INTERMITTENT CENTRAL SUPPRESSION: A missing link in reading problems?

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ABSTRACT: Past research on the possible role of suppression in reading problems is contradictory. Some confusion may stem from the assumption that strabismic and non-strabismic suppression are the same and may be diagnosed using the same tests.

This study tested for Intermittent Central Suppression (ICS) using the Worth 4-dot, the Jampolsky 4-prism test and Wirt stereopsis. The responses on these tests were compared to the reference criterion of an intermittent suppression response on vectographic binocular refraction. These suppression tests showed significantly different results in their diagnosis of ICS. Use of different tests may, therefore, help explain the confusion in the literature on suppression and reading.

Characteristics of ICS and of intermittent suppressors were explored. ICS has been implicated in reading problems, and these data strongly suggest a distance refraction and acuities cannot provide the information necessary to comment on possible visual causes for a reading problem.

KEY WORDS: Suppression, intermittent central suppression, reading problems, dyslexia, binocularity.

INTRODUCTION

Much work has been done searching for a link between vision problems and reading problems. Certainly, a strong case can be made that ocular motor malfunctions can affect reading efficiency. The picture in the literature of sensory malfunction, and specifically suppression and reading, is less clear. Does suppression, or does it not, affect reading? Further, does the type of suppression, constant or intermittent, make a difference in the effect on reading?

Some opinions suggest a disruption of continuous normal vision by an intermittent suppression should negatively affect reading. Other studies, sometimes blurring the division between non-strabismic suppression and the constant suppression of strabismus and amblyopia, suggest no link. Further obscuring the picture of sensory malfunction (suppression) and reading is the myriad of tests used to operationally define suppression in those studies. The apparent assumption is that strabismic and non-strabismic suppression are the same and can be diagnosed using the same tests. In order to answer the questions about suppression and reading, we first have to answer the question of whether the tests used in the literature are equivalent. Can varying results of different suppression tests help explain the discrepancies in opinion in the literature?

Strauss and Immerman found the most direct link of suppression to reading, finding a significant number of students with reading problems also had "macular suppression." Macular suppression was defined as "an involuntary, temporary suspension of vision in one or both eyes..." in non-strabismic/non-amblyopic persons. Renaming this condition Intermittent Central Suppression (ICS) removes a questionable anatomical basis.

The clinical implication of Strauss and Immerman's study is that intermittent central suppression (ICS) in non-strabis-
mic/non-amblyopic patients must be considered suspect in the search for a visual cause for reading problems. Certainly ICS deserves exploration in patients who complain of reading problems. However, the same question of relative effectiveness of common suppression tests that may be clouding the literature may also be responsible for errors in clinical diagnosis. Treatment, as well as evaluation of treatment of vision/reading problems, depends on accurate diagnosis. Is accurate diagnosis of ICS prevented by suppression tests that differ in their diagnostic effectiveness?

Using diagnosis of ICS with vectographic binocular refraction as a reference diagnostic criterion, this study will test the hypothesis that suppression tests used in the literature and used clinically vary in their results when used to diagnose intermittent suppression. Again, this has implications not only clinically, but in evaluation of the literature on suppression and reading.

In addition, the possibility that other visual characteristics may provide clues to the presence of ICS will be explored through refractive data from the group. No attempt will be made to conduct a large random population study to determine possible false positives in the diagnosis of ICS; or perhaps more precisely, how much, if any, intermittent central suppression may be considered clinically insignificant.

SUBJECTS

Sixty subjects were evaluated, all patients in a private optometric practice. Each had a normal, negative eye health examination, no positive history of head trauma, and were non-strabismic and non-amblyopic.

Subjects were chosen at random from those patients who showed ICS while viewing projected vectographic targets (American Optical Project-O-Chart) during a standard refraction procedure. All examination patients in the practice who could respond to a full refraction procedure received a vectographic examination. Each was asked if any of the vectographic targets repeatedly “disappeared” or were “erased” and then returned.

Those who showed an intermittent suppression also received the Wirt dot, Worth and Jampolsky tests as described below. The bisected diamond test (below) was part of the routine examination refraction procedure. The first sixty patients who responded to all the above tests were the subjects for this study. No attempt was made to choose patients who complained of reading problems, although on retrospective analysis, 40(66.7%) of the subjects specifically complained of reading problems during the patient interview.

Subjects ranged in age from 6 to 33 years with a mean age of 10.3. Forty-nine of the 60 subjects (82%) were grade school age, under 13 years.

METHODS

The results of suppression tests possibly used for diagnosing ICS need to be compared. However, simply comparing test results where no diagnostic criteria for ICS exist may only show the tests agree or disagree in diagnosing an unknown, but suspected, condition. Clinicians could then be left in the position of administering a huge battery of suppression tests to be minimally sure of an ICS diagnosis. Picking a reference diagnostic criterion for this study, as far above reproach as possible, allows the study group to be defined as a group of suppressors. The tests can then be given to the group defined as having ICS and the test results and effectiveness compared.

Stereoscope skills testing, the Worth 4-dot, color luster, the Jampolsky 4-prism test, vectographic ductions, stereopsis, vectographic binocular refraction, and other tests have all been used to test for or comment on suppression. Out of these, vectographic binocular refraction at 6 meters was chosen as a reference criterion for four reasons: First, it is non-rivalrous. Second, vectographic refraction provides an absolutely routine ICS diagnostic tool without the need for extra or special testing. Third, if we have defined ICS as a temporary suspension of vision, we can agree that this is, indeed, a suppression as the patient announces targets disappearing and returning. The importance of this is that in the absence of one test that is considered the clinical definition of the condition, the next best test is one that, by the nature of the response, assures general agreement that the condition is present. Whether the test identifies all cases of ICS is a separate consideration, probably best answered by further studies of ICS. The clinical advantage of the patient reporting the target disappearing is the ease with which a parent can witness the problem. Fourth, retest reliability is good. Thirty-four of the subjects from this study were later routinely re-examined and all showed suppression on vectographic testing at the second examination.

Other tests for intermittent suppression were compared to vectographic testing. These included (a) Wirt dot stereopsis, (b) Worth 4-dot at 50cm, including (c) color luster, and (d) the Jampolsky 4-prism test at 0.4 and 5 meters. The Wirt dot stereopsis test required patients to point to the closest dot of each set with the test card held at a normal reading distance. For the Worth 4-dot test, patients were asked how many lights were present and if that number ever changed. Presence of color luster was determined by questioning while the patients watched the lights, and any changes in luster while continuing to watch were noted. The Jampolsky 4-prism test was carried out somewhat deliberately, with the four dioptric prism held in front of each eye for three to five seconds while watching for any late eye movements in response to the introduction of the prism.

In addition, preliminary results are reported on a new ICS test: (e) a post-near duction questioning for suppression using a Borish near point vectographic test card at 40cm, modified by the addition of two polaroid filters over the diamond target (figure 1). After taking three sets of near ductions, the rotary prisms were removed and the patients were asked to simply watch the diamond target with both eyes open and report if and when either side of the target went completely black, obscuring the letters beneath the polaroid filters. Near testing (40cm), including the bisected diamond test, routinely preceded the distance vectographic refraction with its ICS reference diagnosis in this procedure.

Bedwell’s duction suppression test and the Spache binocular reading test were excluded from this study. The former proved useless, producing only patient confusion; the latter has been shown unreliable elsewhere.

Patient reporting was used to determine (f) a frequency and duration of the suppression periods (30 to 90 second timing) and (g) the relative frequencies of alternating and monocular suppressions. Other visual data tabulated were (h) corrected visual acuities, (i) refractive errors, (j) Pierce Saccade Test scores, and (k) ±2.00 dioptric bilateral refractor accommodative facility (pass/fail). In addition to providing possible referral criteria for suspected ICS cases, these data may help build an ICS patient profile that would aid clinicians in differentiating ICS from other conditions such as the suppression of intermittent or alternating strabismus.
RESULTS

Relative diagnostic effectiveness of the five possible suppression tests is shown in Figure 2.

a. Seven (11.7%) subjects scored less than 9 (40 arcseconds) on the Titmus Worth dot test. The Test of

Diagnosis of Intermittent Central Suppression:
Commonly used tests compared to vectographic refraction
n = 60 subjects

Proportions shows this is significantly different from the reference criterion (z=9.74, p<0.01). In this group stereopsis did not effectively diagnose ICS.

b. Eight (13.3%) subjects showed a suppression (loss of lights) with the Worth 4-dot at 50cm. This is significantly different from the reference (z=9.58, p<0.01). ICS was not effectively diagnosed by the Worth 4-dot. (A smaller ICS group was tested at 3.5 meters with the Worth 4-dot showing 19% suppression responses.)

c. Including any color luster abnormalities noted with the Worth 4-dot diagnosed an additional 17 subjects for a total of 24 (41.7%). This is significantly different from the reference (z=7.03, p<0.01).

d. Seventeen (28.3%) of the ICS subjects showed a definite suppression response with the Jampolsky 4-prism test. This is significantly different from the reference (z=8.19, p<0.01). Considering any questionable responses (slow or late vergence movements after introduction of the prism) to be a suppression response diagnosed an additional 10 ICS patients for a total of 45% of the 60 subjects. This is significantly different from the reference (z=6.75, p<0.01).

e. The new bisected diamond test diagnosed 58 (96.7%) of the 60 ICS patients. This is not significantly different from the reference (z=1.43, p>0.10) indicating the two tests diagnosed the same populations and therefore the same condition.

Table 1 (following page) shows inter-test correlations for these suppression tests using phi coefficients. Note that only the Worth 4-dot (loss of lights) and the Worth test including luster anomalies correlate more than weakly.

f. Figure 3 (following page) shows duration and frequency of suppression periods in ICS. A typical intermittent central suppression would be two to five
Phi Coefficients between Common Suppression Tests

<table>
<thead>
<tr>
<th></th>
<th>Worth 4-dot with luster anomalies</th>
<th>Worth 4-dot loss of lights</th>
<th>Wirt stereopsis &lt;40 arcsec</th>
<th>4° including questionable responses</th>
<th>4° including questionable responses</th>
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<td>diamond</td>
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Phi Coefficients between Common Suppression Tests

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<th>Refractive Error</th>
<th>Eyes</th>
<th>Percent</th>
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<td>70</td>
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<td>Cyl. ≤ -1.00 D.C.</td>
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<td>18</td>
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<tr>
<td>Cyl. ≤ -1.00 D.C.</td>
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<tr>
<td>Sphere or Cylinder</td>
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<td>12</td>
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<td>&gt; ±1.00 D.</td>
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TABLE 1

Average Duration of Suppression

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<th>20%</th>
<th>10%</th>
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<td>3 to 4 &lt; 5</td>
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<tr>
<td>4 to 5 or more</td>
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Average Frequency of Suppression

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<th></th>
<th>60%</th>
<th>50%</th>
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<th>30%</th>
<th>20%</th>
<th>10%</th>
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<tr>
<td>2 to 3 &lt; 4</td>
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<td>3 to 4 &lt; 5</td>
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FIGURE 3

Subjective Refractive Error

j. This group of ICS patients showed a tendency toward eye movement deficiencies and accommodative infacility. Thirty-seven (61.7%) tested either 1 standard deviation slow or 1 year low in accuracy on the Pierce Saccade Test.

k. Forty-two (70%) failed the accommodative rock. Twenty-four (40%) showed both accommodative and eye movement deficiencies on these tests.

DISCUSSION

These data can help explain how different studies can explore the relationship between suppression and reading and produce contradictory results: the studies have used different suppression tests or have not differentiated ICS from constant suppression. The low inter-test correlations from Table 1 cast doubt on the validity and usefulness of the Wirt, Worth, and Jampolsky tests in diagnosing ICS. If the reference criterion (suppression on vectorographic refraction, the operational definition of ICS in this study) were chosen in error, other recognized suppression tests should still show some level of agreement in their diagnosis—as vectorographic refraction and the bisected diamond agree (z-score). No agreement with the reference (z-score) and no agreement with each other (phi) rejects Wirt dot stereopsis, the Worth 4-dot, and the Jampolsky 4-prism tests as intermittent suppression tests in non-strabismic/non-ambyliopic patients. Any study on suppression and reading that uses these strabismus suppression tests would likely find that suppression affects reading very little.

The intermittency of ICS may frustrate attempts at diagnosis with a quick screening test. For example, the timing and speed
of a 4-prism test might determine whether 1) the suppression is detected, 2) a delayed vergence response is seen as binocularity resumes, or 3) a normal response is seen. Perhaps a test protocol difference of this type might explain the contradictory results of Norm and Bettman, et al. with dyslexics. Other studies might research changes in protocol for each of these strabismus suppression tests to make them more usable in testing for ICS. These findings say nothing regarding the tests' well established usefulness in strabismus and amblyopia.

In this group of suppressors, ICS exists concurrently with normal refractive findings, acuities, and stereopsis. This suggests two things. First, a simple distance refraction can't be used to comment on suppression or reading problems related to vision. Second, the impact of minimal hyperopic corrections on the visual system should be investigated. A causal relationship should be explored, or possibly an at-risk group defined among those presently considered visually normal.

Seventy-seven percent of these intermittent suppressors failed either accommodative facility or saccade testing. These tests could provide a referral criterion for clinicians not involved in therapy, or possibly for screenings. Certainly combined with the knowledge that intermittent suppressors tend to complain about reading, a strong case for referral to a developmental optometrist for complete testing could be made. Special care should be taken to not dismiss a reading complaint in the presence of normal acuity. Forty-one (68.3%) complained of reading problems, blur or discomfort, but showed acuities of 20/25 or better. The implications of these data for school screenings will become more important as the effects of intermittent central suppression on reading and perception are investigated more fully.

An unknown in the detection of intermittent central suppression is the effect of fatigue. In the refraction procedure for this study, near testing (and thereby some fatigue) preceded the distance refraction where the reference diagnosis of ICS was made. The Wirt-dot, Worth, and 4-prism tests were given after all other testing, which should have maximized any fatigue effects. If fatigue is a factor, the fatigue from repeat near vergences appears to be enough to elicit a suppression with the bisected diamond test.

Is it possible intermittent central suppression as further defined by these data can help explain, or aid interpretation of, findings in the literature on vision and reading? For example, visual confusion is a consistent symptom in studies of reading problems. Mower states, and is supported by some of the findings of Schilder and Vellutino et al., that when impaired readers are placed in a forced-choice situation in reading words, they make the necessary substitutions and reversals of letters to construct acceptable words, violating rules for correctly decoding words. ICS may contribute to visual confusion, resulting in a forced-choice situation.

One possible explanation for the visual confusion is that ICS might impair contour detection and resolution. A purely mechanical explanation might be that the suppression of one eye's central field allows a minor vergence fluctuation, causing a non-registered aiming error. Then, as the suppression left and binocularity returned, diplopia and super-position of letters would occur. A correctional vergence movement would follow.
the whole process to be repeated in another 3 seconds or so. Visual confusion would occur as the patient becomes binocular, before and during the correcting vergence movement. Since this would randomly affect specific words while reading, this may help explain why parents complain their child will read a particular word differently each time it appears. In fact, ICS may make the word look different each time he sees it.

If accurate, this model could affect the conclusions drawn about poor readers in tachistoscope studies, if a constant perceptual problem, such as a constant mirror vision were present, tachistoscopic presentation shouldn’t necessarily make a difference in perception. However, individual cases have shown facilitation of recognition of simple isolated words, letters, and digits, by the tachistoscope. The short tachistoscope time may randomly select out the visual confusion period theorized.

CONCLUSION

Certainly these findings only begin to clarify our understanding of intermittent central suppression. However, they provide some guidelines for both clinicians and scientists.

Clinicians should understand that the simple distance refraction of a child with reading problems often seen in the literature will not yield the information necessary to comment on possible visual causes for that reading problem. Even if extra testing is done to try to find a reading related vision problem, care must be taken to test thoroughly for intermittent central suppression, using valid tests and understanding the intermittency of ICS.

This same care in choosing tests should be taken in research. This implies the conclusions of Norn, et al., Park, Bedwell, et al., Bishop, et al., Schor and Svag, Bettman, et al., Norn, and Aasved that suppression is not related to reading, may be invalid, incorrect, or should at least be modified to be specific for type of suppression and diagnostic criteria. Yet to be firmly established is whether ICS directly causes reading problems. However, if we exclude the above studies as having used questionable techniques, and re-evaluate the literature on suppression and reading, the literature supports intermittent central suppression (ICS) as a probable cause of reading problems.

ICS patients tend to show accommodative and eye movement problems, as do poor readers. These three, ICS, accommodative infacility, and slow, inaccurate eye movements, may form the foundation of a quantifiable visual syndrome that affects reading. Accommodative and eye movement normative tests can, and have, helped identify patients with these visual problems that affect reading. But, because of invalid testing, intermittent central suppression may have been a missing link in the diagnosis and remediation of reading problems.

REFERENCES