A Contrast Polarity Search Effect in Letter Identification

Lauren Scharff *lauren.scharff@usafa.edu*
Albert Ahumada *al.ahumada@nasa.gov*

Introduction

Scharff and Ahumada (2002, 2003abc) measured text legibility for light text and dark text. For paragraph scanning and letter identification, performance was better for dark text than light text when we equate Weber contrast (the difference between text and background luminance divided by the background luminance). In recent studies with better stimulus control (Scharff & Ahumada, 2005; 2008), we continued to find a small, but consistent benefit of dark text for letter identification. Reading involves both scanning and identification. In the experiments below we replicate our scanning result with our improved apparatus and add scanning to our letter identification task by manipulating eccentricity.

Experiment 1: Scanning for Target Words

Stimuli: Blocks of 10 lines with 7 words each line (all words 6 letters in length). Full letter height was 0.2 deg. using TNR font. Position of the target word was randomized within each block with constraints: equal number of placements in each of six block sub-zones; never in outer ring of words.

Polarity and Weber Contrast: Positive and Negative contrast (0.1, 0.2, 0.4) on a background of 30 cd/m^2.

Task and Procedure: Find one of three target words: "course"," phrase"," smiled" and press the corresponding target-word key as quickly as possible. Participants given 2 practice trials with feedback, and 48 trials (8 each of the 6 conditions) with no feedback.

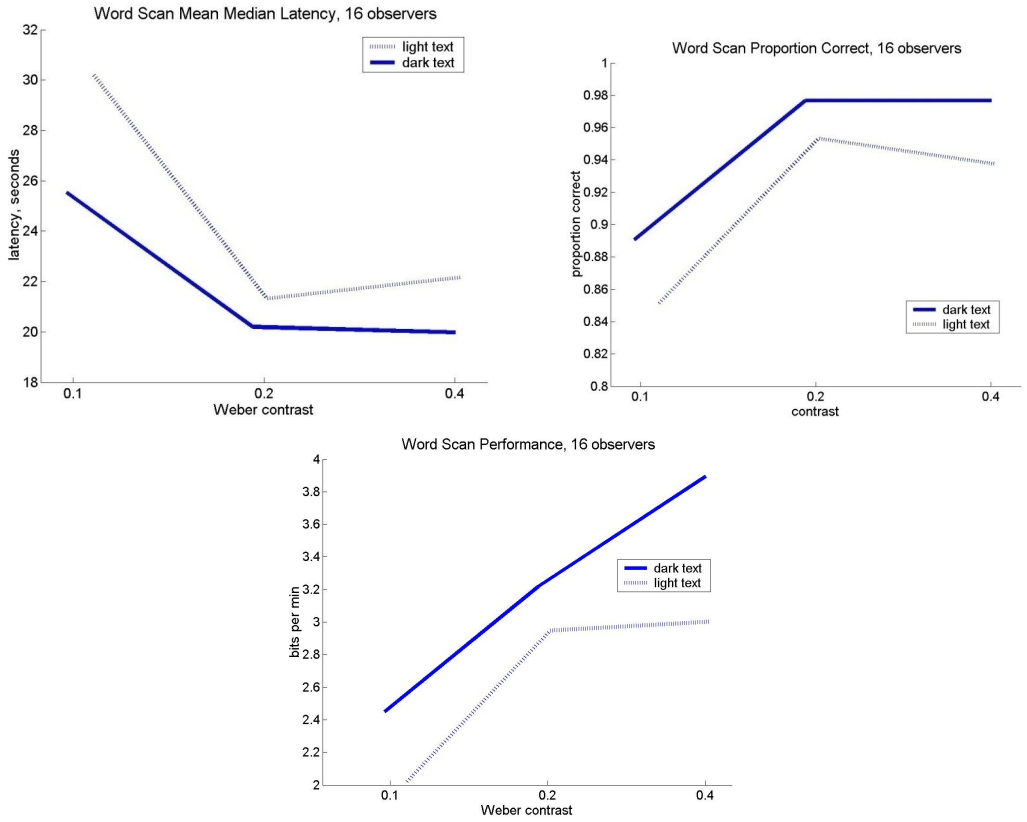

Figure 1: Observer performance for each of the six polarity and contrast conditions (N=16): mean proportion correct over replications and observers (left graph); median latency over replications (middle graph), and a combined speed-accuracy performance measure: (right graph).

Results:

The combined measure (far right graph in Figure 1) is the information transmitted in the stimulus-response confusion matrix pooled over replications divided by the mean latency.

For the combined measure, the increase in performance with contrast is significant ($F(1,15) = 11.368$, $p < 0.01$); the better performance for the dark text is significant ($F(1,15)=8.20$, $p<.05$); and neither the linear nor the quadratic component of the contrast interaction with contrast polarity were significant ($F(1,15)=0.53$, $p>0.05$; $F(1,15)=0.359$, $p>0.05$).
Results of the proportion correct and latency analyses support the idea that the effects of contrast saturate early, but the combined score indicates that performance may not even be at asymptote at a contrast of 0.4.

Experiments 2 and 3: Letter Identification with Scanning

Stimuli and Eccentricity: 12 letters (acegilnqrstu) were presented one at a time. Full letter height was 0.2 deg using TNR font. The letter was either at central fixation or at one of the four corners of a square centered at fixation. In Exp. 2 both ordinary letters and pedestal letters (above Figure) were used. In Exp. 3 only ordinary letters were used.
The possible eccentricities were 0, 3 deg (Exp. 2) and 0, 1.5, 3, 4.5 deg (Exp.3).
Polarity and Weber Contrast: Positive and Negative contrast (0.1, 0.2, Exp. 2 and 0.1, 0.2, 0.4, Exp. 3) on a background of 30 cd/m^2.
Task and Procedure: Identify the letter as quickly and as accurately as possible. Exp. 2 had 3 repetitions of 12 letters in 2 formats x 2 polarities x 3 contrasts x 2 eccentricities (432 trials). Exp. Included three blocks with 12 trials (on each of the tested letters) for each of the 16 conditions (4 eccentricities x 2 contrasts x 2 polarities) (576 trials total)

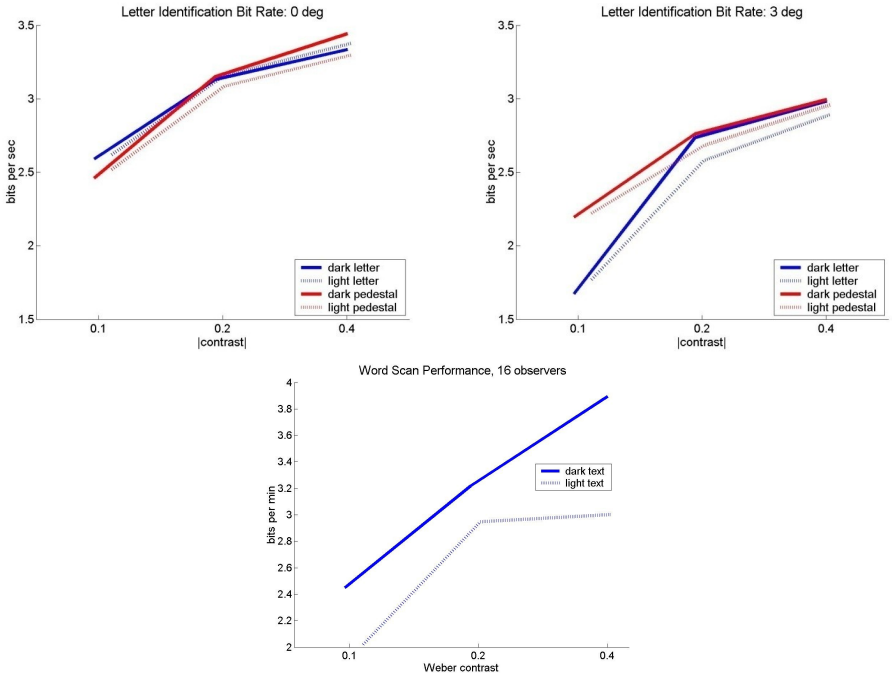

Figure 2: Mean observer (N=16) letter identification performance in Experiment 2 for the pedestal, polarity, and contrast conditions at fixation (left graph) and at 3 deg eccentricity (middle graph). Mean observer (N=19) performance as a function of eccentricity for contrast and polarity conditions in Experiment 3 (right graph).

Results:

Experiment 2: The main effects of eccentricity, contrast, and pedestal are significant ($F(1,15) = 177.1$, 83.4, 36.7, respectively, $p < 0.01$). The main effect of polarity is not significant ($F(1,15) = 2.15$, $p > 0.05$).

The improved performance of the pedestal letters at low contrast in the periphery illustrates the importance of contrast energy on the search component of the task.
Experiment 3: The linear effect of eccentricity and the main effects of contrast and polarity are all significant ($F(1,18) = 93.7, 167.2, 17.9$, respectively, $p< 0.01$).
Experiment 2 vs 3: A comparison between the two experiments on the polarity effect averaged over the common conditions (no pedestals, 0 and 3 deg eccentricity) found a significantly larger polarity effect for Experiment 3 ($F(1,33) =6.27$, $p< 0.05$).

Conclusions

For paragraph scanning and letter identification, in 2 of the 3 experiments performance was better for dark text than light text when we equate Weber contrast. We found no variation of this effect with eccentricity.

References

Lauren F.V. Scharff, Albert J. Ahumada, Jr. (2002) Predicting the Readability of Transparent Text, JOV 2(9), 653-666. DOI 10:1167/2.9.7 http://www.journalofvision.org/2/9/7/ ISSN 1534-7362

Lauren F.V. Scharff, A. J. Ahumada (2003a) Contrast measures for predicting text readability, B. E. Rogowitz and T. N. Pappas, eds., Human Vision and Electronic Imaging VIII, SPIE Proc. 5007, 463-472. HTML paper, PDF paper.

Lauren F.V. Scharff, Albert J. Ahumada, Jr. (2003b) Letter identification latencies are predicted by an asymmetric contrast metric, Vision Sciences Society Abstracts, TU752, p. 223, http://www.journalofvision.org/3/9/816/. HTML handout text (revised and expanded). PDF handout text.

Albert J. Ahumada, Jr., Lauren F.V. Scharff. (2003c) Letter identification: Contrast polarity and speed-accuracy trade-off strategies, Abstracts of the Psychonomic Society 44th Annual Meeting, Vol. 8, p. 67. HTML handout, PDF handout.

Lauren F.V. Scharff, Albert J. Ahumada (2005) Understanding text polarity effects, European Conference on Visual Perception. HTML handout, PDF handout.

Scharff, Lauren V., Ahumada, Albert J. (2008) Contrast Polarity in Letter Identification, Vision Sciences Society Abstracts, http://journalofvision.org/8/6/627/, PDF handout..

Acknowledgements: Support provided by NASA Aerospace Systems and the San Jose State University Foundation. Many thanks to Bryan Taylor for data collection assistance.