1)

A stereoscope is used. A dot-to-dot target is placed before one eye and a pointer is used to follow the dots while the patient is asked to visualize what the final product will be. The procedure works monocular fixations in a binocular field, both eyes being open but only one eye seeing the target. The procedure stresses first the right eye and hand and then the left eye and hand further equalizing the two eyes and possibly strengthening reflex convergence/accommodation. Monocular fixation in a binocular field is also traditionally used to strengthen fusion. Behaviorally, the light information tells the participant that the target is at 20 feet while the hand tells the patient that the target is at 20 centimeters. Thus, novel light information has to guide mismatched body information increasing exploration and ultimately improving coherence between the four circles. The procedure similarly works saccades and fixations in a novel world as well as working visualization, visual closure, peripheral awareness, and spatial relations to consider the direction of each dot relative to prior dot.

11. Bernell-O-Scope (Level 2)

This procedure is basically the same at 8.5.10 except the patient traces mazes instead of connecting dot-to-dot pictures. The procedure similarly equalizes the two eyes, works monocular fixation in a binocular field, and mismatches light information and hand information to create a novel, exploratory visual world including the centering, identification, anti-gravity and language circles.

12. Bernell-O-Scope (Level 3)

This procedure uses a flat fusion target; convergence and accommodation are at optical infinity. The participant, while viewing in the instrument, is asked to point at objects in the right-eye and left-eye views. If the suppression controls are suppressed, the patient is asked to blink eyes to reestablish fusion. The participant is asked to keep the target clear and visible for 10 seconds. The procedure directly works reflex fusion even though this work is done at infinity (reflex convergence is used to compensate for any esophoria or exophoria at optical infinity). The procedure works relaxation of accommodation to keep things clear. Classically, the blinking works anti-suppression to strengthen the reflex fusion. Behaviorally, the procedure works simultaneous perception which may increase the size of the ZOSA. The procedure places the patient in a novel environment encouraging exploration of novel actions. The procedure works coherence between hand-pointing mismatched with light information.

13. After-image Transfer Therapy

In this procedure a transferred after-image is used to provide biofeedback for accurate fixation. Again, the target must be fixated for 10 seconds. Classically, transferred after-images are used to train fixation and strengthen correspondence/fusion between the two eyes. The procedure could easily strengthen reflex convergence/fusion as well as attention. Behaviorally, we once more are learning to move the eyes in a novel environment improving the exploration, and visual performance necessary for maintain coherence/fusion of the four circles.

14. Red/Red Therapy

In this procedure, the participant uses a light to trace a maze behind a red filter. Both eyes see the

light and maze as red. The participant wears a red filter over one eye that reduces the amount of light reaching one eye. The participant is encouraged to blink in an effort to get both eyes to see the light at the same time. The procedure could teach the patient to fuse unequal images, thus strengthening reflex fusion. The procedure also works eye- hand coordination and attention. The patient is given another opportunity to move in a novel four-circle world to increase exploration and coherence.

15. Therapy Playing Cards

Participant wears gray filters, tries to see the suit and number of a playing card the moment the card to turned over and to remain aware of the number and suit of the card while a card game is placed. The participant is encouraged to blink to make sure both eyes are working together. Classically, the blinking could improve reflex convergence/fusion. Behaviorally, seeing the number and suit the second it is exposed could improve speed of perception. Remaining aware of the number and suit as the card game is played, if done with direct vision rather than auditory sequential memory, could improve pursuits, saccades, and attention. The novel gray-filtered new world and being visually aware of the number and suit during play could expand the ZOSA.

16. VTS Vergence

Wearing liquid-crystal glasses, which alternately flash between the two eyes 60 times per second, the participant views a non-disparated large rectangular randot target with a central letter and a 3D square appearing in the periphery—up, down, left, or right. The target is at 30 inches so as not to increase the convergence demand. The participant has to press the game-pad button to reflect the position of the 3D square. The disparity of the randot target does not change. There is no BI or BO demand. The rapidly flashing/alternating liquid crystal randot target demands exact alignment to be seen. The target could strengthen simultaneous perception and reflex fusion. The world is novel and if the participant keeps the central letter clear while locating the peripheral target the procedure could expand the ZOSA which could also strengthen reflex convergence/fusion. In addition, the target reinforces right-left awareness in space—directionality. Use of a randot target requires global fusion, engaging simultaneous awareness of a larger peripheral area.

17. Hess Lancaster or Strabismo Trainer

At a 2-meter distance, so as to require neither convergence nor accommodation, participant views a red light with one eye and a green light with the other. The therapist moves one light to different positions in the room. The participant moves the other light until the two lights are perceived as superimposed, blinking if a light is suppressed. The filters are later switched to equalize the inputs. Endpoint: "The participant can superimpose his light on the therapist's light in all positions of gaze [for ten seconds] without suppression." Again, classically, the procedure works MFBF for each eye possibly strengthening sensory fusion and, as a result, reflex fusion.

Behaviorally, the procedure works eye-hand coordination in a novel world, possibly increasing exploration and performance, developing coherence between the four circles.

18. Yoked Prism Flipper/Binocular Yoked Prism Rock

The participant views a Hart Chart about 5 or 6 feet away through flippers with 2-diopter yoked prisms, one side base right, the other base left. The patient is asked to look for perceived size or distance changes through the different prisms. While rocking the flippers, the patient then makes left-to-right saccades, calling out the next letter with each rock of the flippers. Classically, the procedure works binocular saccadic eye movements and alignment, accurate accommodative posture, and visual attention. Behaviorally, the procedure creates a novel world mismatching light and body information and

encouraging exploration and performance. Since SILO awareness improves with increased size of the ZOSA, exploring for prism-induced size and distance changes could quite possibly increase the size of the ZOSA and thus indirectly increase reflex fusion. The change would be particularly suited to central sequential processors, who otherwise generally fail to observe such size and distance changes.

19. Aperture Rule

A different aperture if situated directly in front of each eye so that both eyes have an uninterrupted view of the same target. The procedure's vergence demand is no different than looking at a single target with both eyes and no apertures. The procedure does not train base-in or base-out ranges but merely bifixation of the same target.

At this stage of the therapy, suppression is unlikely because it has been eliminated in a number of other "inert" procedures. Pointers are held in each hand to touch the target requiring a degree of body bilaterality although both eyes can see both pointers. Yoked prisms are added further mismatching body and light information. Classically, the procedure requires simple, central fusion with the periphery eliminated. Eyes must be accurately aligned and accommodative posture most also be accurate. Behaviorally, we are in a novel world inviting bilaterality and exploration.

20. Tranaglyph Levels 1-4

Participant views a green tranaglyph. A red lens is placed over one eye and later over the other. Thus, both eyes simultaneously see the same tranaglyph, but one eye sees the tranaglyph green while the other eye sees a tranaglyph black. The participant is asked to blink to compensate for the unilateral-filter-compromised fusion, questioned about clarity, and asked to point at various points within the tranaglyph with, first, a penlight and, second, a pointer. A plano lens flipper and, later, a yoked prism flipper is added, increasing the novelty. Classically, the procedure works fusion of different colored targets. Behaviorally, the procedure invites movement, exploration, and creation in a novel world.

21. Modified Thorington Card

With a Maddox rod in front of one eye, one eye sees a light in the center of a card, the other eye sees a vertical line, their relative position demonstrating esophoria, orthophoria, or exophoria. OU -0.50 lenses are added, requiring accurate accommodation to change the phoria. A distance card is held at 1 and 2 meters, a near card at 40 and 50 cm. The procedure works accuracy of accommodation, anti-suppression, and simultaneous perception. The card invites light-inspired movement and exploration in a novel world.

22. Double Maddox Rod

With red Maddox rod before one eye, white Maddox rod in front of the other, and a vertical prism to separate the two eye's perceptions, the patient aligns the white and red streaks of light. Patient is asked about kinesthetic awareness of eyes. The procedure works anti-suppression and simultaneous perception, possibly further equalizing the two eyes and strengthening reflex convergence/fusion. Behaviorally the procedure offers an opportunity to explore, direct action in a novel world, and possibly expand the ZOSA.

8.6.1-6 Home Nonvergence/Accommodative Therapy

In addition to the in-office non-vergence/non-accommodative therapy, a number of activities were assigned for home. Overall, these included, among others, Monocular Brock String and HTS and did not vary significantly from the in-office non-vergence/non-accommodative therapy except as with most home therapy there is no therapist present asking questions that create novelty to encourage exploration.

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ARTICLE

Objective Vision-Based Testing in Mild Traumatic Brain Injury: A Bibliography

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ABSTRACT

The area of traumatic brain injury has received considerable attention in the medical and related health care communities over the past three decades. One major focus has been on the constellation of visual deficits and correlated symptoms frequently found in these patients. A subset of intense focus has involved the use of objectively-based vision testing for diagnostic, prognostic, and therapeutic purposes. The assembled bibliography provides a listing of the major published research papers and chapters over the past 30 years involving objective vision testing using an array of instrumentations and protocols. This should help both the clinician and researcher obtain a broad perspective in this important and rapidly evolving area.

INTRODUCTION: THE TWO WORLDS

The area of traumatic brain injury has exploded over the past two decades. This is primarily due to two factors: first, the many brain injuries related to the United States mideast military encounters, and second, concern over sports-related concussions.[1,2] This renewed interest has led to the development of new clinical and laboratory tests to assist in its diagnosis and treatment.[2]

This has been especially true with respect to the visual system. It is not surprising, as over 300 intracortical pathways linking more that 30 cortical areas are involved in vision.[3] This has resulted in a constellation of visual dysfunctions of a sensory (e.g., photosensitivity, impaired contrast sensitivity), motor (e.g., saccadic dysmetria, slowed vergence), and perceptual (e.g., abnormal egocentric localization, impaired distance perception) nature.[1,2,4,5,6,7]

One area of particular interest has been the use of objective testing to detect and quantify a visual deficit. There are several important benefits derived from objective testing. First, it serves to support the patient's symptom(s) and related problem(s). Second, it circumvents the problem of malingering, unreliable responses in young children, and potential difficulties with special populations. Third, with such tools, treatment can be more targeted for the affected neural site, and hence be more

efficacious. Fourth, and related to #3, it could help set a more targeted research agenda. And lastly, it could serve as critical information in the case of an expert witness: it is difficult to argue against one's claim of "brain injury" and related visual dysfunctions when the objective test findings (e.g., visual-evoked response, diffusion tensor imaging, eye movement recordings) clearly reveal a correlated abnormality.

Thus, the purpose of this paper is to furnish a bibliography of objective, vision-based tests, by category, in the patient with mild traumatic brain injury. It involved extensive searches of the literature via *PubMed, Google, Google Scholar, APA PsychNet,* and *Semantic Scholar,* as well as other related papers and books. This should assist the neuro-optometrist, and others, in the aforementioned five areas. Furthermore, this bibliography reflects the successful diagnostic and therapeutic approaches used in the field across a wide range of visual dysfunctions.

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CASE REPORT

Clinical Management of Vertical Hyperphoria and Photophobia Following Mild Traumatic Brain Injury: A Case Study

Bryan Sixkiller, OD, FAAO

ABSTRACT

Background

Following a mild TBI, symptoms of diplopia and photosensitivity are common. Findings such as a vertical deviation, may contribute to exasperating symptoms. Treatment of vertical deviations may cause hesitation for the provider as there is not a consensus in relation to prescribing vertical prism amounts. In regards to photosensitivity, fortunately most diminishes in intensity over the first couple of months following injury. Further treatment, including tints and sunglasses, improves patient comfort.

Case Report

A 24 year old male horse trainer presents to the TBI optometry clinic following a kick to the face from a horse. His primary complaints of diplopia and photosensitivity, as well as his phorometric data are discussed. Diagnostic and treatment strategies, including vertical prism, are incorporated to remedy his symptoms.

Conclusions

After correction of ametropia with spectacles and vertical prism, the patient's symptoms were ameliorated. Furthermore, prescription sunglasses permitted the patient to return to work outdoors without discomfort.

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INTRODUCTION

Following mild traumatic brain injury (mTBI), binocular vision deficits are common.[1] This paper will focus on vertical ocular alignment. Patients with mTBI may show increased symptoms with small vertical heterophorias. Scheiman and Wick define a vertical deviation as an upward or downward misalignment of the visual axis of one eye from the object of regard.[1] Additionally, mTBI may create light sensitivity, or photophobia following an injury.[2] In this paper, the management of symptomatic vertical heterophorias (VH) and photophobia in the presence of mTBI will be presented.

The mTBI patient may be unaware that symptoms they are experiencing may be the result of a visual dysfunction, such as a vertical misalignment. This underscores the importance of optometry's role in the care of mTBI patients. Vertical misalignments commonly cause headache, dizziness, nausea, motion sickness, reading difficulties, visual fatigue, asthenopia, or even anxiety, neck pain, and low back pain among others.[3-6] If a patient reports a history of mTBI in the primary care setting, then a symptom questionnaire, such as the Brain Injury Vision Symptom Survey (BIVSS),[7,8] should be administered. On the BIVSS, scores of 31 or greater may require further evaluation by an optometrist who specializes in TBI. In lieu of immediately referring patients who have had a history of mTBI, the optometrist should first attempt to eliminate any sensory mismatch.[9] This can be accomplished by providing best spectacle correction at distance and near eliminating blur or any anisometropia. Also, treating vertical misalignments may lead to a

remedy in horizontal vergence difficulties.[9] Since mTBI may present with many comorbidities, treating the VH, and in turn improving sensory integration, may also lead to further progress in concurrent rehabilitation such as vestibular, physical, or occupational therapies.[5] It is not uncommon for long standing asymptomatic vertical deviations to become symptomatic, especially if previous coping mechanisms are disrupted.[9,6] These vertical deviations are often less than two prism diopters, and are commonly only 0.5 prism diopters.[3] In the absence of the aforementioned symptoms, a vertical phoria is generally not treated.[10] This accentuates the importance of acquiring a symptom questionnaire for each mTBI patient so that symptomatic patients may be identified and concerns addressed.

To understand why a vertical misalignment may create symptoms, the following explanations have been provided. Rosner, et al, discuss the theory that symptoms occur due to a vertically misaligned vestibular reflex struggling to pair with a correcting fusional reflex. This pits opposing extraocular muscles against each other, leading to excessive fatigue, which, in turn, leads to common mTBI symptoms of nausea, dizziness, vestibular and motion sickness.[11] Doble, et al, similarly states that opposing elevator and depressor muscles are strained and struggling against each other due to misalignment. As a result of elevator and depressor fatigue, they hypothesize that the eyes are unable to maintain fusion, which results in an inability to maintain reading tasks or other near tasks. They go on to explain that while the individual is not moving, this muscle struggle informs the brain that it is in motion. Consequently, this creates a visual, vestibular, and proprioceptive mismatch.[5] Small amounts of prism are effective in permitting balance between the elevator and depressor muscles, resulting in resolution of symptoms.[3]

Prior to evaluating the vertical misalignment, it is important to assess refractive status, as small ametropias are likely to be more problematic in the mTBI population.[9] Ocular health must be assessed to rule out the effect of disease processes, such as dry eye. Additionally, binocular vision must be assessed to determine if there are accommodative or vergence deficiencies. Our clinical flow includes dry manifest refraction, followed by in-phoropter phoria and accommodative testing, and then testing in free space through a trial frame. We test distance and near vergence facility using 6 base-out/2 base-in and 12 base-out/3 base-in respectively. To determine if a vertical heterophoria is present, one may do Maddox rod testing, vertical Von Graefe phoria, fixation disparity, or cover test. Objectively, it may be difficult to see vertical movement on cover test. Therefore, it is important to ask the patient if they see a subjective movement of the target moving vertically or diagonally during the alternating cover test. Feinberg and Rosner found that the most reliable indicator of a vertical misalignment is if the patient exhibited a head tilt.[3] When determining the amount of vertical prism to prescribe, there is not a universally held consensus on the appropriate test to use. Scheiman and Wick, Goss, and the AOA Vision Rehabilitation Section's Brain Injury Electronic Resource Manual (BIERM) all suggest balancing the vertical vergence ranges to determine the appropriate amount of prism to prescribe.[10,1,9] Goss uses the following formula:[10]

Base-down to break minus Base-up to break / (divided) by 2 = Prism prescribed
(Positive = base-down // Negative = base-up)

Another method to determine the amount of prism to prescribe is fixation disparity.[1] This method was not incorporated in this paper due to being unavailable in clinic. It is important to note that determining the presence of vertical misalignment and determining the appropriate prism power to prescribe is not always straightforward. Rosner, et al, cites three things the practitioner should be aware of. First, the symptoms may not be visually associated. Second, the tests used to identify and prescribe don't always agree. Finally, the amount of prism found does not correlate well to how severe the patient's symptoms may be.[11] Anecdotally, the author has rarely found agreement in vertical Von Graefe, subjective cover test, and Maddox rod testing results. Therefore, I lean heavily on balancing the vertical vergence ranges. Once a

neutralizing prism is determined, it is best to trial frame the prism over the best spectacle correction. The patient should be asked to read, scroll their phone, conduct a gait trial, and provide a comfort response to elicit the patient's subjective response to the prism. Objectively, we retest the distance or near vergence facility through the resultant vertical prism. Sometimes it is more feasible to accomplish this at the follow up. Normative values for distance and near facility are 15 cycles per minute (cpm) with each standard deviation consisting of 3 cpm.[1] If the patient can achieve 3 cpm or more improvement on retest, then it is considered a success.

The follow up examination should take place after the patient has had an opportunity to wear the vertical prism for at least 2 weeks. In our setting, this generally occurs about 1 to 2 months after initial evaluation. During this exam, the patient is queried about symptoms, retested on distance and near vergence facility, vertical vergence ranges are rebalanced, and any other deficient findings are repeated to see if there is an improvement in performance. The patient's feedback is taken into consideration and any changes are made to the spectacle prescription prior to finalization. Most importantly, the patient is educated about the potential that the vertical prism may nor may not be prescribed long term. Any ensuing follow up is tailored to the patient who might need more frequent exams. Commonly, this occurs on an annual basis.[5] Wearing the vertical prism for one to two months gives the visual system an opportunity to learn to use the prism. Some lateral binocular deficiencies may be remedied by correcting the vertical deviation due to improvements in the patient's ability to maintain fusional alignment and obtain stable vision.[9] If, after follow up, the patient is still symptomatic or deficient in binocularity, then neuro-optometric rehabilitation is likely indicated. Through neuro-optometric rehabilitation, the patient works to develop greater degrees of vergence facility, fusional control, speed, and stability.[9]

One must also consider comitancy when evaluating vertical deviations. The AOA's Brain Injury Electronoic Resource Manual (BIERM) volume 1A states non-pathological deviations such as congenital or accommodative esotropia tend to be comitant or in other words maintain the same degree of deviation in all positions of gaze. With TBI, a patient may have injured cranial nerves. This can result in non-comitant postures. The non-comitant postures may become more comitant over time due to the body's ability to acclimate such as with head turns or tilts.[12]

The prevalence of photophobia following mTBI has historically been reported at varying rates in the literature to include 14.85% to 30.46% and 11.3% to 52.1%.[2,13] This reinforces the use of symptom questionnaires to elicit photophobia responses.[2] The patient may also self-report or fail to report. Therefore, the clinician must be pro-active in attempting to elicit symptom responses from the patient. Merezhinskaya, et al, report that prevalence is higher within 7 days after TBI; then the photophobia tends to decline over time. In those individuals who report photophobia after 3 months, there is a risk of developing chronic photophobia, which may last longer than a year.[2] Because photophobia may be persistent, it is important to discuss and provide some of the common treatments for photophobia which include tints, sunglasses, wide brimmed hats or adjusting monitor settings to low brightness.

In consideration of what makes light painful, Theis summarized multiple causes including comorbidities such as dry eye or migraine and non-image forming pathways in the brain that may responsible. These pathways include the trigeminal afferent pathway, the retino-pretectal-parasympathetic and retino-hypthalamic-sympathetic-trigeminovascular pathway, and the retino-thalamo-cortical pathway. These various pathways may activate nociceptors initiating a cascade of physiological responses including pain.[13]

It is important to realize the effect of photophobia on the patient. The pain associated with bright lighting can have emotional and mental degradation, which can lead to poor quality of life for the individual.[13] Photophobia must be addressed during the TBI eye evaluation to ensure the patient does not suffer excessively in uncomfortable lighting settings. The current protocol used in our clinic for tint trials is based simply on trial and error. We have

the patient try on 85% transmission green, blue, pink, amber, and FL41 tints. If the patient notices improved comfort with one of these colors, then we provide a pair of prescription spectacles with the selected tint. We avoid darker tints to prevent dark adaptation or "cocooning." Patients who keep all the lights off and windows sealed while at home tend to become hypersensitive to light.[13] Although the patient may be more comfortable in this setting, it is generally detrimental to recovery. Therefore, the provider must document and educate the patient about the potential effect of wearing sunglasses or dark tints indoors and the risk of dark adaptation. Otherwise, what seems a remedy to photophobia may inadvertently cause harm.

CASE REPORT

GP is an active duty 24 year old male who presented to the TBI optometry clinic following a kick to the face from a horse on July 6th, 2022. His record indicates loss of consciousness for less than 1 minute, alteration of consciousness for about 24 hours, and post-traumatic amnesia for about 24 hours following the injury. His physiologic dysfunction, combined with his initial Glasgow coma score of 15, met mTBI criteria.[14] He was evaluated by his primary care team and referred to the National Intrepid Center of Excellence, the Department of Defense's TBI specialty center, for evaluation. As part his care plan, he was sent to the TBI optometry clinic on October 19th, 2022. His primary complaint was laterally displaced diplopia. Additionally, he reported intense outdoor light sensitivity that triggered headaches. He was struggling with functioning on the job since he primarily worked outdoors. Fortunately, he had no broken bones and the contusion he suffered was nearly healed when the author saw him. His last eye exam was approximately 18 months prior where he had an unremarkable comprehensive evaluation with dilated fundus exam and no spectacle prescription. Preceding the injury, he had no visual complaints. Now, his primary goals were to remedy the diplopia and lessen the light sensitivity. Table 1

Table 1: KEY: 0=never, 1=mild, 2=moderate, 3=severe, 4=very severe

Symptom	**Initial Eval** – *19 OCT 2022*	**Follow Up** – *10 JAN 2023*
Distance Blur	2, feels like vision is degrading	0, with correction
Near Blur	1, worse since injury	0, with correction
Double Vision	2-3, feels diplopia worse in extreme R/L/up/down gazes	0, with correction. If uncorrected, difficult to tell if blurry or double
Reading Difficulties	1, randomly occurring	0
Brow Ache or Headache While Reading	1, randomly occurring	0
Covering/Closing an Eye to See Better	3, due to binocular blur	0, with correction
Blur with Transitioning from Distance to Near and Near to Distance	2	0
Sensitivity to Light	3, mostly outdoor light, transitioning from shade to full sun	1, mostly with quick transitions from dark to bright environments. Improving
Flashing Lights or Floaters in Your Vision	1, floaters only	0
Dryness or Sandy, Gritty Feeling in Eyes	0	0
Side Vision (Peripheral Vision) Problems	2, OD temporal periphery not as good as it was prior to injury	0
Balance Problems or Dizziness	4, improving, but notes that if he stands at attention, he still sways	1-2, improving compared to October
Bothered by Busy Visual Environments	2, primarily in crowded room w/ lots of people	1
Motion Sickness, Ability to be Passenger/Read in Vehicle	0	0

summarizes his symptom questionnaire at initial presentation and at follow up.

GP's history revealed he was not taking any medications although he had been prescribed sumatriptan and magnesium for headache relief. He had not picked up the medications from the pharmacy yet. He reported no allergies to medications. Ocular health exam, including dilated fundus views at initial presentation, were unremarkable for the duration of care in this clinic. His entrance skills including extraocular muscle movements, pupils, confrontation fields, and intraocular pressure were unremarkable. His uncorrected visual acuity was 20/20 OD and OS at distance and near although he complained of blurry vision. On October 19th, 2022, the following data was collected:

Saccades: Undershoots left and right gaze, no head movement

Pursuits: Smooth, no head movement

Fixation: Steady for at least 10 seconds

Worth 4 dot (at 20 ft): 5 dots, eso presentation

Stereo (wirt circles): 70"

In-Phoropter Testing:

Manifest Refraction: OD: PL-0.25x105 20/15
OS: PL-1.00x008 20/15

Distance Lateral Von Graefe: 2 esophoria

Distance Vertical Von Graefe: 1 base-down OS

Near Lateral Von Graefe: 2 esophoria

Near Lateral w/ +1.00: Ortho

Clinical AC/A: 2:1

Near Vertical Von Graefe: 2.5 base-down OS

Negative Relative Accommodation: +1.75

Positive Relative Accommodation: -3.75

Minus Lens Amplitude: OD: +8.50 // OS: +8.50

He was correctable to 20/15 in each eye. In-phoropter testing showed equal esophoria at distance and near. His vertical phoria was greater at near. Also, his accommodation testing indicated that he was at the minimum expected for his age.

The tests presented in Table 2 were completed both at initial and follow up examination outside of the phoropter in free space. They are listed sequentially for comparison.

The vertical deviation was confirmed by multiple means. The Von Graefe, subjective cover test at distance, Maddox Rod, and vertical vergence ranges all agree that there was a left hyper deviation. Balancing the vertical vergence range was best accomplished with 1 base down OS. GP reported good comfort and improvement in clarity during the gait trial with 1 base down over the left eye. Although the near point of convergence was receded, he did not demonstrate a larger exophoria at near compared to distance. Distance and near base out ranges appeared near normal. The relatively normal phoria at distance and near and normal base out ranges did not suggest convergence insufficiency. The vertical deviation was corrected for in the hope that any vergence difficulties may be remedied. The following prescription was provided for full time wear. He was provided one pair of clear spectacle lenses with anti-reflective coating and one pair of prescription sunglasses.

Final Spectacle Prescription OD: PLANO-0.25x105
OS: PLANO-1.00x008
with 1.0 base down

Nearly 3 months later, GP returned for follow up. He was very happy that nearly all his symptoms had resolved. He was wearing the spectacles full time and was happy to have prescription sunglasses for his outdoor duties. He remarked that if he did not wear the spectacles for 30 minutes to 1 hour, then headache symptoms began. Table 1 demonstrates his subjective symptoms. His light sensitivity was greatly improved per his response and nearly all the dizzy complaints he initially had were resolved.

Table 2 shows follow up vision evaluation from January 10th, 2023. It is presented next to the initial data from October 19th, 2022, for comparison. The author was especially pleased to see GP's improvement in convergence and divergence

Table 2: cpm=cycles per minute

Vision Test	**Initial Eval** - *19 OCT 2022* ***Thru Manifest Trial Frame***	**Follow Up** – *10 JAN 2023* ***Thru Habitual Spectacles***	**Normative Values**[1]
Cover Test Distance Near	D: 1-2 esophoria, left subjective hyper deviation N: orthophoria	D: orthophoria, no subjective vertical N: low exophoria	D: 1 exophoria (SD = 2D) N: 3 exophoria (SD = 3D)
Distance Vergence Facility (6 base out / 2 base in)	2 cpm, delay on base in Retest with 1 base down OS: 5 cpm, delay on base in	10 cpm	
Near Vergence Facility (12 base out / 3 base in)	4 cpm, delay on base in Retest with 1 base down OS: 5 cpm, delay on base in	9 cpm, delay on base out	15 cycles/min
Distance Base In (Step) (blur/break/recovery)	x/6/4	x/8/6	x/7/4
Distance Base Out (Step)	x/14/12	x/16/12	9/19/10
Near Base In (Step)	x/10/8	x/10/6	13/21/13
Near Base Out (Step)	x/25/18	x/20/18	17/21/12
Maddox Rod	D: 6 BO/1 BD OS N: 3 BO/2 BD OS		
Vertical Vergence Range (Break/Recovery)	Base Down OD: 1.0/0.5 Base Down OS: 5.0/4.0 Retest with 1 Base Down OS Base Down OD: 2.0/1.5 Base Down OS: 2.5/2.0 Retest with 2 Base Down OS Base Down OD: 2.5/2.0 Base Down OS: 1.5/1.0	Base Down OD: 2.5/2.0 Base Down OS: 2.0/1.5 Retest with 0.5 Base Down OD OD: 2.0/1.5 OS: 2.5/2.0	3-4 prism diopters break / 1.5-2.0 prism diopters recovery
Near Point of Convergence (Break/Recovery)	>30 cm x 2	7/12 cm x 2	5 cm break / 7 cm recovery
Head tilt	Slight right tilt	none	
Prism gait trial in trial frame w/ patient response	#1) Manifest Only – baseline #2) With 1 base down OS: "comfortable/stable, not disorienting" #3) With 1 base down OD: "Double vision worse, not comfortable"		
Initial Spec Rx	OD: PL-0.25x105 OS: PL-1.00x008 1.0 BD OS 1 CL w/ AR 1 Sunglasses		
PLAN:	RTC 2 months for follow up/wear Rx full time	RTC 6 month, recheck vertical symptoms	

testing. His vergence facility testing improved by 2 standard deviations both at distance and near. Although greatly improved from initial presentation, his NPC was slightly below normal. He had no asthenopia complaints. Vertical vergence ranges were retested. While wearing the habitual

prescription with 1.0 base down in the left eye, there appeared to be a right hyper deviation. However, when the vertical vergence ranges were repeated with a loose lens 0.5 base down over the right eye, the finding was reversed. Due to the patient being happy with the spectacles, and reversing the vertical vergence ranges, there was no change to the spectacle prescription. The patient was informed that the vertical prism may or may not be maintained in the spectacle prescription long term. We recommended follow up in 6 months to repeat vertical testing and review symptoms. The patient agreed with the treatment plan. According to the patient, his goals of improving diplopia and light sensitivity had been achieved.

DISCUSSION

This case demonstrates the importance of optometric evaluation in patients with mTBI. His symptoms of diplopia and light sensitivity were addressed and remedied. His diplopia, although reported laterally, was likely due to the vertical deviation. After sensorimotor evaluation, an appropriate spectacle prescription correcting the small ametropia and vertical prism remedied the patient's symptoms.

There are a few key considerations to employ when evaluating patients with mTBI. They may not always respond as quickly or accurately as they did prior to injury.[9] Notwithstanding, patient evaluations in the presence of mTBI may take extended periods of time to evaluate. For vertical deviations, it is important to only treat symptomatic patients. Sometimes difficulties arise when the symptoms are not associated with vision by the patient, such as dizziness, nausea, and motion sensitivity. These symptoms are best elicited through questionnaires, as they play an important role in identifying and tracking symptoms over time. In addition to questionnaires, one must remember to permit the patient an opportunity to state their specific symptoms and tell their story so that the clinician can elicit symptoms that may not have an obvious visual connection. Developing treatment goals provides a framework and destination for successful outcomes.

Another important factor the clinician must attend to during testing is head tilt. Head tilts of 5 degrees can lead to significant deviation of vergence range.[15] Therefore, monitoring head position is vital to obtaining useful data. Additionally, one must be sure there is no tilt of the phoropter or of the trial frame spectacles as to avoid inducing a phoria.[10] It may also be useful to know whether the patient exhibited a head tilt prior to a brain injury. This would be useful clinically to help establish if a vertical deviation was long standing or more acute. While it is important to identify and attempt to limit the effects of head tilt, diagnostically, a head tilt may be the most reliable indicator that a vertical deviation is present.[3]

The patient was asked about photophobia during the initial exam by questionnaire. He was provided a pair of prescription sunglasses due to his complaint being primarily outdoors with sunlight. Had he provided an indoor complaint, the author would have considered an additional tint trial. Beyond questionnaires and patient symptoms, there is not a validated way to quantify a patient's photophobia. Fortunately, most mTBI related photophobia improves or resolves within three months of injury.[2] This patient's photophobia resolved approximately 6 months following his initial injury. It was recommended that he continue sunglasses wear while outdoors if there was any discomfort.

In our clinic, we educate the photophobic patients about cocooning, or negatively dark adapting. It is detrimental for the patient to stay in very dark rooms, keep lights off, and wear darkly tinted sunglasses while indoors. These patterns of behavior tend to set a new baseline of brightness acceptability to the patient, which may cause difficulty adapting back to normal levels of illumination. Our practice is to provide the maximum transmittance while also providing symptomatic relief of their photophobia.

This case demonstrates successful symptom relief by providing vertical prism with spectacle correction and outdoor sunglasses to a patient who suffered mTBI.

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Currently, he is completing a residency in vision rehabilitation and brain injury at Walter Reed National Military Medical Center in Bethesda, Maryland. He will follow on at the 15th Operational Medical Readiness Squadron.

Dr. Sixkiller, and his wife, Lisa, have three sons, Gregor, Mason, and Henry which drive all hobbies, interests, and endeavors.

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