ARE KALICHROME LENSES EFFECTIVE IN HAZY ENVIRONMENT?

Curtis E. Wee
Senior Research
Dr. Vincent King
March 1, 1982

Title: Are Kalichrome Lenses Effective In Hazy Environment?

Introduction: Numerous authors have advocated the use of yellow tinted lenses (henceforth, the tradename Kalichrome will be used) in hazy or foggy environmental conditions to improve visibility.[12345] Many observers report that the apparent increase in brightness associated with the application of the Kalichrome lenses improves discrimination of the target. Others report an increase in contrast. Professional drivers, hunters, and target pistol enthusiasts, to name a few, feel that these qualities of the Kalichrome lenses will improve their respective task performance relative to Kalichrome lens application.

Design: In a given hazy environment, the shooting performances of twelve experienced pistol shooters were evaluated in a matched pairs statistical design. The City of Big Rapids Police Department consented to serve as the experimental group. The officers were asked to shoot back to back qualifying trials on their training range with clear and Kalichrome lenses over their habitual visual correction (if any). In order to minimize the Hawthorne Phenomenon, the officers were told that the investigation was conducted to "study the feasibility of different lens materials." The decision as to which lenses would be worn in the first trial was determined by a random selection. Performance was assessed by the point score assigned to each officer based on their respective shooting accuracy. A maximum score of 600 points is considered perfect for the combat style shooting format used.

Combat Style shooting format:

1) 12 rounds @ 7 yards in 25 seconds
2) 6 rounds @ 25 yards in 12 seconds
3) 18 rounds @ 25 yards in 90 seconds
    a) 6 rounds kneeling
    b) 6 rounds right hand barricade
    c) 6 rounds left hand barricade

4) 24 rounds @ 25 yards in 165 seconds (Reduced B-27 target)
   a) 6 rounds sitting
   b) 6 rounds prone
   c) 6 rounds right hand
   d) 6 rounds left hand

Materials: Kalichrome lenses supplied by Bausch and Lomb (mounted in an aviator style frame)

B-27 target, Human silhouette

Reduced B-27 target, Human silhouette (½ the size of B-27 target)

Bausch and Lomb safety glasses - clear

Standard police issue .357 caliber revolver

Conditions: June 22, 1981, 8:15 a.m., cloudy, overcast, and hazy (immediately following rain), to well lit and overcast. The officers were shooting toward the West.

Results:

	Kalichrome	Clear	delta
Wr	437	469	-32
Hr	400	453	-53
Ht	514	526	-12
R	497	539	-42
Wd	516	573	-57
D	471	491	-20
J	456	440	+16
Ck	545	555	-10
L	547	487	+60
Cn	453	480	-27
V	393	467	-74
A	438	435	+3

Type I two-tail t-test
alpha = 0.10
$t_{critical}$ = +/- 1.79
$t_{calculated}$ = 2.023

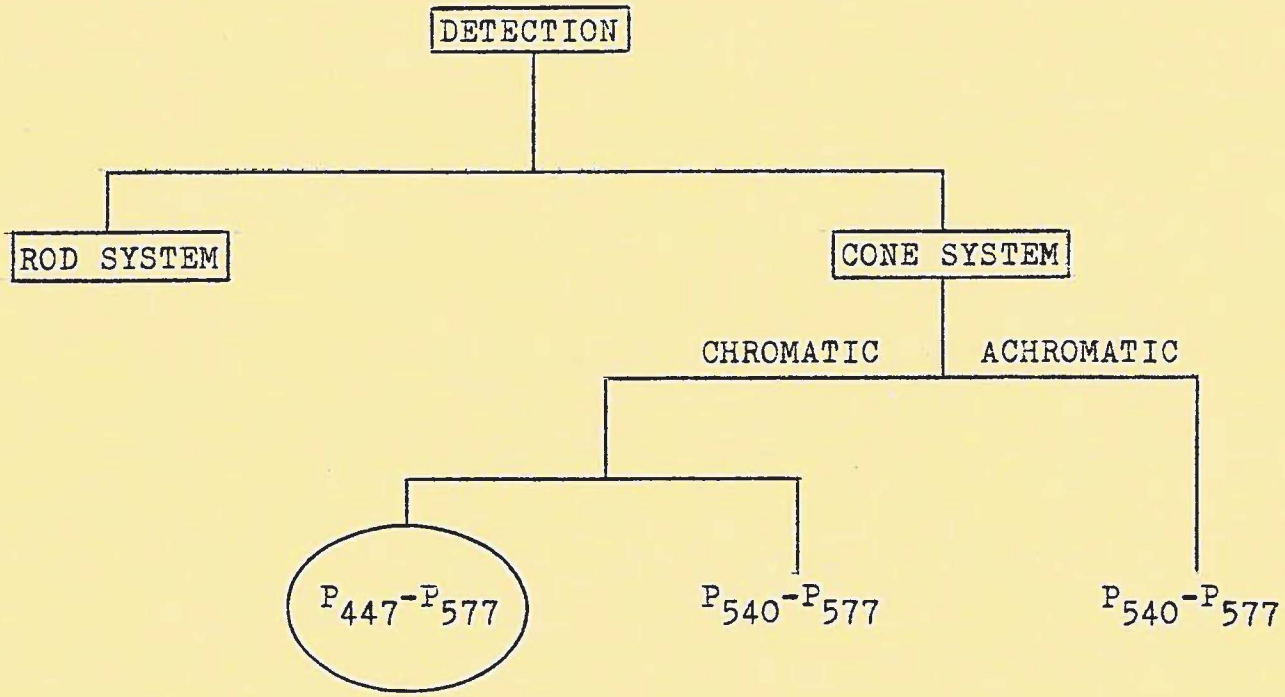
Type II one-tail t-test
alpha = 0.05
$t_{critical}$ = +/- 1.75
$t_{calculated}$ = 2.023

Evaluation: It is important that the reader is cognizant of the fact that only performance is being evaluated with respect to the application of Kalichrome and clear lenses. However, the implications are that increased visibility and contrast reported with Kalichrome useage may increase task performance.

By gross inspection of the data it was decided that the majority of the officers performed better with the clear lenses. A One-tail t-test was performed using the TRS-80 MICROSTT statistical analysis program. Statistical significance was shown utilizing the alpha = 0.05 confidence level. (e.g. based on this sampling, one may state with 95% confidence that the shooting performance attained using Kalichrome lenses is less than that achieved with clear lenses.) The reader should also keep in mind that the sampling was performed under "near optimal" conditions for the Kalichrome lenses, early morning and hazy.

Discussion: All of the subjects reported an apparent increase in brightness as the Kalichrome lenses were used. A mechanism to account for the subjective reports of brightness increase relative to Kalichrome lens application has been suggested by Guth utilizing contemporary color vision models.[6] This model describes the light detection process as a complex relationship between the rod receptor system and two unique cone systems. The achromatic cone system response is comprised of the linear summation of the cones. The chromatic cone system response is the net effect of the mutually inhibitory cone components. (see diagram #1)

diagram #1



The application of Kalichrome lenses impacts on the P_{447}-P_{577} opponent cone relationship by reducing the incident wavelengths below 500nm. The net effect is to potentiate the P_{577} response by removing its inhibitory (P_{447}) component. Our detection system experiences the potentiated response perceptually as an increase in brightness. In addition, we would expect this effect to be more significant in a hazy environment since water droplets tend to scatter the blue end of the spectrum more effectively.[7]

An obvious paradox arises between the apparent increase in brightness and yet seemingly unchanged ability to discriminate, and the apparent decrease in shooting performance shown in this study. In response to a questionnaire circulated following the study, participating officers were nearly split when asked, "... which lenses made the target easiest to see?" (six officers stated a preference for the Kalichrome lenses, five officers stated a preference for the clear

lenses, and one officer had no preference) Research seems to indicate that Kalichrome lenses are not the panacea for all tasks requiring performance in hazy environments. Kinney reported decreased contrast sensitivity using yellow tinted lenses when high luminance conditions prevailed.[8] Also, there appears to be no advantage to using Kalichrome filters when the object of regard is of high contrast. (I will re-emphasize that the targets used in this study were black silhouettes on manilla colored paper.)

The judicious use of Kalichrome lenses in limited contour environments where the illumination level is in the mesopic range seems to offer the greatest potential application. It is important that the vision care practitioner counsel wisely to prevent the uninformed public from experiencing the visual degradation associated with the imprudent use of filters in scotopic luminance ranges.

Acknowledgements:

Bausch and Lomb Consumer Products Division - Barb Groh
City of Big Rapids Police Department.
Firearms Instructor/Coordinator - Sgt. Gary Ward
Research Consultant - Harold Abraham

FOOTNOTES

1) Gregg, J.R. The Sportsman's Eye. New York: Winchester Press, 1971

2) Jalie, M. Principles of Ophthalmic Lenses, 2nd ed. Great Britain: Hazel, Watson, and Viney, Ltd.

3) Wilder, B., and Rubin, M. The Fine Art of Prescribing Glasses. Triad Scientific Pub., 1915

4) Drew, R. Professional Ophthalmic Dispensing. Chicago: The Professional Press, 1970

5) Borish, I.M. Clinical Refraction, 3rd ed. Chicago: The Professional Press, 1970

6) Guth, S.L., J.V. Alexander, J.I. Chumbly, C.B. Gillman, and M.M. Patterson. Factors Affecting Luminance Additivity At Threshold. Vision Research, volume 8, 913-926, 1968.

7) Rubin, M.L. Perspectives In Refraction. Survey of Ophthalmology, volume 17, 52-55, July-August, 1972

8) Kinney, J.A.S., C.L. Schlichting, D.F. Neri, S.W. Kindness. Various Measures Of The Effectiveness Of Yellow Goggles. Naval Submarine Medical Research Laboratory, Report #941, October, 1980

Related Readings

Clark, B.A. Color In Sunglass Lenses. American Journal of Optometry and Archives of the American Academy of Optometry, volume 46, 825-840, 1969

Wyszecki, G. Theoretical Investigation of Colored Lenses For Snow Goggles. Journal of the Optical Society of America, volume 46, 1071-1074, 1956

Hurvich, L.M., and D. Jameson, Some Quantitative Aspects of An Opponent-Colors Theory; A Physiological Color Specification System. Journal of the Optical Society of America, volume 51, 46-53, 1961

Guth, S.L., and H.R. Lodge. Heterochromatic Additivity, Foveal Spectral Sensitivity, and A New Color Model. Journal of the Optical Society of America, volume 63, 450-63, 1973

Guth, S.L., R.W. Massof, and T. Benzschawel. Vector Model For Normal and Dichromatic Color Vision. Journal of the Optical Society of America, volume 70, 197-212, 1980

King-Smith, P.E., and D. Carden. Luminance and Opponent-Color Contribution to Visual Detection and Adaptation To Temporal and Spatial Integration. Journal of the Optical of America, volume 66, 709-717, 1976

Boyton, R.M., and P.K. Kaiser. Vision: The Additivity Law Made To Work For Heterochromatic Photometry With Bipartite Fields. Science, 161, 366-68, 1968

Ingling, C.R., Jr. The Spectral Sensitivity of the Opponent-Color Channels. Vision Research, volume 17, 1083-1089, 1977

Ingling, C.R., Jr. Luminance and Opponent Color Contributions To Visual Detection and To Temporal and Spatial Integration. Journal of the Optical Society of America, volume 68, 1143-46, 1978

Kinney, J.A.S., S.M. Luria., C.L. Schlichting, and D.F. Neri. Depth Perception With Yellow Goggles, Naval Submarine Medical Research Laboratory, Report #960, October, 1980

Schlichting, C.L., S.M. Luria, J.A.S. Kinney, D.F. Neri, W. Kindness, and H.M. Paulson. Aids for Improving Vision In Whiteout. Naval Submarine Medical Research Laboratory, Report # 937, August, 1980

Ingling, C.R., Jr., S. Burns, and B.A. Drum. Desaturating Blue Increases Only Chromatic Brightness. Vision Research, volume 17, 501-503

Bierman, M.D. Lenses In Shooting. American Journal of Ophthalmology, volume 35, 859-860, 1953