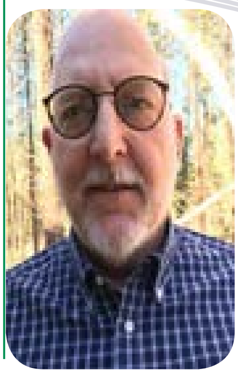
Article · Suppression Does Not Just Go Away, But Treatment Might Change a VO Star-Case Series Retrospectives

Article • Suppression Does Not Just Go Away, But Treatment Might Change a VO Star—Case Series Retrospectives

Eric Hussey, OD • Spokane, Washington



Eric Hussey, OD
Spokane, Washington
OD & BS (Physics)-Pacific University College of Optometry, 1975
President, Optometric Extension Program Foundation
Chair, Organizing Committee for the International Congress of Behavioral Optometry 2024
Chair, Northwest Congress of Optometry

ABSTRACT

Background: Intermittent central suppression (ICS) is an intermittent loss of central visual sensation. Treating ICS has improved quality-of-life symptoms and reading levels. Improvements in ICS hold over time. A score based on ICS—percentage of binocularity during waking hours—can be used to quantify binocularity and changes in binocularity.

Subjects and Methods: Two case-series groups, 36 treatment-with-therapy subjects and 36 age-matched no-therapy subjects who had two ICS examinations, were retrospectively put together from records in a private optometric clinic. Percentages of binocularity were calculated for both groups. Prior studies are added to compare diagnostic data over a larger group. In addition, preliminary results of measurements of apical scatter on VO star drawings are presented.

Results: The treatment and non-treatment groups show remarkable consistency in visual characteristics and ICS timing. ICS patients tend to be refractively "normal." Vision therapy for ICS works. Time without vision therapy does not improve ICS. Lenses do not improve ICS over time, but reading lenses may have a slight, not statistically significant, but positive effect on ICS. Improvement in binocularity may have a positive effect on VO star apical scatter.

Keywords: intermittent central suppression, lateral geniculate nucleus, magnocellular pathway, suppression, Troxler's perceptual fading, visibility, VO star

Introduction

Intermittent central suppression (ICS) is an intermittent loss of central visual sensation. An encapsulation of what we know about ICS might be broken into three parts: diagnosis, results of therapy, and probable neurology.

Diagnosis of ICS at our current understanding requires dichoptic presentation, with that dichoptic presentation held over time. Quick screening tests such as the Jampolsky 4-prism test or Wirt stereopsis fail to specifically and reliably diagnosis ICS.[1] Those failures probably are due to some of the diagnostic characteristics of ICS: specifically, its intermittency and the 80 to 90% of ICS patients whose suppressions alternate sides.[1,2] By definition, ICS is not associated with strabismus or amblyopia. However, given that the visual neurology is consistent in being the visual neurology whether strabismus and amblyopia are present or not, those theorized distortions of function that constitute ICS may be part of the neurological distortions of strabismus and amblyopia.[3] Refractive errors and acuities are consistent with that non-association with strabismus and amblyopia: group data for ICS patients show normal, equal acuities and a very normal refractive status curve.[1]

Timing the ICS presentation in patients shows a roughly 2- to 3-second "on-off" cycle. That intermittency was projected early on to be detrimental to reading,[4-6] which is borne out by later studies on treatment.[7,8]

Therapeutically, ICS can be treated successfully with current therapies and technology.[7-9] When ICS is treated successfully, quality-of-life (QOL) questions of visual well-being, as well as reading-specific QOL question scores, improve. Concurrently with those quality-of-life score improvements, reading levels improve.[7] Not only do QOL scores improve with improvement of ICS, but those improvements hold over time, as do the improvements in binocularity represented by decreases in ICS.[9]

A score for binocularity—percentage of binocularity during waking hours—can be calculated. Percentage of binocularity during waking hours is admittedly limited in its scope since it uses a sub-test vignette, usually at near, for its calculation. While such a calculated binocularity score may potentially be useful clinical information, perhaps more importantly, it may be understandable to patients and parents. Suggesting, for example, that a patient sees with both eyes simultaneously 40% of their waking hours has seemed clinically to be understandable at a non-technical level. The caveat here is to explain the limitations on this binocularity scoring as part of the case presentation.[8]

The suggested neurology of ICS is useful in explaining ICS characteristics, such as the intermittency and alternation, that cannot be explained by the conventional wisdom of suppression as a cortical inhibition.[10] By moving the site of the suppression from the cortex (V1) to the lateral geniculate nucleus (LGN) and changing the mechanism from simple inhibition to the drop-out of Troxler's perceptual fading, most aspects of ICS become explainable. Troxler's perceptual fading can be defined as the loss of visibility at the LGN due to decrease or loss of the visual motion signal, or perhaps decrease of activity in the visual-motion neurology.[11]

As visibility, or central visual sensation, drops out, an afferent disruption of fixation sensory data for fixation control results. That afferent intermittent loss of central visual sensation, by its removal of the information necessary to maintain accurate fixation, creates a variable sensory signal to the cortex.[1,11] Is it any wonder that reading—especially with a novice reader such as a schoolchild—becomes more difficult? The "picture" received by the cortex is literally unstable; it changes over time.

Moving the primary site of the suppression to the LGN, and thereby making the dropout of the visual signal afferent, introduces the possibility of an internal deprivation to visual neurology beyond the LGN that could explain some neural changes in amblyopia. All that is required is for the timing of the sensory dropout to be such that it occurs during a period of "hot" neural development downstream from the LGN. Given concurrent timing of active neural development and dropout of the visual signal at the LGN, deprivation to the visual neurology is possible, if not probable.[3] The developing neurology requires an intact visual signal in order to develop normally.[12] If the signal drops out at the LGN, neurology past that point will be deprived of the full-strength signal needed for full-strength development.

Moving the suppression to the LGN can also help explain the sole documented genesis of suppression, in a case study of whiplash. The LGN is situated around the brain stem close to one of the pivot points for the head in whiplash. That suggests that this is a point where neurology, and specifically synapses, can be jerked and stretched as the head whips back and forth around that pivot point, creating neural havoc without requiring cortical damage.[13]

Further, by changing the discussion of suppression to loss of visibility versus inhibition at the cortex, we can answer the question of why a suppressor doesn't see a black spot when an eye's sensation is lost. When visibility drops out at the LGN—Troxler's fading—a perceptual fill-in is generated somewhere beyond V1 and fed back down to the region of the LGN. That fill-in, which is visual "junk" that in its very general characteristics fits with the visual scene, has its own consequences for sensation, since it apparently is strong enough to create rivalry with the signal from the other eye.[11,14]

Two more questions deserve attention. First, does ICS just go away over time? Does it even lessen over time? We know that suppression in strabismus does not go away with surgical alignment.[15] By definition, ICS excludes strabismus. If we change the variables from eye alignment and suppression[15] to passage-of-time and pattern-of-sensation-over-time, does the same hold for ICS? That is, untreated, does ICS remain the same over the long term, just as a strabismic suppression remains unchanged with surgical alignment? If we treat ICS, does a traditional behavioral vision perceptual test such as the Van Orden star (VO star) change?[16]

Two new retrospective case-series groups will attempt to answer those questions. Two groups from the records of a private optometric practice were searched. The first retrospective series was a group of ICS suppressors who had been treated with vision therapy and also had VO star drawings both before and at the end of therapy. The second group was a group searched to form an age-matched non-treatment group, the majority of whom also had VO stars from their initial examinations. The age-matched group was also required to have two examinations, both of which included timings of their ICS suppression cycles.

Subjects

The first patient file group searched was an ICS treatment group. A desire to look at changes in the VO star with therapy for ICS triggered the initial search. Therefore, the search criteria were treatment of ICS to a level of completion and having a pre- and a post-therapy VO star. Thirty-six patient records were found in the initial search that fit those criteria. All completed therapy for their ICS.

As that group was being assembled, the decision was made also to look for an age-matched comparison group. The primary criterion for that group was two examinations that included timings of the suppression cycle. As a matter of year-to-year clinical expediency, rigorous second-examination ICS timings sometimes give way to a less-rigorously timed confirmation of the previous diagnosis. Therefore, two time-separated rigorous suppression timings were required for inclusion. Preference was given for records with a VO star, with the thought that the apical scatter on those might provide valuable data. Twenty-eight of the 36 had VO stars, but a lack of follow-up VO stars limited VO star data to pilot-study status.

The age-matched group did not participate in therapy in any form other than lenses. Of the 36, only 3 had no lenses prescribed. Sixteen received prescriptions for reading/schoolwork lenses. Nine opted for correction of myopia as diagnosed. The other 10 had a variety of stronger hyperopic and astigmatic lens prescriptions. With 33 of the 36 age-matches having some sort of lens power at least prescribed, a possible lens effect on suppression might be visible at the second-examination ICS timing. To search for a possible reading-lens effect, the 16 reading-lens cases were separated out, and changes in the suppression over time that could be attributed to the presence (or possibly influence) of reading lenses were assessed.

Methods

Grouped examination data from a private optometric practice are presented. The examining doctor tests almost all patients in the same manner. This testing has been described before, and as routinely applied in the clinic, affords some level of repeated evaluation of visual sensation over time.[9,17] Further, reliability of diagnosis in repeated examinations over time appears good.[1]

Polarized (vectographic) targets both at distance and at near (40 cm) provided the dichoptic test conditions for the evaluation of binocularity in both groups. At the initial examination, during which an ICS diagnosis is made, a timing of the on-off sequence is done, and the percentage of binocularity during waking hours is calculated. As suggested above, that calculation has proven valuable in reporting concerns about vision. When therapy is chosen by the patient or parent to treat the ICS, percentage of binocularity also aids in reporting measurable changes in the ICS at evaluations.

When the patient does not choose to do therapy for ICS, but returns later for routine follow-up examination, the same test sequence is done. Since a prior stringent timing has been done, in later examinations, the choice may be made to let that initial stringent timing suffice rather than over-exposing a child to the test questioning. Those non-therapy records of examinations that included a stringent second fully-timed diagnosis formed the age-matched group and had first- and second-examination percentages of binocularity calculated. The ICS timings from the two separated-in-time examinations give a non-treatment, age-matched comparison group for changes in ICS over time. A majority of those non-therapy patients also had one VO star done as part of the initial therapy-related testing at the first examination when ICS is diagnosed.

One significant difference between the treatment and age-matched non-treatment groups is time between first and second examinations: 8.5 months on average for pre- to post-therapy examinations versus 23.2 months between first and second no-therapy examinations. The longer time in the age-matched no-therapy group should allow time for non-therapy improvements from either lenses or time to manifest.

Two methods of comparing percentages of binocularity at different times in the same group are available, both using this calculation: [(average non-suppressed seconds) / (average suppressed seconds + average non-suppressed seconds)] x 100.[8] The percentage of binocularity can be calculated individually for each subject based on that person's timed suppressions. Then, to determine the average percentage of binocularity, those individual percentages can be averaged. Alternatively, the timings themselves can be averaged, and then the same calculation can be applied to those average timings. Different results between the two methods seem minimal, but results of both methods are reported.

The treatment group was treated specifically for ICS and had both a pre-therapy VO star as well as a post-therapy VO star. As part of routine treatment for the ICS, progress evaluations are done at 4- to 6-week intervals, and the ICS is timed as it was previously in order to have a direct comparison for

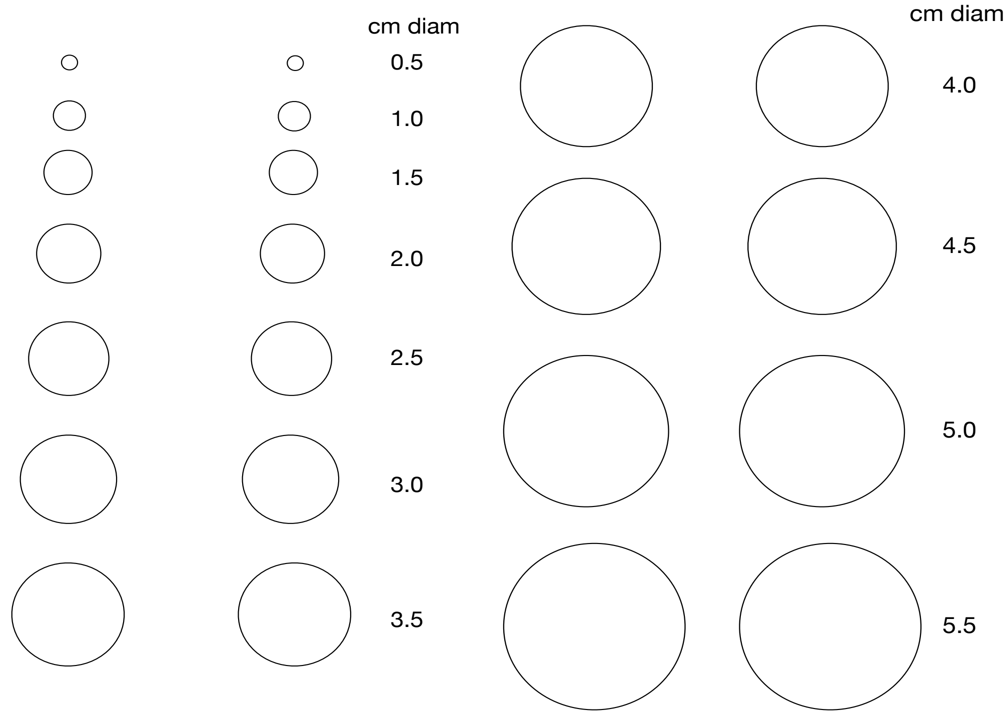


Figure 1. *Circles printed on clear acetate used to measure apical scatter of VO stars*

improvement. From that progress evaluation timing, a new percentage of binocularity during waking hours can be calculated. Therefore, pre-therapy and post-therapy percentages of binocularity during waking hours can be calculated to show whether therapy has improved sensation by reducing ICS. In addition, having the VO stars in this series of cases gives the opportunity for another pre-therapy/post-therapy measure of any improvements in sensation or perception. If improvements in VO stars occur concomitantly with therapeutic improvements in binocularity, the suggestion can be made that improvement in binocularity improves those perceptual functions thought to be represented in a VO star drawing.

The Van Orden star has been a fixture of optometric vision therapy for decades, both as a test device as well as a training device.[6,16,18] The original Van Orden technique manual included examples of VO star drawings. Those drawing patterns were echoed by Kaplan and Lydon,[19] who developed star drawing patterns into a system to analyze how a patient views space. They describe and show an example of a star pattern with "poorly formed apices," attributing that pattern to poor central-peripheral orientation and organization, potentially including emotional issues.

The central vision represents the central 4-5 degrees of the visual field.[20] Without debating the larger meaning of an imperfect VO star, it might be possible to measure, in some rough manner, the scatter, the breadth of line endpoint variation, as a performance test measure of changes in central vision and indirectly, fixational accuracy. To that end, a series of circles of increasing diameter from 0.5 to 5.5 cm in 0.5 cm increments, printed on clear acetate overlays, were used to measure apical scatter (Figure1). While very crude from a scientific measurement viewpoint, considering the general increase, decrease, or stability of that central visual scatter might point toward performance changes with measurable changes in ICS and potentially in fixation.

Staff members used those overlays to estimate the apex line scatter, uninfluenced by the examining doctor. The before- and after-therapy measurements are reported, with the understanding that the measurement device is crude. They are added to the changes in percentage of binocularity as an introductory performance measurement that may bring changes in percentage of binocularity into more discussions of changes in visual perception with therapy, and specifically with therapy for ICS.

Methods of treatment

Active treatment of ICS requires two simultaneous constituents: bilateral sight and visual motion. Virtually all active anti-suppression procedures break down on a stimulus level into those components. Included in that is rapid alternation with liquid crystal lenses. The visual carry-over, probably from temporal

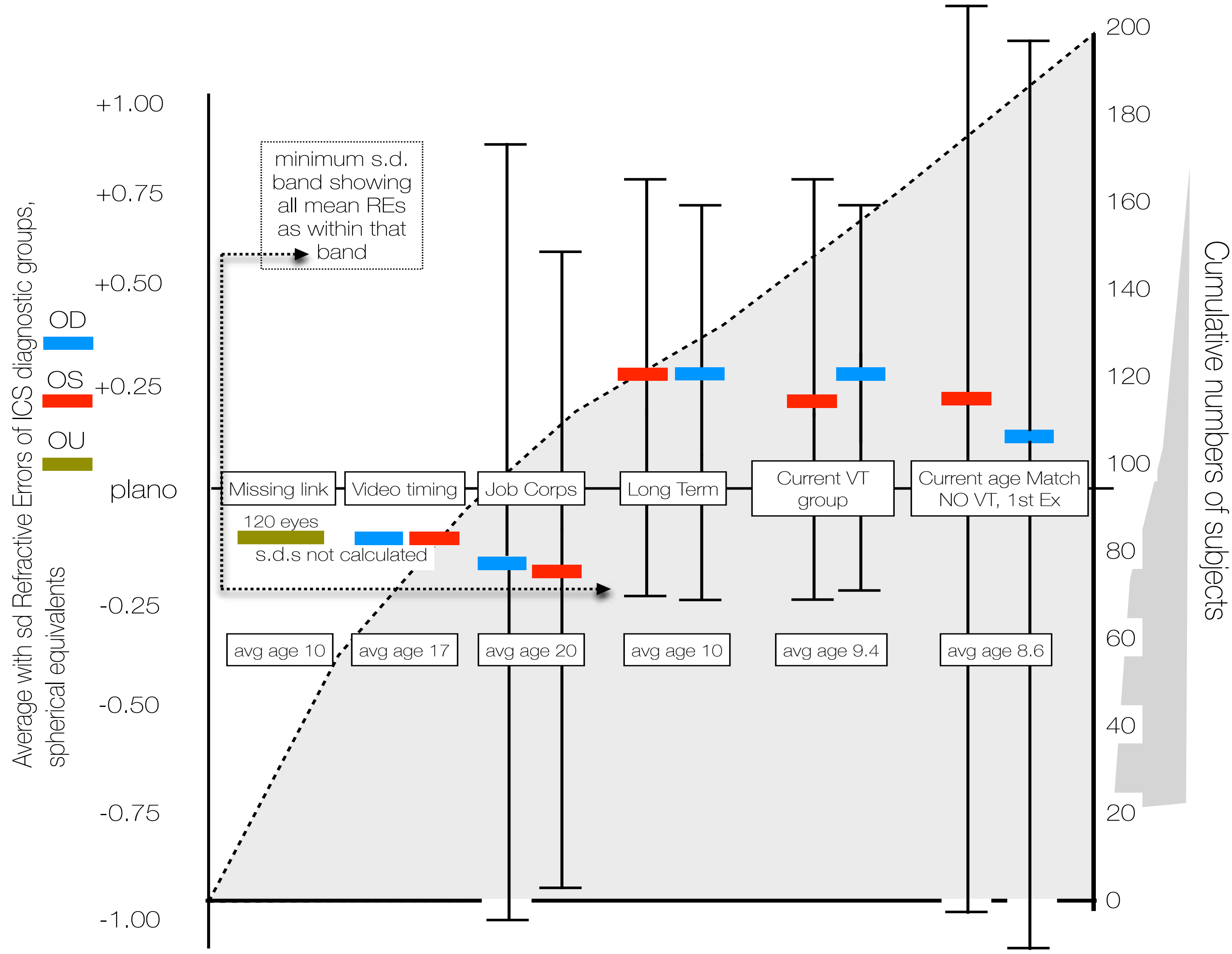


Figure 2. *Refractive status for ICS diagnostic and treatment groups (see text). The current therapy and age-matched groups are at the right of the graph. The "minimum SD band" is the tightest combination of standard deviation bands, in an effort to show that all mean refractive errors at initial diagnosis are statistically equivalent.*

summation, from one side to the other during the alternation (at the typical 5- to 7-Hz pace), provides the cortex with a bilateral stimulus and on-off flicker that is a strong motion stimulus, perhaps 7 times the strength of a moving grating stimulus.[3,11,21] Eight of the treatment group members were treated almost exclusively with rapid alternation, and their treatment data are also part of a previous study.[9] Other, perhaps more classic, therapies include repetitive stereoscope drawing and coloring activities,[23] dissociated/diplopic rotation therapies, and Brock string activities. All of those must be applied repetitively.

As part of a wider view of changes with increasing binocularity, pre-therapy and post-therapy, patients did VO stars, which were measured for scatter as discussed above. Instructions for the VO star drawings were:

"Get close and look through the lenses with both eyes open. Do you see the numbers 1 to 11 and 11 to 1 on both sides?" (Use a finger to show where.) "I am going to give you two pencils; you will put one in each hand, put them on the number 1s, then you will draw lines toward each other and you will stop right when it looks to you like the pencils are touching." (Demonstrate this while the patient is looking through the lenses.)

Hand them the pencils, and talk them through it again as they try the first 2-3. "Now keep going all the way to 11."

"Be sure to draw the lines so that I can see them."

"Draw the pencils together until it LOOKS like they touch, not when they ACTUALLY touch."

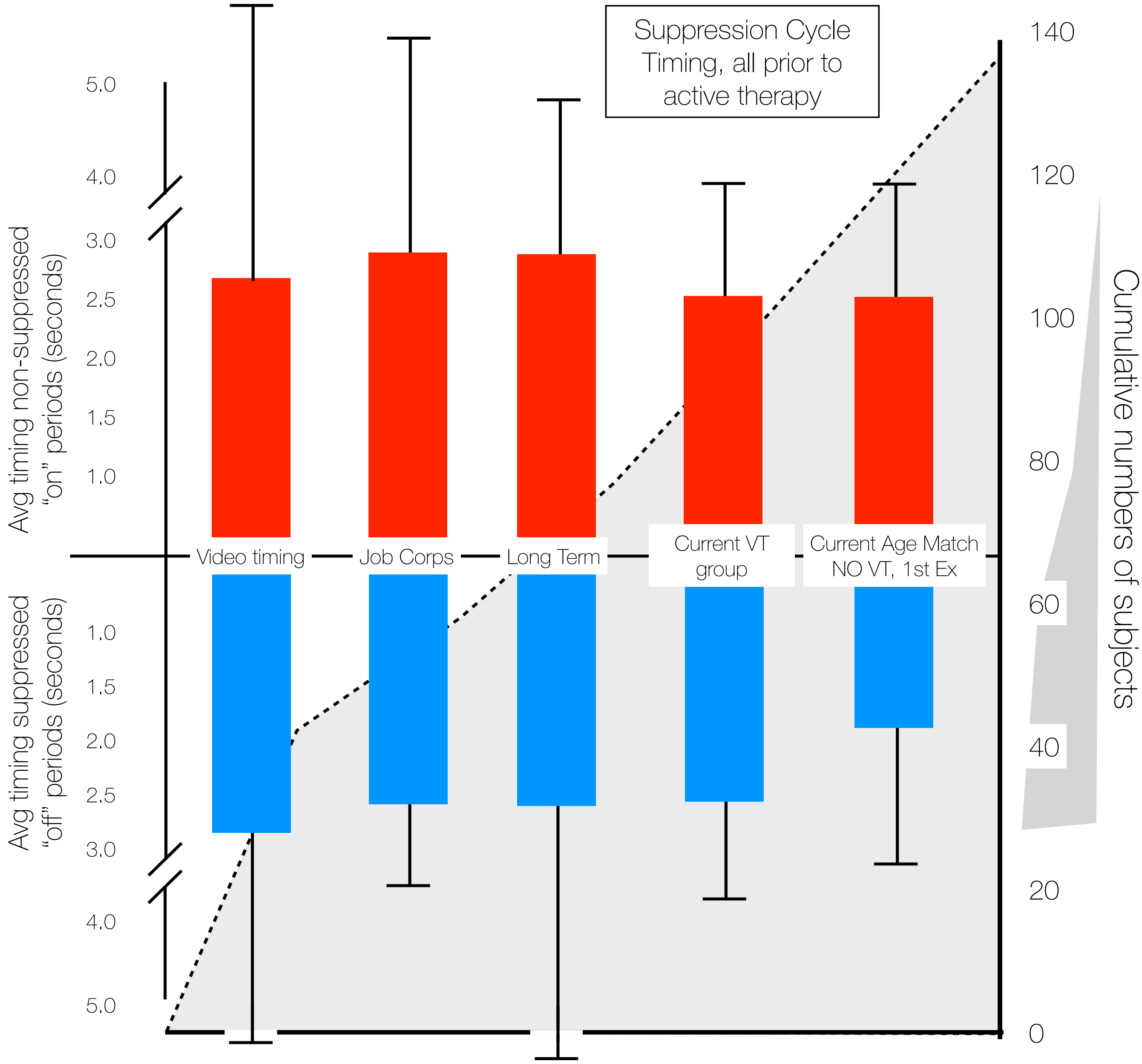


***Figure 3.** Averaged initial "on" (non-suppressed, red) and "off" (suppressed, blue) period timings for 5 diagnostic groups with SD bars (see text). The current therapy and age-matched groups are at the right of the graph.*

Results

Retrospective 1: Construction of an age-matched group, including comparison to prior diagnostic groups and consistency of diagnostic data

Thirty-six members comprised the therapy and the non-therapy age-matched groups for this retrospective. The therapy group had 15 females and the non-therapy group 21 females. Average age at the start of therapy in the therapy group was 9.4±3 years (95% confidence interval =0.95; 8.45 to 10.35), ranging from 6 to 21 years. The average age of the age-matched group at the first examination was 8.6±2.5 years (95% confidence interval =0.82; 7.78 to 9.42), ranging from 6 to 16 years. Standard deviations and confidence intervals show these two groups—treated and non-treated with therapy—not to be different in age.

Average best acuity for each eye for each group at first examination was just better than 20/25. After therapy, average best acuities for the therapy group improved to better than 20/20. At the second examination, after just less than two years in the non-therapy group, average acuities improved but remained between 20/20 and 20/25. Therefore, increased age, perhaps by improving test responsiveness, had some effect on acuity in this group. In averaged initial acuities, these two groups match well, both starting just better than 20/25. The two groups also match the largest diagnostic study to date, where 90% of subjects showed 20/25 or better acuity.[1]

Similarly, refractive status at the first visit (spherical equivalents) are much the same between the two groups, with the treatment group averaging +0.28 OD and +0.19 OS (±0.5 D), and the non-therapy group +0.07 OD and +0.15 OS (±1.2 D). Figure 2 displays refractive status averages with standard deviations. In addition, refractive data from four other ICS diagnostic studies (including two diagnostic-therapeutic) are displayed.[1,2,7,9] Figure 2 shows what would be the narrowest standard deviation band represented by choosing the most restrictive endpoints from the combination of the associated standard deviations. All refractive error averages reside within that narrowest standard deviation band. Two of the four added studies[1,2] did not have standard deviations calculated. The six studies represented bring the total number of diagnostic subjects in the figure to just under 200 ICS diagnoses (198).

The slightly older-in-age Job Corps group was a little more myopic on average; average refractive errors were: OD -0.17±0.86, OS -0.18±0.74. Even with this shift toward myopia, the Job Corps group's average refractive error was within the minimal standard deviation band of the other five diagnostic groups (Figure 2).[7]

The similarities between groups continue in initial timings of the ICS off-on sequence: the therapy group showed an average 2.4 (±1.2) seconds suppressed/2.5 (±1.8) seconds not suppressed sequence pre-therapy, while the non-therapy group initially showed timings of 2.0±0.8 seconds suppressed and 2.4±1.6 seconds not suppressed. Again, all four means are included within the standard deviation of the respective paired timing and so are matched well. Figure 3, with the two right-hand bars representing current VT and age-matched groups, shows the non-suppressed periods (red) and the suppressed periods (blue) with standard deviations at initial examination.

Figure 3 also includes three more diagnostic studies that used the same near vectographic timing technique.[2,7,9] Therefore, in toto, Figure 3 shows the pre-therapy diagnostic ICS timings for 5 groups studied, starting in 2002 up to the current study. Across that time period, with average ages ranging from 8 to 20 years old and individuals up to 43 years of age, ICS timing periods, on average, are remarkably similar. Starting from the left in Figure 3, a prior paper that used video timing of the suppression sequences of 30 non-treated ICS patients ranging in age from 6 to 43 years (averaging 16.7 years) showed 2.8±2.7 second suppressions and 3.4±4.4 second non-suppressed periods.[2] That paper was used to confirm that ICS timing will be, as had been said previously, on average, a roughly 2 to 3 second on-off sequence for visual sensation.[24] The timings of this current study are well within the standard deviations of the video timing, as well as the Job Corps study pre-therapy suppression timings of young adults: 2.5±1.1 seconds suppressed and 2.8±2 seconds non-suppressed.[7] Similarly, the long-term study group (middle column) started with 3.3±3.8-second suppression periods spaced by 2.5±2.2-second periods of bilateral visual sensation.[9] Therefore, not only does the current therapy treatment group align with the age-matched non-treatment group in initial timings of the suppression sequences, but the diagnostic suppressed/non-suppressed visual sensation time sequence is substantially the same across five diagnostic groups covering 138 subjects over 18 years.

The standard deviations suggest that much individual variability in suppression temporal sequences exists. Part of that variability between individuals may be a function of the subjective nature of testing for ICS. It may also reflect that ICS itself is variable, both between and within individuals. Clinically, fatigue can have an effect. Taking those factors into account, it is still reasonable to suggest that ICS will typically be a repetitive, roughly 2- to 3-second suppressed/non-suppressed sequence. Further, if the non-suppressed periods in a particular patient are consistently 11 seconds or more throughout the diagnostic timing, that is two standard deviations away from average non-suppressed periods, which suggests less strength to the ICS diagnosis.[7]

In summary for retrospective 1, the treatment and age-matched groups from the current study are well-matched in age, visual acuities, refractive status, and timing of suppressed/non-suppressed periods. That is, the treatment and age-matched groups are largely the same diagnostically. Second, looking across diagnostic data from this and the additional studies cited in figures 2 and 3, ICS is remarkably consistent in its timing and refractive characteristics. If only acuities, refractive characteristics, and eye health were considered for any of these diagnostic groups, they would be considered very normal. That is, these 198 intermittent suppressors are unlikely to be detected by distance acuity and distance refractive status tests. ICS has shown a consistently high level of reading complaint.[1,2,7,9] Therefore, in a sense, the diagnostic onus for a child suffering from ICS falls increasingly on an adult who will persist in

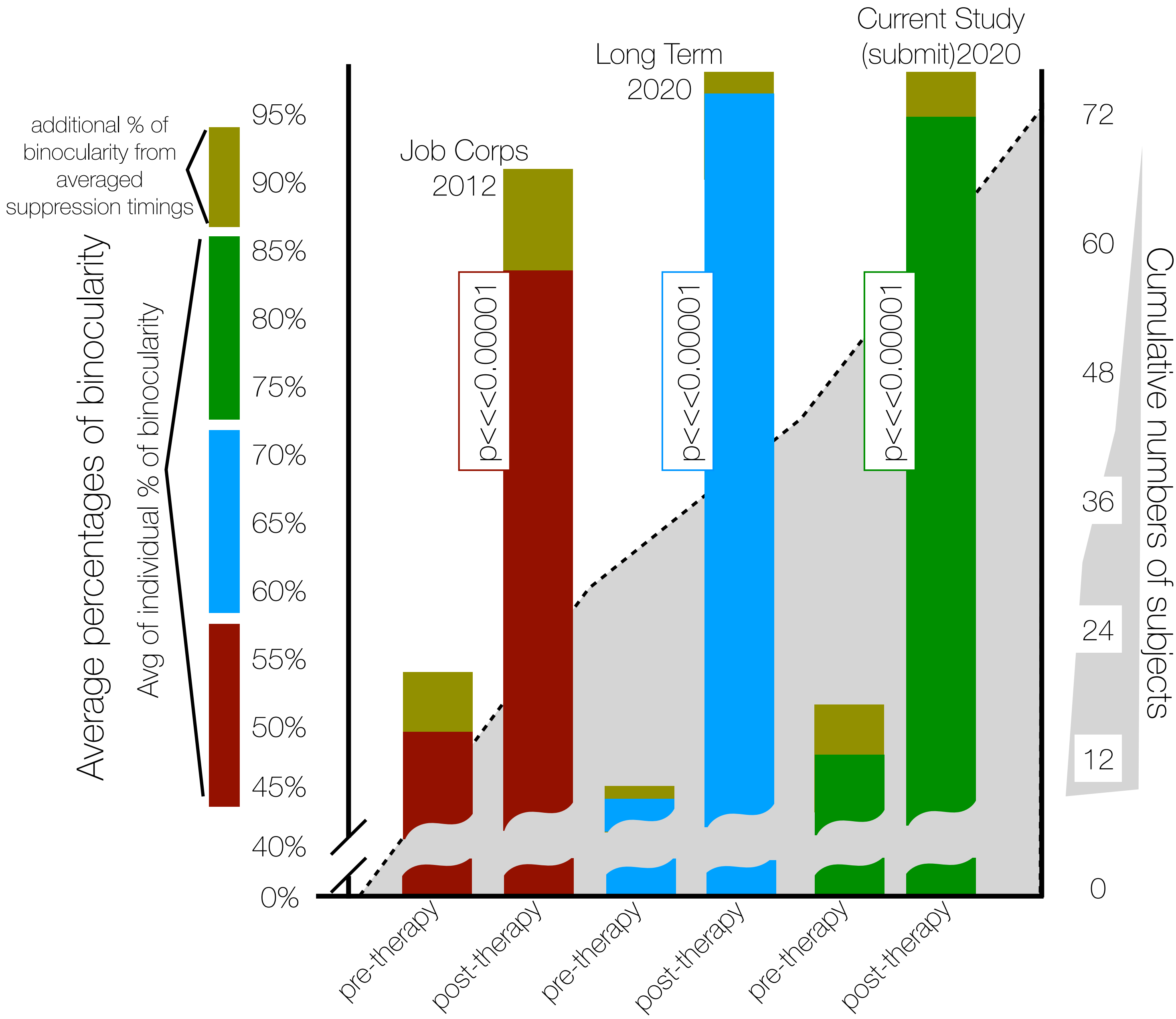


Figure 4. *Percentage of binocularity during waking hours pre- and post-therapy for three treatment groups, the current study at the far right. Percentage of binocularity is calculated two ways, as averaged individual percentages and then as averaged suppression timings that are then calculated as a single percentage of binocularity for each group.*

the search for an optometrist who will go beyond eye health and refractive status. Even if diagnosis and treatment are not offered by a given optometrist, just recognizing the possibility of an ICS diagnosis is a very important first step. Conversely, that refractive status consistency should not be used to generate an excluding factor for ICS diagnosis. In the presence of a reading complaint, "your child doesn't need glasses" bears a rough equivalence to suggesting that all is well with a red eye if no discharge is present. Refractive status does not equate to temporally sustained visual sensory competence.

If we use averaged suppression-cycle timings to calculate percentages of binocularity during waking hours for the five diagnostic groups (138 subjects prior to any therapy) for whom we have suppression cycle timings (Figure 3), the percentage of binocularity ranges from just over 43% to just under 55% of waking hours. Therefore, assuming acceptance of the concept of percentage of binocularity during waking hours, this group sees with both eyes simultaneously about half of the day. It is important to remember that the half of the day with bilateral sight is not in one chunk of time, but in continuously, incessantly repetitive spurts of about two to three seconds.

Another way to translate the concept of percentage of binocularity into a more common vernacular might be to talk about a typical grading system. The classic letter grading system in use in the US segments a possible 0 to 100 percent performance into letter grades: 90% or better is an A, 80% or better is a B, 70% or better is a C, 60% or better is a D. The rest are classified as F for Failure.[25] On a grading system such as this, the five diagnostic groups from Figure 3 are failures. They receive Fs. Some of them are fairly high Fs, but they are still Fs. The good news, as will be seen below, is that therapy can routinely raise those grades to As. Whether this successfully analogizes percentage of binocularity during waking hours in any meaningful way is for the reader to determine.

Retrospective 2: Treatment of ICS with vision therapy

The therapy group was treated for an average of 8.5 months (sd 3.6 mo). Using the calculation of percentage of binocularity during waking hours, it is readily evident that vision therapy can increase binocularity. At first examination, the vision therapy group measured 47.33±19.5%. After therapy, the percentage of binocularity during waking hours was 94.59±8.1%. A paired t-test shows that change is significant ($p<<0.00001$). That represents a change in the pre-therapy off-on timing sequence of just under a 2-second decrease in the average off/suppressed period to about 1/2 second. Average on/non-suppressed periods increased by just over 10 seconds, increasing that averaged non-suppressed timing to 12.5 seconds. Paired t-tests of both pre-therapy/post-therapy suppressed and non-suppressed periods show that both changed significantly ($p<<0.00001$).

Figure 4 shows three different treatment groups, including the current group.[7,9] All three groups show significant changes with therapy ($p<<0.00001$ for each group). Therefore, the therapy results for this present group are in line with prior therapy results for intermittent central suppression. Foundationally, that suggests that therapy for intermittent central suppression works. If anti-suppression therapy procedures are carried out properly over time for a patient diagnosed with ICS, those therapies are overwhelmingly successful. ICS can be changed and reliably improved using current techniques. Figure 4 illustrates that type of success with a significant number of therapy patients (72) over three studies over 8 years.

The current study does not look at symptom changes, but prior treatment groups have evaluated symptoms and reading performance, showing that as binocularity improves, visual symptoms improve, reading symptoms improve, and reading levels improve.[7,9] Previous research has also shown that those improvements in binocularity can be expected to hold over time, implying that the function of the underlying neurology has changed.[9]

If the analogy to grading in US schools has any merit for communication of change, the treatment group averaged 47%, a very solid F prior to therapy. At the end of therapy, that averaged grade changed to almost 95%, a very solid A. In terms of binocularity, spectacular failure has changed into honor student grades. Therapy works; therapy increases binocularity.

Retrospective 3: Non-treatment with vision therapy

The age-matched group did not receive therapy to treat their ICS; that is, to increase their binocularity. The group matches very well with the therapy treatment group at initial examination in age, acuity, refractive status, and ICS timed suppressed/non-suppressed temporal sequence.

The age-matched non-therapy group had two examinations, spaced by an average of 23.2 months, similar to the time span between first and second examinations of the long-term therapy study,[9] allowing some evaluation of the effects of time and lens use on ICS. In that age-matched group, 16 of the subjects received individually prescribed reading glasses. Two received no lenses, and the others received a variety of appropriate prescription lens powers. Table 1 compares the percentages of binocularity for the therapy and non-therapy age-matched groups. Already established is that therapy improves binocularity. Figure 5 graphically shows that the therapy group improved in binocularity ($p<<0.00001$). The full age-matched group did not. Their level of binocularity actually decreased slightly, from 49.2 to 48.4%, but a t-test shows the two values not to be different ($p>0.8$).

When the reading lens group (n=16) is separated out, those subjects did show a slight increase in binocularity, from 46.5 to 51.4% (Table 2). A t-test shows that this change is not significant. Nonetheless, it is improvement; it is the correct direction.

Even with the small improvement in binocularity with reading lenses, both beginning and second-examination 23-month binocularity findings would rank as Fs, or failures. Reading lens prescriptions do not improve binocularity percentages. The good news is that reading lenses certainly didn't hurt and may minimally help. Further, the risk/benefit ratio with lenses is vanishingly small. As speculation, the slight improvement in binocularity may reflect an anti-fatigue effect with reading lens use.[22] The bad news is that neither lenses nor time significantly improve

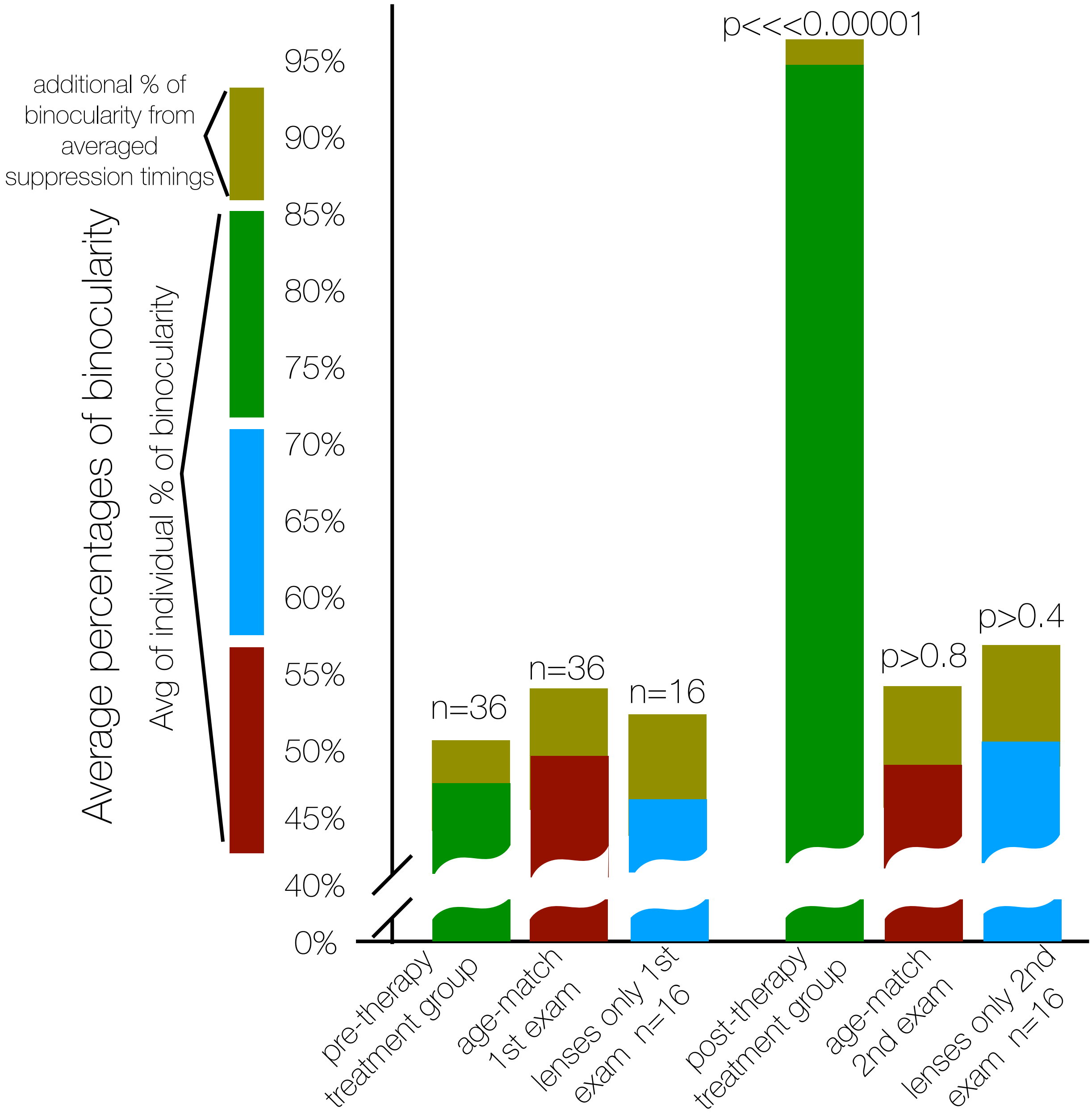


Figure 5. *Percentage of binocularity during waking hours pre- and post-therapy for the current treatment group (green) vs. age-matched no-therapy (red) and reading lens treatment group (blue) at the far right. Percentage of binocularity is calculated two ways, as averaged individual percentages and then as averaged suppression timings that are then calculated as a single percentage of binocularity for each group.*

binocularity, as defined by percentage of binocularity during waking hours. Figure 6 shows pie graphs of improvements in "binocularity grades" using therapy versus no changes with lenses.

Another suggestion falls from this finding of no anti-suppression effect from lens use. By definition, ICS does not involve strabismus or amblyopia and on average is associated with relatively low, even "normal" refractive status. To these, we add that ICS is not significantly changed by lenses, implying no real link at all of ICS to refractive status, the blur, and the accommodative effort that refractive status might entail. That combination of classic clinical normalcy of eye conditions that have no suppression-triggering characteristic, such as an eye turn, to explain the suppression, in combination with lack of any significant suppression response to lenses, suggests that ICS is not a secondary problem, not secondary to other eye or vision conditions. If the neurological explanation of ICS as loss of visibility at or near the LGN is correct, the explanation for ICS would most likely be developmental delay in the magnocellular pathway (genetic?), but also possibly trauma.[3,11,13] Neither explanation would suggest any influence by lenses; therefore, this lack of lens response could be expected. Bluntly, ICS should be considered a primary

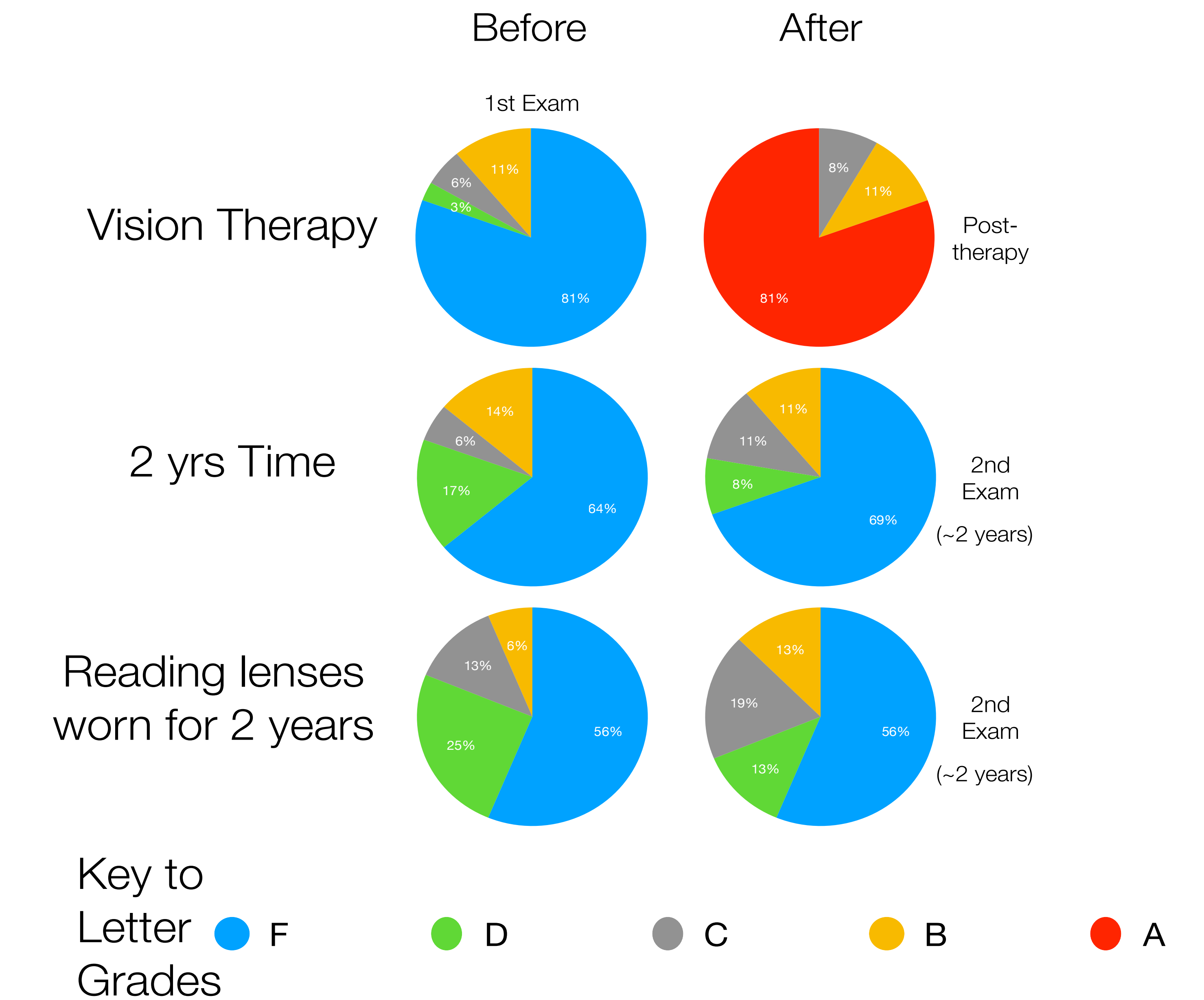


Figure 6. *Analogizing percentage of binocularity during waking hours using standard US grading system showing therapy, age-matched, and reading lens group grades at initial visit, then either post-therapy or at 2nd exam after 23 mo. Notice red limited to therapy group.*

visual defect rather than being secondary to other visual conditions.

Retrospective 4: A pilot study report on VO star changes with vision therapy

The original inspiration for data mining for this study was the VO star. The question posed was whether the VO star changes with improvements in binocularity. Preliminary data are presented only from the treatment group, suggesting that increasing binocularity increases VO star accuracy. However, a non-treatment comparison group is not available. Therefore, this preliminary report forms only a suggestion for further study.

The apical scatter of the VO star may well be only one small variable in the overall view of the VO star as a testing-therapy device. As described above, a crude measurement device (Figure 1) can give an idea about changes with therapy. Figure 7, panels 1 and 3 illustrate that measurement device for patient JG, one of the treatment group in this retrospective.

Panel 1 of Figure 7 shows the pre-therapy VO star, then panel 2 shows what that central apical scatter might represent in central perception, if the two sides are moved together to show the central vision overlap, as seen with a stereoscope. The bar at the top in panel 2 represents approximately the central 5 degrees of vision, generally considered to be central vision. Considering that the point of the VO star is to draw pencils together into the perceived middle of the central vision, this does suggest some disturbance of central visual sensation. Whether or not that shows central-peripheral issues is open to conjecture.

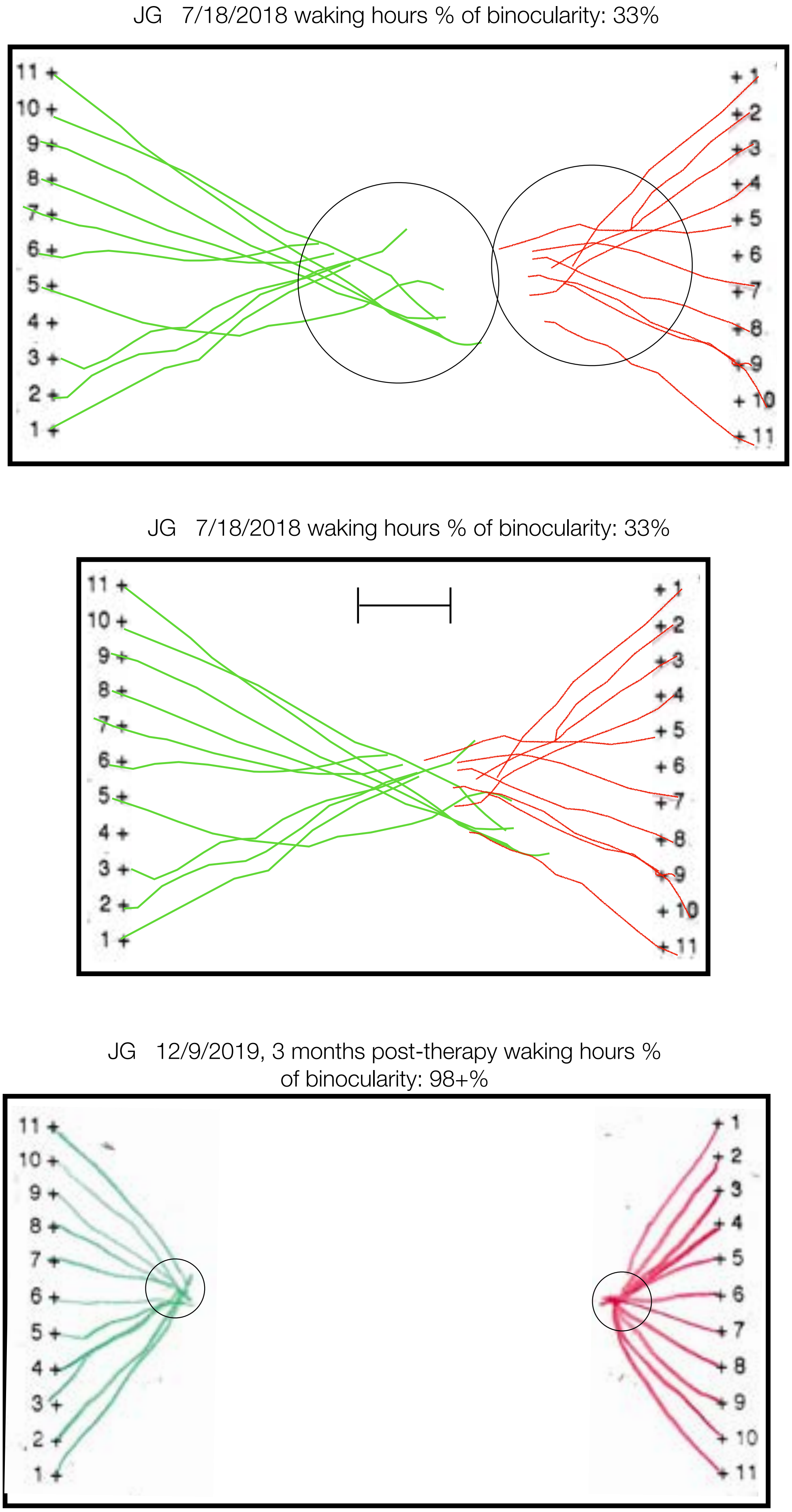


Figure 6. *VO star for patient JG (member of the treatment group) showing pre-therapy (33% binocularity) drawing with illustrative circles used to approximate central scatter (panel 1), and (panel 2) with the drawing collapsed to approximate bilateral central image (bar at the top is 5° marker for central vision). Panel 3 is post-therapy illustrating smaller scatter circles.*

Acknowledging the crudeness of measurement, and even the subjectivity of the measurement device, pre-therapy apical scatter in the therapy group averaged 3.6±1.1 cm for either side. In no way should this number be viewed as a standardization of apical scatter responses in an effort to suggest a VO star test for ICS. Rather, this is a measurement of a behavioral perception test in the presence of ICS and an effort to observe changes in that behavioral perception test with therapy for the ICS.

Post-therapy, the scatter measured 2.3±1.0 cm OD and 2.5±1.1 cm OS. A t-test shows those changes to be significant, $p<<0.00001$. Since in the same group, percentage of binocularity increased, this suggests that as binocularity increases, VO star spread decreases. A concept similar to scatter in ICS therapy has been used previously in looking at pistol marksmanship: accuracy and variability improved pre- to post-therapy in that case study as ICS decreased and binocularity improved. [26]

This pilot study information suggests that if a more accurate measurement device for VO star apical spread can be developed, and therapy and non-therapy age-matched groups set up, the VO star might provide a measurement tool for perceptual changes with therapy to decrease suppression and increase binocularity.

Conclusions

Four case-series retrospectives have been presented dealing with diagnosis and treatment of intermittent central suppression, ICS. These four retrospectives add together to make a more complete picture of ICS.

Recapitulating the attributes listed above, ICS is an intermittent, usually alternating loss of central visual sensation not associated with strabismus and amblyopia. The off (suppressed)-on (non-suppressed) cycle of ICS, often in a time frame of 2-3 seconds for each segment, means that testing must occur over enough time to see that off/on cycle. Quick screening tests do not effectively and reliably diagnose ICS, but dichoptic presentation sustained over time can. Very normal acuities and refractive status are associated with ICS.

ICS can be treated effectively with current technology and therapies. With treatment, quality-of-life scores, reading symptoms, and reading levels have improved. A calculation can be made to suggest that improved ICS means increased binocularity. That improved binocularity remains largely intact over (at least) a two-year period, and improved quality-of-life symptoms remain improved.

To those descriptors and attributes for ICS, we now add:

1. ICS diagnostic attributes are consistent, perhaps remarkably consistent, given that ICS testing is subjective, and many ICS patients are children.

When dichoptic presentation and questioning over time is used, the description of ICS as a repetitive, intermittent, usually alternating loss of central visual sensation with about a 2- to 3-second "off-on" suppressed/non-suppressed cycle stands as a good rule of thumb in diagnosis. By definition, ICS excludes strabismus and amblyopia. It also coexists with very normal refractive and acuity measurements. This again suggests that short screening tests, as well as acuity/refractive/health evaluations, are not only ineffective at diagnosing ICS, but given the link to reading issues, are diagnostically misleading when case history quality-of-life discussions suggest reading and school problems.

2. Vision therapy, including rapid alternate occlusion, is very effective at reducing ICS and increasing binocularity across 72 subjects over 8 years.

Prior studies have shown better reading and fewer symptoms with improved binocularity during waking hours. Case studies show improving binocularity associated with improved sports performance, shooting, and bricklaying.

3. Intermittent central suppression doesn't get better over time without therapy, even with lens use.

Two years with lenses or without lenses does not reduce the suppression. Reading lenses may aid binocularity a bit, but they do not significantly change the suppression. They certainly do not hurt, so unquestionably, they should be used for the other appropriate visual needs of the patient. One possible explanation for the minor improvement with reading lenses is that reading lenses may reduce fatigue. That suggestion should be explored since fatigue and its effect on fixational eye movements is an active area of research. Given the exceedingly low risk-to-potential-benefit ratio, doctors should not shy away from using appropriate reading lenses, even though improvement in binocularity as defined by reduced intermittent central suppression should not be the sole justification for their use. On the other hand, minimal/subclinical ICS that exhibits suppression periods less frequently than every 11 seconds (2 SD from average) may be a justification for reading lens use; increasing binocularity by a small amount might foster its clinical diagnostic disappearance. Presumably, that would be accompanied by a decrease in any ICS-related symptoms.

The assertion was made regarding students in the Job Corps study that they were young adults (average age almost 20 years) and therefore past the age where development could or should be considered a causative factor for improvements in any suppression. These current data should put to rest any thought that development was responsible for suppression improvements seen in that and in other treatment studies, and also possibly for the changes in symptoms and reading behavior shown in those studies through ICS treatment.

4. Treatment of intermittent central suppression and improvement in binocularity may aid central visual sensation, as demonstrated with a VO star stereoscopic drawing task.

This should also be studied, preferably with both a treatment and a non-treatment group that includes VO stars at the beginning and the end of therapy, as well as at the beginning and the end of a similar non-treatment period of time. Initial results are encouraging that accuracy and probably stability of central visual sensation and perception improve as binocularity improves.

5. ICS should be considered a successfully treatable primary, not secondary, visual defect.

References

1. Hussey ES. Intermittent central suppression: A missing link in reading problems? J Optom Vis Devel 1990;21:11-6.
2. Hussey ES. Temporal characteristics of intermittent central suppression. J Behav Optom 2002;13(6):149-52.
3. Hussey ES. Visibility, suppression, and implications for downstream visual development. Optom Vis Perf 2018;6(4):222-4.
4. Strauss RJ, Immerman AS. The relation of macular suppression and other normal binocular visual functions to reading underachievement. Rev Optom (Part I) 1964 Nov 15;101(22)31-34; (Part II) 1964 Dec 1;101(23):25-32; (Part III) 1964 Dec 15;101(24):27-34 (Part IV) 1965 Jan 1; 102(1):25-32.
5. Annapole L. Visual skills survey of dyslexic students. J Am Optom Assoc 1967;38(10):853-9.
6. Jaques L Sr. Synchronized Optometry. Monograph privately published, 1956.
7. Hussey ES. Remote treatment of intermittent central suppression improves quality of life measures. Optom 2012; 83(1):19-26.
8. Hussey ES. Percentage of binocularity through waking hours - Re-calculations and case studies. Accepted for publication. Optom Vis Perform 2021.
9. Hussey ES. What's Next? Long-term improvements from ICS therapy using rapid alternation. Accepted for publication. Optom Vis Perform 2021.
10. Bielschowsky A. Lectures on Motor Anomalies. Hanover: Dartmouth College Publications, 1943:32.
11. Hussey ES. Is anti-suppression the quest for visibility? Optom Vi Perform 2015;3(1):33-41.
12. Wiesel TN, Hubel DH. Single-cell responses in striate cortex of kittens deprived of vision in one eye. J Neurophysiol 1963;26:1003-17.
13. Hussey ES. Intermittent central suppression caused by cervical trauma (whiplash). J Behav Optom 1997;8(2):31-6.
14. Komatsu H. The neural mechanisms of filling-in. Nat Rev/ Neurosci 2006;7:220-31.
15. Zhou J, Wang Y, Feng L, Wang J, Hess RF. Straightening the eyes doesn't rebalance the brain. Front Hum Neurosci 2017;11:453. doi: 10.3389/fnhum.2017.00453.
16. Visual Skills Program. Instruction Manual. Van Orden Technique of Visual Rehabilitation. Available from https://www.keystoneview.com/wp-content/uploads/2018/10/6104_van_orden.pdf Last Accessed April 16, 2020.
17. Hussey ES. Examination of binocular sensation over time with routine testing. J Behav Optom 2000;11(2):31-4.
18. Harris P. The prevalence of visual conditions in a population of juvenile delinquents. OEPF Curriculum II, January 1989;61(4):1-10.
19. Kaplan M, Lydon CM. The Van Orden star: A window into personal space. J Optometric Vis Devel 2002;(33):21-8.
20. Wang P, Cottrell GW. Central and peripheral vision for scene recognition: A neurocomputational modeling exploration. J Vis 2017(4):9:1-22.
21. Greschner M, Bongard M, Rujan P, Ammermuller J. Retinal ganglion cell synchronization by fixational eye movements improves feature estimation. Nat Neurosc 2002;5:341-7.
22. Di Stasi LL, McCamy MB, Catena A, Macknik SL, et al. Microsaccade and drift dynamics reflect mental fatigue. Eur J Neurosci 2013. Available from http://bit.ly/36DyWNL Last Accessed October 29, 2021.
23. Hussey ES. Intermittent central suppression suffered after a rough landing on a bicycle. Optom Vis Perf 2017;5(4):153-7.
24. Hussey ES. Binocular visual sensation in reading: A unified theory. J Behav Optom 2001;12(5):119-26.
25. Olivares M. The American Grading System from A to F and GPA. Available from https://www.mooxye.com/blog/en/american-grading-system-and-gpa/ Last Accessed April 28, 2020.
26. Hussey ES. Correcting intermittent central suppression improves binocular marksmanship. J Military Med 2007;172(4):414-7.

Correspondence regarding this article should be emailed to Eric Hussey, OD at spacegoggle@icloud.com

Hussey E. Suppression doesn't just go away, but treatment might change a VO star—Case series retrospectives. Optom Vis Perf 2021;9(4):204-17.