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Final Technical Report

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PROJECT IDENTIFICATION INFORMATION

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Final Grant Report
to
NASA Johnson Space Center

This report summarizes the results of a grant from NASA Johnson Space Center to David S. Loshin, O.D., Ph.D. of the University of Houston College of Optometry. The grant spanned over a four year period and was a continuation of a collaboration between Dr. Loshin and Dr. Richard Juday of NASA JSC. The bulk of this research was to design and determine the potential of the Programmable Remapper (PR) as a device to enhance vision for the visually handicapped. The Programmable Remapper was originally developed at NASA JSC to supplement autonomous docking of the shuttle with the future space station. The PR redistributes video input information into a new coordinate system at video rates; the new coordinate system is completely flexible as long as it may be defined mathematically.

Many ocular diseases may result in non-function regions of the retina of the eye. These regions are commonly called a visual field defects. For diseases such as macular degeneration, the field defect or scotoma is located in the central retina or the most sensitive portion of the retina. Patients thus experience difficulty with reading, facial recognition, driving, and localization of objects. For diseases that effect the peripheral retina (e.g. retinitis pigmentosa) difficulty with mobility and night vision loss is a common complaint. The premise for the use of the PR as a low vision device was that information lost in the non-functioning retina could be redistributed to functioning retina by altering the coordinate system of the image displaced on a video screen.

The bulk of the funds from this grant supported two graduate students at the University of Houston. The research from the resulting thesis's (abstracts are attached and complete thesis's are available at the University of Houston College of Optometry library) investigated potential of the PR as a low vision device to aid patients with central field defects. Dr. Janice Wensveen's thesis, *Reading rates with simulated central scotomata*, investigated reading rate with simulated field defects with and without remapped images. Her conclusion was that "Although reading rates only increased slightly with radial eccentric remapping, algorithms producing less distortion or remapped print may improve reading rate".

Dr. Jenny Ho-Fan continued this research with patients with actual central retinal defects. Her thesis, *Reading rates of patients with central scotomas with electronic remapping*, investigated reading rates using several remapping algorithms under stabilized and unstabilized conditions. Her conclusion indicated that remapping did not assist reading with conventional viewing, however, if remapping could be used in conjunction with natural eye movements, there is a potential in developing remapping that will assist reading with central scotomas.

This research indicated that remapping would have potential as a low vision device if the eye position could be monitored with feedback to specify the proper location of the remapped image. This must be accomplished at high rate so that there is no lag of the image behind the eye position. Since at this time, there is no portable eye monitor device (at a reasonable cost) that will operate under the required conditions, it would not be feasible to continue with remapping experiments for patients with central field defects. However, since patients with peripheral field defects do not have the same eye positioning requirements, they may indeed benefit from this technology. Further investigations must be performed to determine plausibility of this application of remapping.

Listed are additional publications and presentations resulting from the grant.

Ho JS, Loshin DS, Barton RS, Juday RD (1995) *Testing of remapping for reading enhancement for patients with central visual field losses*. Proceedings of the SPIE.

Weensveen JM, Bedell HE, Loshin DS (1995) *Reading rate with artificial central scotomata with and without spatial remapping of print*. AM J Optom Physiol Opt 72(2); 100-114.

Juday RD, Barton RS, Johnson CD, Loshin DS (1994) *Conformal and other image warpings for reading with field defects*. Proceedings of SPIE(2239); 92-102.

Loshin DS, Weensween JM, Juday RD, Barton RS (1993) *Design of a reading test for low vision image warping*. Proceedings of the SPIE(1706); 67-72.

Juday RD, Smith AT, Loshin DS (1992) *Human low vision image warping: channel matching considerations*. Proceedings of the SPIE(1705); 304-313.

Attached are sample related articles supporting this research.

Abstract

Jenny Ho-Fen

Patients with central field defect experience difficulty in visual tasks such as reading. The purpose of this study was to investigate whether electronic remapping of reading material around the central scotomas of patients with Age Related Macular Degeneration (ARMD) and Juvenile Macular Degeneration (JMD) improves reading rates. Reading rates were measured in five ARMD patients, ages 66 to 84, and one JMD patient, age 35. The subjects read aloud random words of equal difficulty on a Closed Circuit Television (CCTV) screen by manually scrolling the words across the screen. Reading rates of nonremapped words and remapped words were compared under three viewing conditions:

- 1) Reading without stabilization under free viewing conditions.
- 2) Reading with image stabilization through the eye tracker.
- 3) Reading without image stabilization through the eye tracker.

The following results were obtained:

- 1) Under the nonstabilized conditions, reading rates of nonremapped words were significantly faster than 'Gausflow' and 'Radial Eccentric' remapped words.
- 2) Reading rates of nonremapped words were not significantly different from 'Gausflow' remapped words and 'Radial Eccentric' remapped words under the stabilized condition.
- 3) Stabilization of the image and reduction of the field of view reduced reading rates of nonremapped words and 'Gausflow' remapped words.
- 4) Reading rates of 'Radial Eccentric' remapped words were not significantly different in the three viewing conditions.

Remapping does not assist in reading with the conventional CCTV method. Stabilization of the image caused an unnatural viewing condition, slowing reading rates of both nonremapped words and 'Gausflow' remapped words. If on-line remapping is employed in conjunction with natural eye movements so that remapping of the image corresponds to the position of gaze, there is potential in developing remapping that will assist in reading with central scotomas.

ABSTRACT

Janice Wensveen

People with central scotomata due to Age Related Macular Degeneration read very slowly. The aim of this study was to determine the effect on reading rate of letter size and presentation duration in subjects with simulated central scotomata. After establishing the optimal letter size and presentation duration for different sizes of scotomata, the effect of remapping the letters to areas surrounding the scotoma was determined.

Central scotomata of 2, 4, and 8 degrees were simulated in the normally sighted right eye of 4 college age observers and in 6 over-60 yr old observers using the SRI dual-Purkinje Eyetracker. Stabilization of the entire field made it impossible for the observer to move the scotoma off of the target words, thereby simulating reading in patients who have central scotomata and do not eccentrically fixate. Reading was assessed for randomly selected 3, 4, 5, and 6 letter words which observers read aloud from a 30 second string. To simulate the fixations and saccades made during normal reading, the word string was presented for a fixed duration (typically 250 msec), followed by a blank interval of 50 msec during which the string was advanced by a fixed number of character spaces. By increasing the number of character spaces jumped during blank intervals, the reading rate was determined that corresponded to 80% correct word identification. In one experiment, subjects read with letter sizes between 0.5 and 5.5 degrees. In another experiment, words of the optimal letter size were presented for a duration of 175, 250, 375, or 500 msec. Finally, reading rates were compared with and without

radial eccentric remapping that exposed 40% and 80% of the text obscured by the 4 and 8 degree scotomata.

Maximum reading rates with no scotoma were about 100 words per minute slower than reported previously for nonstabilized text. The letter size at which the maximum reading speed occurred increased with the size of the scotoma for both age groups, from 1.5 degrees with no scotoma, to 4.5 degrees with the 8 degree scotoma. Reading rates were maximal for presentation durations shorter than 250 msec and declined for longer durations. Remapping slightly but significantly increased reading rates for both the 4 and 8 degree scotomata. Elderly observers read consistently slower than younger observers by about 30 words per minute. The idiosyncratic nystagmus that occurred when subjects read was unrelated to reading rate.

Even with the optimal letter size, maximal reading rates with a scotoma did not approach reading rates without a scotoma. Factors other than spatial scaling must contribute to the lower maximal reading rates observed. Although reading rates only increased slightly with radial eccentric remapping, algorithms producing less distortion of remapped print may improve reading rates more dramatically.