

## 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

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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.

### 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<sup>1</sup>. 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.”<sup>2</sup>

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 interpreted 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....”<sup>3</sup> 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-funded and reviewed study was examined and dismissed or at least critically questioned in an accompanying editorial<sup>4</sup> 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.”<sup>5</sup> 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.”<sup>6</sup> 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.<sup>7</sup>*

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.”<sup>8</sup> 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;<sup>9</sup> one, before-and-after therapy standardized reading scores;<sup>10</sup> and one, before-and-after standardized attention scores.<sup>11</sup>

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*.<sup>12</sup> 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."<sup>13</sup> 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.<sup>14</sup>

Our blindness aside, however, the strength of the scientific method is that it inspires us to reflect on our approaches.<sup>15</sup> 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.<sup>16</sup> 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."<sup>17</sup>

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<sup>18</sup> "On Muscular Asthenopia" appeared in the journal he founded: *Archives of Ophthalmology*. The "founder of modern ophthalmology"<sup>19</sup> 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*<sup>20</sup> appeared. Maddox hypothesized—based on clinical observation and speculation rather than formal experimentation<sup>21</sup>—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"<sup>22</sup> will all suffice to reduce tonic convergence just as wearing "adducting prism ... for ten minutes"<sup>23</sup> or "prolonged use of the eyes for near work"<sup>24</sup> 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*."<sup>25</sup>

A second component of convergence is *accommodative convergence*, "due chiefly to sympathy with accommodation but also to the habit of converging."<sup>26</sup> 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."<sup>27</sup> 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<sup>28</sup> "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:<sup>29</sup>

*[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.<sup>30</sup>*

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*.<sup>31</sup> The model problem involved a "defect of the fusion faculty,"<sup>32</sup> 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."<sup>33</sup> 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."<sup>34</sup> 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."<sup>35</sup> 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.<sup>36</sup>*

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.*<sup>37</sup>

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.*<sup>38</sup>

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<sup>39</sup> 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.”<sup>40</sup> 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.

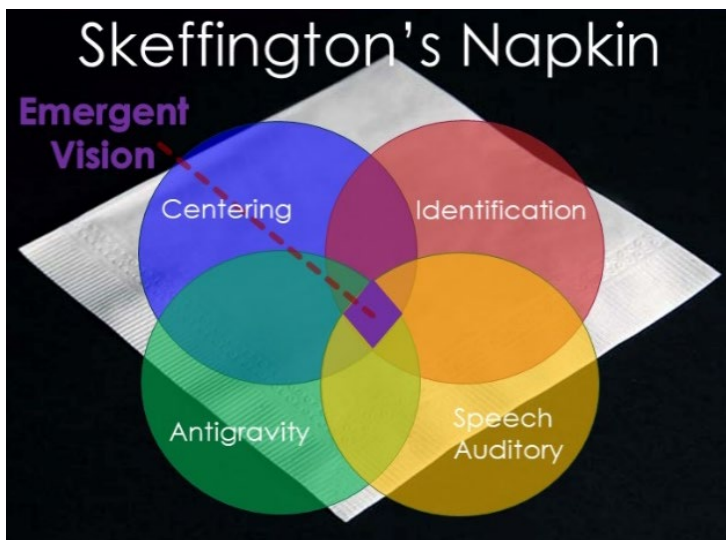
Sheard once wrote, “I venture to say that there are almost as many opinions regarding ocular exercises, their character, their frequency, their modus operandi, and so forth, as there are individuals who hold any opinions on these matters.”<sup>41</sup> Little has changed. When we look at vision therapy 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*.<sup>42</sup> 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<sup>43</sup> 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.<sup>44</sup> 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."<sup>45</sup> 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."<sup>46</sup>

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,"<sup>47</sup> or the "zone of simultaneous awareness (ZOSA)."<sup>48,49,50</sup> 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,<sup>51</sup> 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 amblyopes and yet insist they perceive the suppression controls in both tubes simultaneously. Brock,<sup>52</sup> 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.*<sup>53</sup>

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

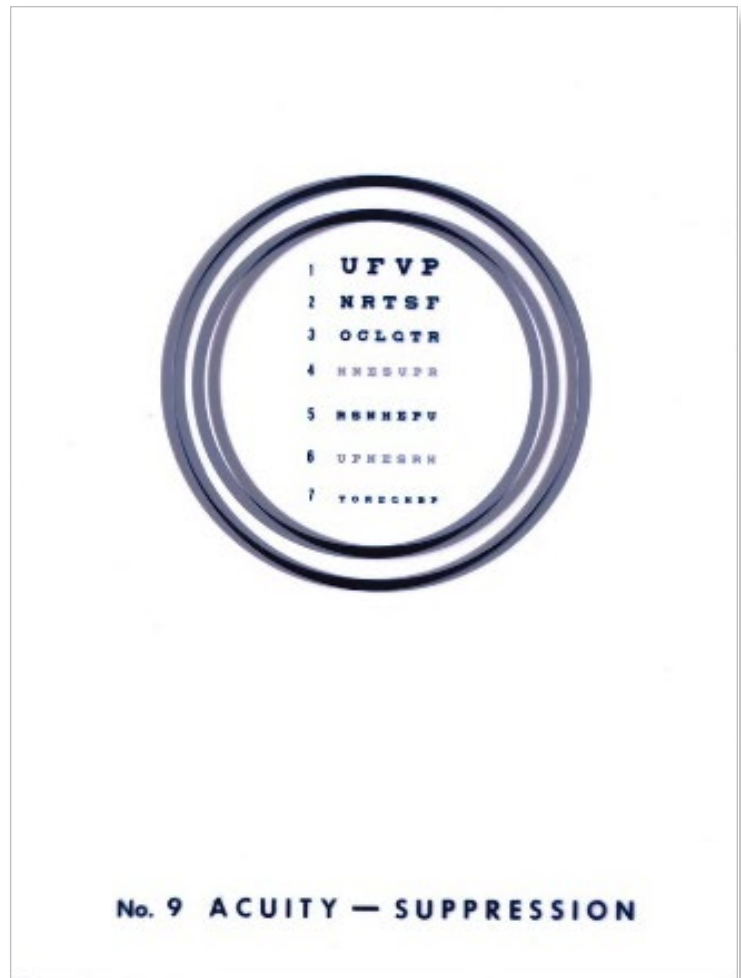
are aware of the position of the screen between yourself and the wall.

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.<sup>54</sup> 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.<sup>55</sup>

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."<sup>56</sup> 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."<sup>57</sup> 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."<sup>58</sup> In Gibson's model, to perceive things is "to perceive what they afford."<sup>59</sup> "The affordances of an environment are what it offers the animal, what it provides or furnishes, either for good or ill."<sup>60</sup> 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."*<sup>61</sup>

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-bowling; 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.”<sup>62</sup> 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.”<sup>63</sup>

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<sup>64</sup> 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.”<sup>65</sup>

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."<sup>66</sup> 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."<sup>67</sup> 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<sup>68</sup> 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]<sup>69</sup>

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.<sup>70</sup>*

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,"<sup>71</sup> and if "any and every failure were ground for theory rejection, all theories ought to be rejected at all times."<sup>72</sup> Similarly, Paul Feyerabend wrote that "there is not a single interesting theory that agrees with all the known facts in its domain."<sup>73</sup>

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.”<sup>74</sup> 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”<sup>75</sup> 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,<sup>76</sup> in some cases even producing “endogenous opioids,”<sup>77</sup> 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.*<sup>78</sup>

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<sup>79</sup> 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*.<sup>80</sup> 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.*<sup>81</sup>

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 seventeenth century, 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?*<sup>82</sup>

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.<sup>83</sup> 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.<sup>84</sup> 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<sup>85-89</sup> 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"<sup>90</sup> or "remembered wellness."<sup>91</sup> I prefer "nonspecific effects,"<sup>92</sup> 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."<sup>93</sup> 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."<sup>94</sup> 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."<sup>95</sup>

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 Swab 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.<sup>96</sup>*

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<sup>97</sup> 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.*<sup>98</sup>

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.*<sup>99</sup>

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."<sup>100</sup> 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<sup>101</sup> 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."<sup>102</sup> 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.*<sup>103</sup>

"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<sup>104</sup> 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."<sup>105</sup> While I hardly doubt the statement is true, the article<sup>106</sup> 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.*<sup>107</sup>

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.*<sup>108</sup>

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.”<sup>109</sup>

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 unsuspected 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].”<sup>110</sup> “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].”<sup>111</sup> “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].”<sup>112</sup>

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.<sup>113</sup>

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.<sup>114</sup> 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  $\leq 6$  cm. NPC break values were  $3.3 \pm 2.6$  cm for kindergarteners,  $4.1 \pm 2.4$  cm for third graders, and  $4.3 \pm 3.4$  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  $5.3 \text{ MA} \times 5.6 \text{ cm pupillary distance} = 30.8$  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,"<sup>115</sup> 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).<sup>116</sup> 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  $19 \pm 9$  prism diopters,<sup>117</sup> the group demonstrated approximately a full standard deviation of change from low normal to slightly above average. According to Morgan's phoropter expecteds (PRC:  $17 \pm 5$ )<sup>118</sup> 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.<sup>119</sup> 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***<sup>120</sup>

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.*<sup>121</sup>

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<sup>122</sup> considered 1082 patients and found an average significant placebo effectiveness of  $35.2 \pm 2.2$  %. 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,<sup>123</sup> 67.3% of the "placebo" group attained a normal NPC or  $\geq 4$  cm of improvement; 50.0% of the "placebo" group attained normal PFV or improved by  $\geq 10$  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."<sup>124</sup> 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 may 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."<sup>125</sup> 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.*<sup>126</sup>

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.

## REFERENCES

1. Reported in Rouse MW, Borsting E, Deland EN, and The Convergence Insufficiency and Reading Study (CIRS). Reliability of Binocular Vision Measurements Used in Classification of Convergence Insufficiency. *Optometry and Vision Science* 2002; 79(4): p. 254.
2. Scheiman M, Mitchell GL, Cotter S, et al. A randomized trial of the effectiveness of treatments for convergence insufficiency in children. *Arch Ophthalmol* 2005; 123(1): 14-24.
3. *Ibid.* 14.
4. Kushner BJ. The Treatment of Convergence Insufficiency. *Arch Ophthalmol* 2005; 123(1), 100-101.
5. Kushner BJ. 2005: 101.
6. Kushner BJ. 2005:102.
7. Kushner BJ. 2005: 102.
8. Feynman, RP. *The Pleasure of Finding Things Out*. Cambridge, Massachusetts: Perseus Books, 1999: 187.

9. Treatment of Symptomatic Convergence Insufficiency in Children Enrolled in the Convergence Insufficiency Treatment Trial—Attention & Reading Trial: A Randomized Clinical Trial. *Optom Visual Sci* 2019; 96(11): 825-835. <https://doi.org/kd6w>
10. CITT-ART Investigator Group. Effect of Vergence/Accommodative Therapy on Attention in Children with Convergence Insufficiency: A Randomized Clinical Trial. *Optom Visual Sci* 2021; 98(3):222-233. <https://doi.org/kd6v>
11. CITT-ART Investigator Group. Effect of Vergence/Accommodative Therapy on Reading in Children with Convergence Insufficiency: A Randomized Trial. *Optom Vis Sci* 2019; 96(11): 836–849. <https://doi.org/kd6v>
12. Open Science Collaboration. Estimating the Reproducibility of Psychological Science. *Science* 349, aac47 16. Reported and analyzed in Johnson VE, Payne RD, Wang T, Asher A Mandal S. On the Reproducibility of Psychological Science, *Journal of the American Statistical Association* 2017; 112 (517): 1-10. <https://doi.org/f975gp>.
13. Kushner BJ. 2005: 102.
14. WR Jarvis, "Handwashing—the Semmelweis lesson forgotten?" *The Lancet* 1994; 344: 1211-1312. <https://doi.org/b3wnbm>
15. Maze DA. The Contrast Between Classical & Behavioral Approaches to Vergence Eye Movements: A Personal Perspective. *VDR* 8(4): 234-247.
16. Morris E. *The Ashtray (Or the Man Who Denied Reality)*. Chicago: University of Chicago Press, 2018.
17. Kuhn TS. *The Structure of Scientific Revolutions*, Third Edition. Chicago: University of Chicago Press, 1996: x.
18. Von Graefe A. "On Muscular Asthenopia." *Arch f Ophth.* 1862. 8:314.
19. Perera CA. "Albrecht Von Graefe, Founder of Modern Ophthalmology: His Life and Works. *Arch Ophthalmol.*" 1935. 14(5), 742-773. <https://doi.org/dbz29s>
20. Maddox EE. *The Clinical Use of Prisms and the Decentering of Lenses*, Second Edition. Bristol England: John Wright & Company. 1893.
21. Morgan MM. The Maddox Classification of Vergence Eye Movements. *Am J Optom & Physio Optics* 1980; 57(9) 537-539: 537-539.
22. Maddox EE. 102.
23. Maddox EE. 90
24. Maddox EE. 92.
25. Maddox EE. 92.
26. Maddox EE. 94.
27. Maddox EE. 106.
28. Maddox EE. 106.
29. Maddox EE. 87.
30. Maddox EE. 103-104.
31. Worth C. *Squint: Its Causes, Pathology, and Treatment*, Third Edition. London: John Bale, Sons & Danielsson, Ltd. 1906.
32. Worth C: 55.
33. Worth C: 129.
34. Worth C: 130.
35. Worth C. 164.
36. Worth C. 165.
37. Percival AS. *The Relation of Convergence to Accommodation and its Practical Bearing*. *Ophth Rev*, Volume XI. London: J & A Churchill. 1892. 322.
38. Sheard C. *Zones of Ocular Comfort*. *American Journal of Optometry* 1930: 7(1):21-22.
39. Scheiman M, Cotter S, Rouse M, et all. Randomized clinical trial of the effectiveness of base-in prism reading glasses versus placebo reading glasses for symptomatic convergence insufficiency in children. *Br J Ophthalmol* 2005; 89(10): 1318-1323.
40. Kuhn TS. 80
41. Sheard C: 22-23.
42. Press L J, Taub MB, Schnell PH. *Applied Concepts in Vision Therapy 2.0*. Timonium, Maryland: Optometric Extension Program Foundation Inc., 2022.
43. Press L J. 2022, 11-28.
44. Kraskin RA. *The Use and Misuse of Language: Centering and Identification*. *Journal of Behavioral Optometry* 2003: 14(4): 87-93.
45. Skeffington AM. *Practical Applied Optometry*. Feb 1959. Series 31(5): 46. In Kraskin RA: 91.
46. Skeffington AM. *Practical Applied Optometry*. Nov 1961. Series 34 (2): 41. In Kraskin RA: 92.
47. Cook DL. *The Shape of the Sky: The Art of Using Egocentric Stereopsis in the Treatment of Strabismus*. *VDR* 2016: 2(4): 211-237. <https://bit.ly/43MvnTe>
48. Cook DL. *The Shape of the Sky: Eye Games and Seeing Stories for Discovering Depth in a Flat World*. Timonium, Maryland: Optometric Extension Program Foundation, Inc., 2019.
49. Cook DL. *MY APPROACH to Relieving Persistent Diplopia in Strabismus*. PracticeUpdate website Sept 5, 2019. <https://bit.ly/3N64piz>. 5:112. 487.
50. Maze DA: 2022.
51. Cook DL, 2016: 213-214.
52. Brock FW. *Visual Training*. *Optom Weekly* Nov. 6, 1947: 38(45): 1680.
53. Lancaster JE. *Some techniques for the analysis and treatment of suppression*. *Am Orthopt J*. 1955.
54. Burian HM. *Fusional Movements: Role of Peripheral Retinal Stimuli*. *Arch Ophthalmol* 1939: 21(3): 486-
55. Brock FW. *A Chronicle of Orthoptic History Covering 25 Years of Practice*. *Optom Weekly* 1966: 57(5):25-31. 57(6): 31-35. 57(7): 23-27.
56. Skeffington AM. *Practical Applied Optometry*. July 1958. Series 30(10): 73. In Kraskin RA: 91.
57. Skeffington AM. *Practical Applied Optometry*. Nov 1963. Series 36(2): 73. In Kraskin RA: 92.
58. Gibson JJ. *The Ecological Approach to Perception*, Classic Edition. New York: Psychology Press, 2015: 119.
59. Ibid.

60. Ibid.
61. Gibson JJ: 125-126.
62. Skeffington AM. Practical Applied Optometry. Oct 1952. Series 24(10): 91. In Kraskin RA: 88.
63. Oxford English Dictionary. Dec 2022. visceral, adj. : Oxford English Dictionary ([oed.com](https://www.oed.com))
64. Solms M. The Hidden Spring: A Journey to the Source of Consciousness. New York: WW Norton & Company, 2021: 103-121.
65. Berthoz, A. The Brain's Sense of Movement. Cambridge Massachusetts: Harvard University Press, 2002, 165.
66. Skeffington AM. A Modern Concept of Vision. Optometry and Visual Performance 2018: 6(6): 359.
67. Skeffington AM. Practical Applied Optometry. Oct 1952. Series 24(10): 92. In Kraskin RA: 88.
68. Donders FC. On the Anomalies of Accommodation and Refraction of the Eye, Translated by William Daniel Moore. London: The New Sydenham Society, 1864.
69. Skeffington AM, 2018: 353.
70. McLaughlin SC. Visual Perception in Strabismus and Amblyopia, Psychological Monographs: General and Applied 1964: 78(12): 17.
71. Kuhn TS. 82.
72. Kuhn TS. 146.
73. Feyerabend P: 14.
74. Feyerabend P: 9.
75. Price DD, Finnis DG, Benedetti F. "A Comprehensive Review of the Placebo Effect: Recent Advances and Current Thought." Annu. Rev. Psychol. 2008. 59:565–90. <https://doi.org/d3kjnp>
76. Benedetti F. Placebo Effects, Second Edition. Oxford University Press, 2014.
77. Benedetti F. 130-131.
78. Miller FG, Colloca L, Kaptchuk TJ. The Placebo Effect: illness and interpersonal healing. Perspect Biol Med. 2009. 52(4): 519. <https://bit.ly/3q18Zfu>
79. 1811, R. Hooper Quincy's Lexicon-medicum (new ed.) Placebo see OED
80. Hall, KT. Placebos. Cambridge, Massachusetts: MIT Press, 2022.
81. Hall, KT: 27.
82. Hall, KT: 41.
83. Makary MA, Daniel M. Medical error—the third leading cause of death in the US. BMJ 2016. 353 doi: <http://doi.org/10.1136/bmj.i2139> (Published 03 May 2016)
84. Williams AR, Bisaga A. From AIDS to Opioids—How to Combat an Epidemic. N Engl J Med 2016. 375: 813-815. <https://doi.org/ghm8sh>.
85. Price DD, Finnis DG, Benedetti F. "A Comprehensive Review of the Placebo Effect: Recent Advances and Current Thought." Annu. Rev. Psychol 2008: 59:565–90. <https://doi.org/d3kjnp>
86. Moerman D. Meaning, Medicine and the 'Placebo Effect'. Cambridge, England: Cambridge University Press, 2002.
87. Benedetti F. Placebo Effects, Second Edition. Oxford: Oxford University Press, 2014.
88. Hall, KT, 2022.
89. Miller FG, Colloca L, Kaptchuk TJ. The placebo effect: illness and interpersonal healing. Perspect Biol Med. 2009:52(4): 518. <https://doi.org/ggt9s3>.
90. Moerman D. Meaning, Medicine and the 'Placebo Effect'. Cambridge, England: Cambridge University Press, 2002.
91. Benson H. Harnessing the Power of the Placebo Effect and Renaming It "Remembered Wellness. Annu Rev Med. 1996. 47:193-99.
92. Kory Z. Specific versus Non-specific effects, Where do we stand? Orthopaedics. Aug 17, 2018: <https://bit.ly/3P7ZEHW>
93. Quoted in Observer (London, Aug. 1, 1982), quoted in Andrews R. The Columbia Dictionary of Quotations. New York: Columbia University Press, 1993, 809.
94. CITT-ART Investigator group 2019b: 841.
95. CITT-ART Investigator Group 2019b: 844.
96. CITT-ART Investigator Group 2021: 222.
97. Summarized in Benedetti F: 208.
98. Benedetti F: 209.
99. CITT-ART Investigator Group 2021: 231.
100. Watson JD, Crick FHC. Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid. Nature 1953: 171: 737-738.
101. American Academy of Pediatrics Joint Organizational Statement. The Eye and Learning Disabilities. Pediatrics 1972: 49(3): 454-455.
102. Pediatrics 2011; 127: e818-e856. <https://bit.ly/45SBx61> Downloaded from www.pediatrics.org on March 1, 2011.
103. Ibid: e832.
104. For an example of the references of a position statement at odds with statement itself see Flax N, Mozlin R, Solan HA. Discrediting the Basis of the AAO Policy: Learning Disabilities, Dyslexia, and Vision. Journal of the American Optometric Association. 1984. 55(6): 399-403.
105. CITT-ART Investigator Group 2019b: 846.
106. Arnold LE, Lofthouse N, Hersch S, et al. EEG Neurofeedback for ADHD: Double-blind Sham-controlled Randomized Pilot Feasibility Trial. J Atten Disord 2013. 17:410–9.
107. CITT-ART Investigator Group 2019a: 825.
108. CITT-ART Investigator Group 2019b: 847.
109. Kushner BJ. 2005: 101.
110. CITT-ART Investigator Group 2019a: 832.
111. CITT-ART Investigator Group 2019b: 844-45.
112. CITT-ART Investigator Group 2021: 231.
113. CITT-ART Investigator Group 2019a: 831.
114. Scheiman M, et al. Nearpoint of Convergence: Test Procedure, Target Selection, and Normative Data. Optometry and Vision Science. 2003. 80(3): 214-225.

115. Cook DL. *Biomythology: the Skeptic's Guide to Charles Darwin and the Science of Persuasion*. Bloomington, IN: AuthorHouse, 2016: 285.
116. Rouse MW, Borsting E, Deland EN, and The Convergence Insufficiency and Reading Study (CIRS). Reliability of Binocular Vision Measurements Used in Classification of Convergence Insufficiency. *Optometry and Vision Science*. 2002. 79(4): 254-264.
117. Wesson MD. Normalization of Prism Bar Vergences. *Am J of Optom & Physiological Optics*. 1982. 59(8): 628-634.
118. Morgan MW. The Clinical Aspects of Accommodation and Convergence. *Am J Optom & Archive Am Acad Optom*. 1944. 21(8): 301-313.
119. Although reason can certainly be used to question my arguments, but the best of reason is no stronger than its premises, and premises are the reason that science demands skepticism.
120. The Ohio State University College of Optometry. CITT-ART Convergence Insufficiency Attention and Treatment Trials Manual of Procedures, Chapter 8, Office-based Placebo Therapy. 8-1 to 8-49. <https://bit.ly/43FkX83>
121. CITT-ART 2019b: 844.
122. Beecher AK. The Powerful Placebo. *JAMA*. 1955. 159(17): 1602-1604.
123. Kulp MT, et al. Feasibility of Using Placebo Vision Therapy in a Multicenter Clinical Trial. *Optometry and Vision Science*. 2008. 85(4): 255-261.
124. Kushner BJ. 2005: 100.
125. <https://www.goodreads.com/quotes/23787>
126. Noë A: *Learning to Look: Dispatches from the Art World*. London: Oxford University Press, 2021: xi.
127. Bruenech JR. Neuroanatomical Structures in Extraocular Muscles and Their Potential Implication in the Management of Strabismus. *Vision Dev & Rehab* 2021; 7(2):117-27.
128. Bruenech JR, Kjellevoid Haugen IB. The neuroanatomical basis for fine tuning of eye movements during close work. In: Salvendy G, editor. *Human computer international 2005*, U.S. CD, aol. 1. New Jersey: Lawrence Erlbaum Associates Inc; 2005. <https://bit.ly/3clq9zL>
129. Feldman AG, Zhang L. Eye and head movements and the vestibulo-ocular reflex in the context of indirect, referent control of motor actions. *J Neurophysiol* 124: 115–133, 2020. First published June 3, 2020; <https://doi.org/kd6r>

**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.<sup>127</sup>

**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.<sup>128</sup>

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,<sup>129</sup> 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 as 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 is turned over and to remain aware of the number and suit of the card while a card game is played. 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-disparted 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 is 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 must 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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