<u>EFFECTS OF HIGH FREQUENCY FILTERING ON VISUAL SEARCH IN READING DISABLED CHILDREN</u>

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# EFFECTS OF HIGH FREQUENCY FILTERING ON VISUAL SEARCH IN READING DISABLED CHILDREN

Recent experimental evidence has described the existence of two parallel visual subsystems which operate from the retina to the visual cortex,[1] the sustained system and the transient system. The primary function of the sustained system is to transmit detailed information about the visual stimulus. It functions predominantly as a pattern detection system. The sustained system is most sensitive to stationary stimuli. It is a high acuity, high spatial and low temporal frequency system. It responds throughout the stimulus presentation and continues its activity after removal of the stimulus, producing a significant persistence effect, thus the name sustained system. The sustained system is most important in visual acuity and color vision.[2] The sustained system seems to be best designed for the identification of patterns, resolution of fine detail and the perception of color.[3,4,5,6]

The transient system transmits general information about stimulus change. It is primarily a flicker or motion detection system and is most sensitive to low spatial and high temporal frequencies. The transient system is thought to be involved in the perception of motion and depth, brightness discrimination, the control of eye movements and the localization of targets in space and seems to function to accomplish a quick global analysis of a visual scene.[2-6]

Although the two subsystems operate in parallel, it is believed that the transient system has temporal precedence. It operates preattentively and functions as an early warning system. It performs a globlal analysis of the incoming stimulus, parsing the field into units and regions and coding the position and movement of objects in space. The transient system may function to direct the sustained system to particularly salient areas where it might be most efficacious to perform a more detailed analysis of the shape and color of objects. The functioning of the sustained system, then, would depend to a degree on the prior output of the transient system.[7]

The two systems can also mutually inhibit each other.[1] However, transient on sustained inhibition is more common. Transient system response from eye movements would inhibit the continuing sustained system response, reducing the duration of the stimulus visible persistence. This termination the sustained response allows the visual system to separate the information extracted from successive fixations. The activation of the transient system after each saccadic eye movement exerts inhibition of the persisting sustained system activity generated during the preceding fixation. The resultant response is a stable, distinct flow of visual input.[3,8] The transient system has a major function in reading tasks requiring eye movements. Transient channels, stimulated by eye movements, diminish the trailing visible persistence of the sustained channels from the previous fixation.

Lovegrove and associates have indentified a transient system deficit in subjects with specific reading disablility.[9-17] They have shown visual processing differences between normal and disabled readers to be evident when transient system processing is involved, but fail to surface under sustained processing conditions. For example, disabled readers are less sensitive than normal readers to low spatial frequencies, but equally or more sensitive to high spatial frequencies.[11,14,18] Additionally, disabled readers show lower overall temporal sensitivity and a different pattern of temporal processing across spatial frequencies,[1] but these temporal processing differences between normal and disabled readers disappear when transient system activity is reduced.[16] These findings indicate that disabled readers have a deficient transient system. Measures of sustained channel processing did not differ between normal and disabled readers, suggesting that the sustained system is intact.[9,20]

In the presence of a transient system deficit, significant masking effects would be evident, rendering the reading process inefficient and confusing. Sustained channel activity is generated during each fixation interval of a fixation-saccade sequence in reading. Due to the long response persistence of sustained channels, this sustained channel activity could interfere, via forward masking by integration, with the sustained activity generated during the following fixation. The finding that disabled readers show longer visual integration times suggests that this masking effect may be more severe in the disabled readers than in normal readers.[3,8,21,22]

When the two systems are operating in a concordant manner, the global precedence of the transient system information allows the subject to perceive a framework and background from which sustaind input can be properly selected, interpreted and integrated.[9-17] Given what is known of the perceptual functions that the transient system performs, it is reasonable to expect that children with a reading disablilty stemming from transient malfunction would show deficits in global, preattentive processing operations and on tasks requiring fine temporal resolution.[7]

A transient system deficit should have its greatest impact on reading tasks that require eye movements.[8] Williams and LeCluyse have demonstrated the differential impact of eye movements in the reading comprehension of disabled readers.

Reading comprehension was reduced when passages of text were displayed line by line, as opposed to single word presentation. This suggests that the demand for eye movements in the reading task has a detrimental effect on reading comprehension in disabled readers.[7] They found that normal readers performed the same when reading without eye movements, with free eye movements and with guided eye movements.

Performance was also measured under blurred conditions to evaluate the contribution of high spatial frequency/sustained system information. In normal readers, blurred image performance deteriorated as eye movement control became more difficult. Disabled readers showed the opposite trend. Under blurred conditions, performance improved in free eye movement condition, demonstrating a beneficial effect of image blurring. Blur was also found to increase the reading rate and decrease the span of apprehension (number of characters processed in each fixation) of disabled readers. No change was found in the single word presentation because transient system function is not a significant factor under these conditions.[8] The dramatic effect of image blurring on visual search and reading performance of disabled readers is believed to be due to the selective diminishing of the contrast of high spatial frequencies and the resultant decrease in the amplitude of the sustained components of a visual response, and as a result, re-establish the normal temporal interaction between sustained system and poorly functioning transient system in disabled readers.[7]

Estimates of the prevalence of reading disablilty in school-age children range from 4% to 15%. Lovegrove and assoc. found over 75% of the specifically reading-disabled studied manifested a transient system deficit.[13] Although research has defined the differences between the transient and sustained systems and described the results of a transient system deficit, there is a need for a practical way to identify reading disabled children with a transient system deficiency. The Developmental Eye Movement (DEM) test will be used as a possible way a identifying transient system deficiency. This test assesses the function of the oculomotor system in an envirionment that simulates reading, but in the absence of significant cognitive loading. It includes a comparison of the differences in time scores with and without horizontal eye movements. The DEM will be administered to a sample of twenty-three children, grades two and three, defined as reading disabled by their school system. The DEM will be administered to each child twice, once under standard conditions and a second time under filtered conditions. A high frequency filter will be used. In order to avoid the effect of improved performance with learning, it will be alternated which method of administration will be given first. A comparison between DEM scores with and without the filter will be made to determine the effects of high frequency filtering on visual search. A significantly improved score under filtered conditions would be indicative of a transient system deficit.

## RESULTS

### Horizontal Time

The horizontal time recorded when adminstering the Developmental Eye Movement test is the time required to read the horizontal arrangement of numbers adjusted for the errors made. The mean horizontal time on the DEM without the filter was 76.12 seconds. The range was from 42 to 109.2 seconds with a standard deviation of 23.598. The mean time with the filter was 73.94 seconds. The range was from 47 to 113.8 seconds with a standard deviation of 27.73 seconds. The Sign test of differences between means showed time required with the filter to be significantly lower than without the filter.

### Ratio

The ratio score that is recorded when administering the DEM is the ratio between the adjusted horizontal time and the sum of the time required to read both vertical sub-tests. This is used to directly compare the vertical (automaticity) and horizontal (automaticity plus oculomotor control) test performance levels. Ratio scores significantly greater than the expected values suggest a greater difficulty in oculomotor control when horizontal eye movements are required.[23]

The mean ratio score without the filter in place was 1.64. The range was from 1 to 2.5 with a standard deviation of .436. The mean ratio with the filter in place was 1.58. The range was from 1.13 to 3.15 with a standard deviation of .435. The differences in the means was not significant according to the Sign test.

**Errors**

There were no errors made on the vertical component of the DEM. Mean errors made on the horizontal component without the use of the filter was 9.35. The range was from 0 to 29 with a standard deviation of 8.39. The mean errors with the filter in place was reduced to 5.83. The range was 0 to 21 with a standard deviation of 7.13. The difference between the two means was not significant according to the Sign test.

**DISCUSSION**

Although the difference between use of the filter and no filter in mean horizontal time was the only difference found to be significant according to the Sign test, there is more to be gained from this study. Seventeen of the 23 students tested made fewer errors with the filter than without. Twelve of the 23 students tested scored lower ratios with the filter than without. Thirteen of the 23 students tested required less time to complete the horizontal portion of the DEM with the filter than without. Twelve students showed improvements in horizontal time, ratio and errors with the use of the filter.

It would appear as if filtering out the high frequency range improved the performance of several of the students tested. This suggests that these are the students with a transient system deficit. Previous studies have found as many as 75% of reading-disabled students to have a transient system deficiency. Using the criteria of improvement in horizontal time, ratio and errors, fifty-two percent of the students tested manifested signs of a transient system.

Comparison of the mean horizontal time of the transient system deficient students shows a 19.6 second reduction in the time required when the filter was used. Mean without the filter was 80.59 seconds, with the filter was 60.99 seconds. Mean ratio of the transient system deficient students was also reduced with the use of the filter. Mean ratio without the filter was 1.84 with the filter was 1.54. Finally, mean errors were greatly reduced with the use of the filter in the transient system deficient students. Mean errors without the filter was 12.42 and with the filter was 6.42. These statistics are believed to much more valuable than a comparison of the means of all the students tested. Analysis of the transient system deficient students' scores indicates that the DEM combined with the use of a filter is an effective way to detect transient system deficiency.

CONCLUSIONS

1. The Developmental Eye Movement test may be a good test to use clinically to determine the presence of a transient system deficit in reading disabled children. Use of a high frequency filter and comparison of the scores with and without the filter may be one way in which to do it. Among children who exhibited improvements in horizontal time, ratio and errors there were large differences with and without the use of a filter.

2. Specific criteria would have to be determined which would be used to determine whether any differences in DEM scores with and without the use of a filter are clinically significant. For instance, are improvements required in horizontal time, ratio and errors or is any one score more significant than the others? Future studies should address this question.

3. Finally, if the DEM could be used to detect transient system

deficits, what would be the indicated therapy for children with transient system deficits?

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