Visual performance of the visually impaired worker as a function of contrast, illumination, and low vision aid usage.

Shelly L. Marmion, Ph.D.

The current study investigated the effects of illumination and contrast on the productivity and comfort of low vision workers, some of whom used low vision aids. The study was guided by several specific objectives: (1) to develop strategies for testing and identifying optimum illumination levels and color contrasts for severely visually impaired persons, (2) to gain some indication of the type and degree of variation among the identified optimum conditions across individuals, (3) to develop strategies for modifying work sites to incorporate such environmental enhancers in a visually meaningful way, (4) to determine the impact of work site modifications on the productivity and comfort of these workers, (5) to determine the impact of low-vision aids on the productivity and comfort of these workers, and (6) to establish the contribution of low vision aids to the efficacy of environmental modifications.

Low-vision subjects (N=13), several of whom first received low-vision aids were tested with respect to various illumination levels and color contrast conditions to identify an optimum level of lighting and color contrast for each subject. Assessment results indicated that for at least some individuals, specific lighting conditions and color contrasts were related to better performance, but there were considerable individual differences in terms of what constituted optimum conditions for each subject and to what degree optimum conditions facilitated visual performance.

The job-site of each subject was modified in accordance with that subject's optimum illumination and color contrast conditions. The subjects, most of whom were employed in industrial sewing jobs, received each modification separately and in combination in a prearranged sequence. Before and after each modification (or treatment) phase, the modifications were withdrawn, resulting in non-treatment phases alternating with treatment phases. The dependent measure was productivity rates.

There was considerable variability among the subjects. Some subjects exhibited higher production rates related to one or more of the modifications, while others did not. Of those who did, better performance was related to the light modifications and not to color modifications. Baseline data taken before and after the receipt of LVA's indicated increased performance for several of those subjects using LVA's as a function of LVA usage.

Subjects were also asked to respond to comfort questionnaires designed to measure their attitudes concerning LVA's and/or color and light modifications. The percentage of favorable responses to each type of modification indicated greatest favorability (i.e. most beneficial) to the LVA, next to the light modification, and least to the color modifications. Discussion of results includes implications for assessment and intervention strategies for the visually impaired worker.

A crucial component of the rehabilitation process for visually impaired workers is the enhancement of visual function through the optimization of residual vision. Intervention strategies are numerous, and relate to various aspects of the visual process. Corn (1983) has proposed a model of visual functioning incorporating three dimensions of the visual situation: (1) visual abilities, including the five physiological components of vision -- acuity, visual fields, mobility, brain function, and light and color reception; (2) stored and available individuality, including past experiences and functions influencing individual's ability to react to stimuli, such as cognition, perception, sensory development and integration, and physical and psychological makeup of the individual; and (3) environmental cues, consisting of the attributes of objects which influence their visibility, such as color, contrast, time, space, and illumination. Comparing this three-dimensional model to a balloon, Corn suggests that in order to perform some function, the balloon must contain a minimum volume of air, without stretching too far in any one direction.

The model assumes interactions among the components of the three dimensions. By intervening in any one of the dimensions, it is theoretically possible to increase visual function. Interventions related to the third dimension (environmental cues) are the easiest and least expensive to make. Such modifications might be made by an employer, a counselor, or by a visually impaired individual, to increase the on-the-job visual function of that individual.

Visual work performance is affected by many variables. The ability of an individual to perceive a stimulus, for example, is dependent on both the process of sight and on the geometric and photometric characteristics of the visual environment. One can have good eyesight and yet fail to perceive a stimulus because of improper illumination, inadequate contrast or size, or any number of such characteristics of the visual environment. On the other hand, one may have relatively poor acuity, but experience little functional loss of vision in situations where characteristics of the visual environment are optimized. The interdependence of variables influencing visual performance underlies common practices designed to compensate for losses in visual acuity such as increasing the illumination, the contrast, or the size of the stimulus.

The human eye contains mechanisms which allow it to adapt to a wide variety of environmental conditions and still maintain reasonable efficiency. With respect to illumination levels, for instance, the normal eye is able to make use of very high and low levels of light, but there are nevertheless, certain optimum conditions in which it works best (Hopkinson & Collins, 1970). The same is true for other characteristics of the visual environment as well. Because many eye pathologies serve to limit the adaptability or functional range of the eye, the optimization of visual environment characteristics is especially crucial to the visual performance of many low-vision persons. Also, because there are many different eye pathologies yielding different types and patterns of functional loss, it appears that there are substantial differences among individual low-vision subjects as to what specific stimulus characteristics constitute optimal visual environments.

The majority of studies which have considered the effects of illumination on the visual functioning of visually impaired populations were not applied to job settings but instead used reading performance as the dependent measure (Gilbert & Hopkinson, 1949; Lehon, 1980; Steiner, 1969). From these studies, it may be concluded that: (1) for most individuals, increasing illumination on a visual task will improve visual performance up to a point, but thereafter improvement will be progressively less for the same magnitude of increase in illumination; and (2) vision-impaired subjects are likely to benefit more from increased illumination (depending on the nature of the preferences of visually impaired subjects in the selection of optimum illumination) than non-visually impaired subjects.

A second variable important for visual performance is contrast. The fact that the human eye can detect not only light but contrast greatly increases the amount of visual information we can see and interpret. A small object can only be seen when superimposed on a larger one if the two differ in luminance (or brightness) contrast, and/or chromatic (or color) contrast. There is also a reciprocal relationship between contrast and illumination such that, in general, greater illumination makes possible the discrimination of objects having less contrast. Conversely, a high degree of contrast between an object and its background allows for visual discrimination even under relatively low levels of illumination. A third factor interacts as well, such that an increase of size has a greater effect on improvement of visibility for objects of weak contrast than for those of strong contrast (Weston, 1962).

Most studies investigating the relationship between contrast and visual performance have considered only luminance contrast. In attempting to optimize contrast, however, it is important to remember that the subjective experience of contrast is a result of both luminance and color contrasts. Color contrast has received some attention as a technique for increasing visual efficiency for visually impaired persons (Corn, 1983; Myers, 1971; Sicurella, 1979). As with illumination, when dealing with visually impaired subjects, optimal contrasts are partially predictable according to the physical properties of luminance and hue, but they are somewhat idiosyncratic as well due to widely differing pathological conditions. Thus, for each variable it appears an appropriate strategy is to individually determine an optimum stimulus configuration of light and color for each subject.

A substantial number of low-vision individuals can be helped to increase their vision through the use of optical aids often referred to as low-vision aids (LVA's). Success in benefiting from an LVA is generally related to the amount of residual vision and also the extent to which the patient can modify acuity by accommodation (the ocular adjustment for vision at various distances). Other factors determining the success in benefiting from LVA's include intelligence, educational background, motivation, specific visual goals (Milder, 1980), and proper training (Mehr & Fried, 1975).

The present investigation was concerned with whether or not (a) optimum illumination levels and color contrasts could be identified for low-vision subjects, and (b) the comfort and/or productivity of visually impaired workers could be improved if the environment were modified to incorporate those stimulus characteristics. Additionally, the contribution of LVA's to this intervention strategy was assessed. Practical and economical assessment techniques were developed to make a functional assessment of each subject. That these assessment strategies be simple, practical, and job-related was a major consideration in their development, in the hopes that they would be widely applicable within the rehabilitation field.

Experiment I

Subjects

Subjects were legally blind individuals employed in industrial sewing jobs at Mississippi Industries for the Blind in Jackson, Mississippi. Selection of individuals to be considered for low vision aids was made from among all low vision workers employed in jobs for which piece-rate production records were available. Those individuals who (a) were prescribed LVA's and (b) performed jobs suitable for both color and illumination modification to be made in the second experiment, were eligible for the LVA group. LVA examinations and prescriptions were made through the Low Vision Aid Clinic of the University of Mississippi Medical School. Testing was not begun on these subjects until they had successfully completed a two-month follow-up examination. Subjects of the non-LVA condition were matched to LVA subjects on the basis of gender and type of job.

The subjects consisted of four males and nine females with an average age of 33. Diagnosed eye pathologies widely varied, with the majority of subjects having multiple visual dysfunctions. All of the subjects had either congenital or early onset visual problems; the majority had progressive conditions.

Apparatus and Materials

The light frame used in the functional assessment consisted of a light track construction with rheostat switches which controlled the illumination levels of each of two incandescent bulbs positioned on either side of the subject's head. A cross-bar acted as a "chin stop" so that a subject's head would be relatively immobile.

Visual acuity was tested with two sets of eleven cards, each containing E-shapes randomly oriented (up, down, left, right). The E's of the first eight cards were the same size as those of the eight lines of the Illiterate E Acuity Chart. Additional cards displayed smaller sizes. Sets were alternately used and were inverted with reuse to eliminate the possibility of memory-aided test responses.

Two sets of stimuli were used to test each subject for optimum color contrast. The background color of both sets of stimuli for a given subject matched his/her dominant work material color. For example, a subject who produces barracks bags would view stimulus cards covered in that same type of cloth. The first set consisted of a Landolt-ring task. Each card contained a Landolt-ring in one of 5 or 6 colors which contrasted highly with the work material background color. The break in each ring (which the subject was instructed to locate and indicate with a stylus) varied from 10mm to 1mm in width. The stimulus set consisted of a Landolt-ring of each contrast color, for each of the five break sizes. Breaks were randomly located.

The second set was devised to provide a more difficult visual task for those subjects with only moderate acuity losses. This set was identical to the first in background color and contrasting colors. However, each card contained a circle the same circumference as the Landolt-rings, with a pin-point area missing through which the background color was visible. Pin-points of five sizes were used, varying from 6mm to 1mm in diameter. See Figure 1 for examples of each type of stimulus.

A neutral stimulus card used to set the subject's "comfort levels" consisted of a circle, half white and half black, mounted on a grey background.

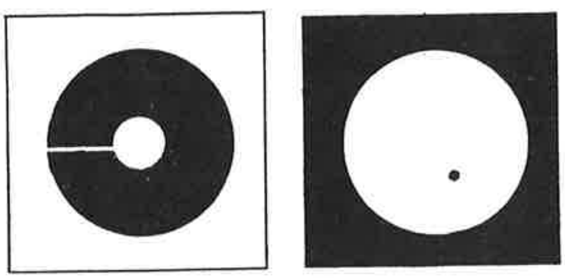

Figure 1. Example stimuli used to determine optimum color contrast

Procedure

The subject was seated before the light frame apparatus. In order to control for ambient lighting factors, the lighting of the test site was adjusted to replicate the lighting condition of the subject's work site (type of lighting and illumination level). After the subject was instructed to rest his/her chin on the chin bar, he/she was instructed to adjust the lighting level with the rheostat control to the level from which he/she could most comfortably view the neutral stimulus card. The preferred illumination level set by the subject was considered his or her "comfort level." Illumination was measured by a standard light meter and was recorded as foot-candle power. Maintaining the illumination level chosen by the subject, the Illiterate E acuity cards were used to test acuity performance. The subject's score was simply the number of the card (1-11) containing the smallest E's for which the subject correctly distinguished E-direction.

Using this same "comfort" illumination level as a starting point, the footcandle intensity was systematically incremented and decremented using a modified "method of limits" procedure for identifying optimum visual performance. At each foot-candle setting, the subject was retested for visual acuity using the Illiterate E cards. Optimum illumination for a subject was operationally defined as the footcandle level yielding best acuity performance. If more than one setting yielded equivalent best performances, that setting nearest the "comfort" level was designated as optimum.

For testing optimum color contrast, the designated optimum illumination level was maintained. The subject was shown the Landolt ring stimulus cards one at a time and was instructed to point out the break in the ring as quickly as possible. A stop-watch was used to measure the response latencies. The same procedure was used with the Pin-point Circle Stimuli. Optimum color contrast was operationally defined as the stimulus color yielding the smallest average response latency over the various size conditions.

All testing materials and the test procedure were pilot tested prior to the study. Specifically tested was the assumption that each subject's optimum color contrast would be the same under other lighting conditions as well. This assumption was confirmed. Although only one of eleven pilot subjects showed 100% consistency across lighting levels, the color contrast yielding best performance for a subject under the optimum lighting level also yielded the best average performance under the majority of other conditions as well.

Results

For the majority of subjects (62%) the foot-candle level found to be optimum was the same as the comfort level chosen by the subject; that is, neither an increase or a decrease in footcandles from the comfort level yielded improved performance for these subjects. The acuity measurement appeared to be reliable; subsequent testing under the comfort level condition yielded equivalent performances for all subjects but one who improved performance by one card. That the comfort level and optimum level proved to be the same for so many individuals would seem to indicate that the subjects were quite accurate in predicting the approximate amount of illumination they required for perceiving non-moving, fine visual tasks.

For the five other subjects, an increase in lighting over the comfort level yielded the best performance. Three of them improved acuity by one card; two improved by two cards. Four of those increasing performance were LVA subjects; one was not. No comparisons to baseline were made at this time. The acuity task should be recognized as somewhat less sensitive to small variations in performance. Each card was scored for right versus wrong responses only. Perhaps recording response latencies in this task as well might have increased the sensitivity of the performance measure and resulted in a greater number of persons exhibiting increased performance.

The average increase in illumination over the comfort level was 35 fc. For each subject, the illumination level identified as optimum was an increase in footcandles from her/his baseline condition. The average increase was 110 fc, ranging from a low of 10 to a high of 250 fc.

Subsequent to all other data collection, acuity was again tested under the various lighting levels (baseline, comfort, and optimum levels) using the same procedures. Of the 11 subjects available for retesting, four exhibited an increase in performance over the various levels (36%). Average gain was 1.25 cards. Although percentages don't significantly differ from the first testing, the results were surprising in two respects: (1) Since baseline lighting was also tested, the various levels of lighting differed more, and would be expected to produce considerably higher rates of increase, and (2) there was only moderate overlap between the two groups of subjects exhibiting increases for the two testing sessions. These results are probably at least partially explained by a further finding relative to the second testing; that is, over half of the subjects (55%) displayed overall decreases in visual acuity. Average performance loss of these subjects was 2.6 cards. For four of these subjects, the losses occurred over a 6-month period, for the other two over a 12-month period.

In the testing of color contrasts, the dependent measure was the reaction time latencies for subject's responses to each color of the stimulus set. The optimum color contrast was that color for which the smallest latencies were obtained. A percentage improvement was computed to indicate to what extent the optimum color improved performance over the stimulus color yielding the longest latencies for that subject. The average percentage improvement was about 9%, ranging from 4% to 14%.

Very small differences, however, may be a simple result of random error. If we arbitrarily choose a 10% increase in speed (when comparing the fastest-performance color to the slowest-performance color) as a cut-off to define a significant increase in performance related to color contrast, seven of the 13 subjects (approximately 54%) exhibited such increases. Thus, for a substantial number of subjects, optimizing color contrast did facilitate this particular type of performance.

The use of LVA's was considered only as a between-subject variable. Since LVA's were prescribed on the basis that increased acuity was obtained with the LVA, subjects who received aids were tested while using their LVA. When comparing the results of testing for optimum stimulus characteristics for non-LVA subjects and LVA subjects, little difference is found. Non-LVA subjects chose somewhat higher "comfort" illumination levels (238 fc compared to 210 fc) than LVA subjects. A greater number of LVA subjects than non-LVA subjects were found to benefit from additional increases in lighting (four out of nine, as compared to zero out of four non-LVA's). The difference in optimum levels is slight (226 fc for LVA's; 238 fc for non-LVA's). Little or no difference between groups was exhibited for any of the performance measures, with the groups having equivalent acuity means under optimum lighting conditions, and having equivalent gains in acuity for optimum color contrast conditions.

Such comparisons should be considered very tentative because of the relatively large variation between subjects and the small number of subjects in each group. The comparison suggests, however, that the use of aids is less critical as a factor influencing performance when the subject is operating under optimum stimulus conditions.

Experiment II

Subjects

Job-site modification and productivity measurements were originally begun on all 13 subjects for whom functional assessments were made and who were located in three separate departments. However, productivity data proved problematic in two departments, so the following description relates to four of the subjects (three LVA's and one non-LVA) employed in the "bartacking" department, performing the task of attaching a heavy off-white drawstring to the dark military green fabric of a barracks bag.

Job-site modifications

The lighting modifications for subjects consisted of increasing the footcandle power falling on the subject's work surface. The lighting strategy was accomplished by either (a) repositioning an incandescent light source closer to the work surface, (b) increasing the intensity (bulb wattage) of the incandescent light source, or both.

All subjects performed a sewing job using various types of modified sewing machines. The color modification consisted of painting the machine part which corresponds to a presser foot on a standard sewing machine. This part is used to hold fabric in place and guide the stitch.

Design

The subjects received each modification (illumination and color) separately and in combination in a prearranged sequence. Before and after each modification (treatment) phase, the modifications were withdrawn, resulting in nontreatment phases alternating with treatment phases. The design was an A-B-A-C-A-D-A single-subject withdrawal design, with A representing non-treatment and B, C, and D representing light-only, color-only, and light-plus-color modification phases. The dependent measure was production rates.

Results and Discussion

Two significant sets of results were obtained for subjects within the barracks bag department. One subject performed significantly better under the light-only conditions than under the non-treatment condition. Another performed better under both light conditions (light-only and light-plus-color) than under other conditions.

These results indicate, then, that for at least some individuals, the lighting variable does influence productivity to some degree. That is, modifying the job-site consistent with an individual's optimum illumination level can produce increases in productivity for some workers. Of the subjects in this department, fifty percent exhibited facilitated performance under increased illumination conditions.

The color contrast modification was less successful in the present experiment. This should not be interpreted, however, as clear evidence that color contrast is a less significant aspect of the stimulus configuration. It may simply reflect the fact that it is more difficult to modify tasks and job-sites with respect to color contrast in visually meaningful ways. In the current situation, the contrast was made in relation to the work material color, over which the study had no control. Thus, resulting contrast ratios were limited to a certain range which may not have been large enough to strongly influence performance. Also, the specific modifications made in the study (primarily painting presser feet) may not have been particularly effective. It is one thing to identify an optimum color contrast for an individual and quite another to incorporate that knowledge into a meaningful job-site modification. In comparing subjects' acuity performances with the different color contrasts in the first experiment, it was found that just over half of the subjects did exhibit an appreciable difference in performance of the least- and most-facilitating contrast. This suggests that the contrast effect is real, but that the procedures used in the productivity experiment were inadequate for replication of the effect within that situation. Different modification strategies in different circumstances might prove more beneficial to performance.

Also, it is important to note that significant losses in visual acuity occurred for several subjects over the period of study. It is possible that light and color modifications designated as optimum were effective only under the specific testing conditions (including the subject's visual abilities at that time) and might decrease in effectiveness as those conditions were changed. Concerning the two subjects for whom the significant results were obtained, neither experienced any noticeable loss of acuity.

The direct influence of low-vision aids on worker productivity can be assessed for some of those individuals receiving an aid. Pre-- and post-LVA comparisions were less appropriate for several of the subjects due to the apparent existence of confounding factors. Of the remaining four recipients, comparisons indicate a consistent relationship between the use of the aid and increased productivity. The extent of the increase ranged from 3 percent to 19 percent; the average increase was 12 percent.

One reason for the relatively high success rate for these subjects is probably the fact that LVA's were prescribed specifically for use on their jobs. Only those subjects for whom a job appropriate aid could be identified were included in the LVA group. Many of these individuals had, for whatever reasons, neglected to have had basic eye care for many years. Thus, when a prescription was given for some type of low-vision aid, the benefit to visual function was often fairly dramatic. However, one should recall that increased visual function does not necessarily translate into increased performance with such measures as productivity. Many other variables complicate the relationship between these indices.

As to whether the LVA's contributed to the efficacy of environmental modifications, the data is inconclusive. Group analyses within departments which compared LVA and non-LVA performances indicated no such effect. Variations in performance patterns were as great between subjects within LVA conditions as between subjects across conditions. On the other hand, the two subjects for whom statistically significant data were obtained (comparing treatment and non-modification phases) were LVA subjects.

Comfort Data

Although any gains (or losses) in comfort resulting from environmental modifications is of interest as a separate, critical issue, there is no direct measure of comfort available. The technique fo measurement employed in the present study involved asking each subject, subsequent to production data collection, a series of questions designed to elicit the subject's perceptions of each modification in terms of problems and benefits. Obtaining this measure was delayed until after all treatment phases were concluded so as not to draw any further attention to the actual modifications and possible consequences, to minimize the likelihood of a Hawthorne effect.

However, it should be kept in mind that self-reporting measures which rely on memory must always be somewhat suspect and that subjects will often respond according to their perceptions regarding the experimenter's expectations. Thus, we might expect to receive somewhat more favorable responses to all modifications than are actually perceived by subjects.

Responses were obtained for eight subjects still available subsequent to the treatment phase. They were drawn from all departments, since there is no reason to assume that comfort ratings of the modifications would be affected by changing performance demands. A review of comfort questionnaire results indicates generally favorable responses to all variables. The six LVA subjects for whom comfort data was obtained responded quite favorably. Overall, only 20 percent of the questions concerning LVA's received a response indicating either negative consequences or no benefit. All of these subjects reported at least some benefit related to the LVA.

For the eight subjects rating the lighting modificaton, 38 percent of the responses were negative. Three subjects, two LVA's and one non-LVA, reported little or no benefit from the increase in lighting; one of those reported trouble doing her job with the increased lighting. Oddly enough, it is this same subject for whom significant results were obtained relative to light conditions. This funding should serve to remind the reader that productivity and comfort do not necessarily go hand-in-hand. However, discrepancies of this magnitude are somewhat curious.

The same eight subjects rated the color modification, giving 61% negative responses. Four subjects perceived no benefit related to the color modification, and the same subject as above reported trouble in doing her job with that modification. It is likely that the responses of this subject to both modifications simply reflected a general negative attitude toward the changes without any careful regard for actual consequences to comfort.

Implications for Assessment Strategies

The difficulties of field research are well-known. Studies of this nature are complicated by many factors beyond the researcher's control. The result of such complications is that while the issues may be particularly germane (based as they are on real-world situations) conclusions often must remain somewhat tentative, since the lack of experimental control does not allow for the complete elimination of alternative explanations for the findings. Further research is necessary to strengthen the conclusiveness of field research findings.

With this qualifier in mind, the following strategies are recommended with respect to performance enhancement through environmental modifications:

1. Individualized testing should be done. Low-vision individuals differ widely in terms of what type modifications are benficial, and the extent to which they may benefit.

2. Frequent retesting is appropriate for individual's with progressive eye conditions. As changes occur in a person's acuity and field characteristics, it is to be expected that visual needs will change as well. For all low-vision persons, periodic retesting with age is recommended.

3. Testing for optimum environmental enhancers should be job-specific. Visual needs are somewhat task-specific, depending on the individual's work strategies, experience with the task, and the nature of the task. An identified "optimum" for one particular task will not necessarily benefit the individual in doing many other tasks and activities. The testing should incorporate as many components (i.e. visual demand characteristics) as possible. The need exists for a protocol to assess the visual demands of specific jobs.

4. Specific environmental modifications should be strategically devised and refined. Knowledge of optimum conditions for an individual is worthless if attempts to modify his/her environment fall short of incorporating those characteristics in a visually meaningful way. This is an especially critical point to make regarding such stimulus characteristics as color contrast, which are not so easily incorporated into some job tasks. Job analysis and visual demand assessments can help to identify what environmental characteristics are both a) modificable, and b) visually meaningful.

5. Where feasible, flexible modifications should be incorporated. A good example of this strategy applied to illumination is the use of rheostatically controlled lighting which an employee can adjust according to need. An example of flexible contrast capabilities is the computer terminal which allows for the selection of figure and background colors. It is important to remember that the conditions which are optimum for a task of limited duration are not necessarily always beneficial. For example, while a very high level of illumination may increase visual function for specific tasks, that same level may result in eye strain or glare discomfort if used for long hours at a time. It is also likely that an individual's visual needs may change according to various internal states and external conditions. Thus, modifications which themselves can be modified are likely to be the most efficient.

REFERENCES

Corn, A. L. (1983). Visual funtion: a theoretical model for individuals with low vision. Journal of Visual Impairment & Blindness, 77, 373-377.

Gilbert, M., and Hopkinson, R. G. (1949). The illumination of the Snellen Chart. British Journal of Opthalmology, 33, 305-310.

Hopkinson, R. G., and Collins, J. B. (1970). The ergonomics of lighting. London: MacDonald Technical and Scientific.

Lehon, L. H. (1980). Development of lighting standards for the visually impaired. Journal of Visual Impairment and Blindness, 74(7), 249-253.

Mehr, E. B.; and Freid, A. N. (1976). Low Vision care. Chicago: The Professional Press.

Milder, B. (1980). Low vision aids programs. In C. W. Hoehne and J. G. Cull's (eds.) Ophthalmological Considerations of the Blind. Springfield, Illinois.

Myers, W. A. Color discriminability for partially seeing children. Exceptional Children. November, 223-228.

Sicurella, V. J. (1977). Color contrast as an aid for visually impaired persons. Journal of Visual Impairment and Blindness, 71, 252-257.

Steiner, B. (1969). Illumination for partially seeing school children. Journal of the American Optometry Association. 40(8), 855-859.

Weston, H. C. (1962). Light, sight and work. London: H. K. Lewis.

Development of this document was supported by the Rehabilitation Research and Training Center Grant G008103981 from the National Institute for Handicapped Research, Department of Education, Washington, D.C. Opinions expressed in this document are not necessarily those of the granting agency.

AUTHOR:
Shelly Marmion, Ph.D.
R & T Center, Low Vision/Blindness
P.O. Drawer 5365
Mississippi State University, Mississippi 39762