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A model of visual discomfort and its implications for efficient reading performance

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A MODEL OF VISUAL DISCOMFORT AND ITS IMPLICATIONS
FOR EFFICIENT READING PERFORMANCE

A thesis submitted in fulfilment of the requirements for the award of the degree

Doctor of Philosophy

from

The University of Wollongong

by

Elizabeth Conlon

B.A. University of Tasmania

Psychology Department

1993

SOURCES STATEMENT

The present thesis describes original research undertaken in the Department of Psychology, University of Wollongong. To the best of my knowledge and belief, any theories and techniques not my own have been acknowledged in the text. The theoretical contributions in this thesis are my own original work and have not been submitted for any other degree.

Signed

ABSTRACT

Visual discomfort has been described as an extreme sensitivity to bright or intermittent light and some forms of repetitive pattern stimuli. This sensitivity can result in physical symptoms of eye-strain and headache and induction of anomalous perceptual features with exposure to pattern (Wilkins et al., 1984). The pattern percept produced by the lines of print on a page of text has been likened to the pattern of anomalous stripes which can induce unpleasant effects in sensitive individuals (Wilkins & Nimmo-Smith, 1987). This sensitivity is increased in observers who report regular headache or those who report eye-strain and headache when reading.

Scotopic Sensitivity Syndrome was a term coined by Irlen (1983) to describe a symptom complex which described anomalous physical, perceptual and performance difficulties reported when reading. This symptom complex is characterised by experience of photophobia, eye-strain difficulties, difficulties with depth perception and experience of anomalous perceptual difficulty with exposure to the print on a page of text (Irlen, 1983). As a result of these difficulties severe reading difficulty has been reported.

In this work a model of visual discomfort was developed which combined the reports of physical and perceptual difficulties induced from observation of high contrast square-wave repetitive spatial patterns and a page of text (Wilkins et al., 1984; Wilkins & Nimmo-Smith, 1984; 1987) and the performance difficulties reported by Irlen (1983) to occur when reading. A unidimensional model of visual discomfort was developed using a rating scale version of the Rasch model in which person and item parameters were combined on a simple logistic scale. From this model it was predicted that as the number of positive responses to items on the visual discomfort scale increased the probability of experiencing more severe visual discomfort increased. This increasing difficulty would be revealed by a greater number of reports of unpleasant physical side-effects and

anomalous perceptual distortion from repetitive spatial patterns. Performance difficulty if present would be reflected in reduced task efficiency.

The similarities between this model and Wilkins (1986a) conceptualisation of visual discomfort was tested with investigation of reports of unpleasant physical side-effects and perceptual distortion from observation of square-wave gratings of intermediate spatial frequency and a page of text. It was found that higher scorers on the visual discomfort scale reported significantly more unpleasant physical side-effects and perceptual distortions from all the pattern types presented than low scorers on the scale. Further analysis demonstrated that high headache susceptibility observers also obtained higher scores on the visual discomfort scale, and reported a significantly greater number of unpleasant physical side-effects from observation of the high contrast square-waves than low headache susceptibility observers. Reports of perceptual distortion among this high headache susceptibility group produced inconsistent results. It was concluded that the visual discomfort scale was a more sensitive measure of visual discomfort than unitary reports of single physical characteristics, although these may contribute.

The spatial frequency at which most severe anomalous effects were induced was also investigated. Classifying observers into groups on the basis of scores obtained on the visual discomfort scale three groups, a severe, moderate visual discomfort and control group were formed. The results of these experiments demonstrated that for the severe visual discomfort group when a large pattern size and ten second exposure duration was used greatest physical unpleasantness and perceptual distortion was reported in the intermediate spatial frequency range and for the control and moderate visual discomfort groups greatest difficulty of both types was reported at high spatial frequency. When pattern size was reduced all groups reported greatest difficulty of both types at high spatial frequencies. These findings were explained in terms of a lower threshold of stimulation for the severe visual discomfort group in the intermediate spatial frequency range when a large pattern size and ten second exposure duration was used.

Additional findings from these studies demonstrated that a single spatial frequency channel may be sufficient to induce unpleasant effects in both groups. The spatial frequency of greatest sensitivity differed among groups. This finding failed to support the hypothesis that the most sensitive spatial frequency channel would correspond to the most sensitive channel at threshold levels. The level in the visual system at which these effects are generated appears to extend from a retinal to cortical level, with the severe visual discomfort group reporting a number of illusory features induced at a cortical level when an intermediate spatial frequency of large size was presented.

In order to examine the effects of this sensitivity a number of performance tests were conducted. Several experiments manipulated the square-wave-like structure of the global pattern. It was found that the severe visual discomfort group performed a letter orientation identification task significantly more slowly than other groups, although the moderate visual discomfort group reported significantly greater subjective difficulty with task performance. The performance of all visual discomfort groups on the Coding-B subtest of the Wechsler Intelligence Scales for Children - Revised differed significantly from one another with the severe visual discomfort group performing least efficiently on the task. A strong relationship was found between total scores on the visual discomfort scale and Coding-B score. As the score on the visual discomfort scale increased the score on the Coding-B test decreased. This relationship accounted for 69% of the variance in the data. The severe visual discomfort group also read a text passage significantly more slowly than other groups, although comprehension did not differ from that of other groups. The performance results were explained in terms of McConkie and Zola's (1987) model of visual attention when reading. This model used a four level object hierarchy extending from the global percept of the page to the word level. It was argued that as a result of extreme sensitivity to the pattern percept the severe visual discomfort group is unable to avoid attending to the global pattern percept of the page. This produces unpleasant somatic and perceptual effects and reduces attention to the word and letter level, thus producing performance difficulties. It was predicted that this

difficulty may be induced by anomalous interactions between the sustained and transient mechanisms, due to increased activity in the transient mechanism or decreased activity in the sustained mechanism. In some cases visual discomfort may be so great that the perceptual and physical difficulty generated may produce interference leading to higher level cognitive difficulties. This explanation does not fully describe visual discomfort as some observers experience performance difficulty when a square-wave-like percept is not presented. In this case more severe difficulty may concurrently exist.

It was concluded that subjective report of physical and perceptual difficulty may suggest the presence of visual discomfort, however, coexisting performance difficulty must also be observable in the case of severe visual discomfort where a visual processing deficit is present. Overall this research demonstrates that a latent visual discomfort trait does exist. Scotopic Sensitivity Syndrome can be explained within this framework as a perceptual difficulty resulting from sensitivity to the pattern percept from the page of printed text. The efficacy of colour in reducing the unpleasant effects induced was less clear, although performance for the severe visual discomfort group only was enhanced when colour was added to the display. The colour producing improved performance, however, varied between observers. More detailed research is required to further investigate this effect.

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