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16. Abstract Thirty-nine human subjects were exposed to repetitive backscatter light stimulation (off a white wall or fog) from a Grimes capacitance discharge airplane anticollision light flashing at 1.27 Hertz. Both tonic (light stimulus absent) and phasic (light stimulus present) stimulus-bound occipital EEG, heart rate, respiration, skin potentials, and eyeblinks were recorded. In the first experiment, response decrement (habituation) to the flashing light occurred only with one out of five response measures (skin potential) over a 40-trial session indicating that the flashing light was a potent stimulus. None of the subjects demonstrated photic driving, seizure activity, or theta wave activity in his EEG. Most subjects reported the light as noxious, none became nauseated, but many became drowsy over the course of the experiment and several reported dark deadaptation from the flashing light. In Experiment II, eyeblink and skin potential measures differentiated between an instrument-rated pilot group and an age-matched control group of non-pilot professional men. The results suggest that, although the flashing anticollision light induces changes in physiological measures which are resistant to habituation, these changes do not extend to the induction of nausea.			
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EFFECTS OF BACKSCATTER OF BRIEF HIGH INTENSITY LIGHT ON PHYSIOLOGICAL REPOSSES OF INSTRUMENT-RATED PILOTS AND NON-PILOTS

The view is fairly common that some of the immediate effects of intermittent photic stimulation may result in altered states of consciousness, vertigo, fear and visceral disturbances.^{2 3 17 18 19} This has wide implications for people exposed to flickering light stimulation. Of most concern is the effect of intermittent light stimulation on airplane pilots since impairment of ability to function can have the gravest consequences in the event of an emergency.

The nature of the evidence for the view that intermittent photic stimulation can cause impairment of ability to function comes from several sources. First, much of the evidence is of an anecdotal sort and as such presents problems of valuation. The second form of evidence comes from clinical EEG laboratories where intermittent photic stimulation is used as a tool in assessing epilepsy. The third type of evidence comes from experimental research laboratories. Since there are wide variations in research methodology, the intensity of the photic stimuli used, the rate at which the light pulses were presented, and in the subject populations employed, there is room for contradictory claims. Discussion of different aspects of the problem as well as good reviews of the literature are abundant.^{1 4 7-11 15 16 20}

Most of the earlier experiments dealing with the effects of intermittent light stimulation on physiological indices and performance have employed frequencies higher than the flash rates of most airplane anticollision lights and have used electroencephalograms almost exclusively as the index of physiological response. These studies do not bear as directly on the problem confronting pilots flying through clouds or fog as would studies which use flash frequencies in the range countered by pilots. It was the purpose of the present experiment to determine under controlled conditions the effects of brief high intensity light

pulses from an actual airplane anticollision light flashing at 1.27 Hertz on a variety of physiological measures in a normal non-pilot population. Post-experimental verbal reports of the experience were also obtained from the subjects.

EXPERIMENT I

Methods

Subjects. A group of 13 young adult males (age range 17-25 years) comprised of medical students from the University of Oklahoma Medical School and introductory psychology classes from Oklahoma City University with no history of epilepsy participated in the experiment. Each experiment lasted for about one hour. Subjects were paid for participation in the experiment.

Procedure. Upon arriving at the laboratory, subjects were told that they would be part of a visual stimulation experiment and that a variety of physiological responses would be monitored. Skin surfaces where recording electrodes were to be attached were cleaned with acetone. Grass silver cup electrodes were used to record EEG and eye blinks. The occipital EEG lead was attached 1 cm above and 1 cm to the right of the occiput. This lead was referenced to the ipsilateral ear lobe. For eye blinks, leads were attached above and below the left eye. Plate EKG leads were attached on the right shoulder and on the chest below the heart. Beckman skin potential leads were attached to the second finger tip of the left hand and to the volar surface of the left arm. A common ground lead was attached to the volar surface of the left arm above the reference skin potential lead. A strain gauge respiration lead was attached across the chest at the bottom of the rib cage. Physiological responses were recorded on a Beckman Type RM rectilinear inkwriting dynograph running at a paper speed of 10 mm/sec.

Design. The experiment was set up to provide 40 trials, each of which was 10 seconds in duration, of high intensity condenser discharge light stimulation. The light source was a Grimes model no. 30-360-1 high intensity condenser discharge airplane anticollision light. Flash rate was constant at 1.27 flashes per second. The intertrial interval between each 10 seconds of flash stimulation was 30-90 seconds, varying randomly in 15-sec steps as determined by a table of random numbers. A Gerbrands tape programmer turned on a Hunter 111C timer for 10-second periods at the randomly prescribed intervals. The Hunter timer, in turn, controlled the power source to the Grimes light. Preliminary tests indicated that the sound of the capacitor charging in the Grimes light was a confounding cue which would trigger physiological responses not due to the light flashes. To circumvent this problem, a Grason-Stadler 901B white noise generator was employed in conjunction with a Koss Pro 4A headphone set. Further testing revealed that an 80 db re: .0002 dyne/cm² white noise effectively masked the capacitor charging sound and other equipment sounds.

Response quantification. Occipital EEG was recorded with a 0.3-second time constant and at a gain of 50 μ volts/cm. To be scored as alpha wave activity, two or more consecutive brain waves of 8-12 Hertz had to be present in the EEG. Visually, alpha stands out from the background EEG in the awake subject by being of larger amplitude than the background activity and by exhibiting synchrony (i.e., when alpha occurs, it is generally present in "bursts" of several waves in a row). The percent alpha in the 10 seconds preceding each stimulus was scored as well as the percent alpha in the 10 seconds during flashing light stimulation.

Eye blinks were recorded at a gain of 0.2 mv/cm with a 0.1-sec time constant. Since spontaneous blinks occur with a frequency greater than zero and the spontaneous blink rate varies among individuals, blinks were scored both during the 10 sec preceding each stimulus and during the 10 sec of each stimulus.

Skin potential responses were recorded with a 1.0-sec time constant at a gain of 0.5 millivolts/cm. Response amplitude was measured in millivolts from response onset to peak of response. Response amplitudes were summed separately for the 10-sec pre-stimulus periods and 10 sec during

light stimulation periods to yield baseline and stimulus-elicited responding scores, respectively.

Respiration rate was recorded with a 1.0-sec time constant. A flexible tube, which changed its resistance when stretched, was taped to the subject's chest. This changing resistance was part of one arm of a Wheatstone bridge circuit. The distance between respiration peaks was measured and converted to rate/min. Rate in the 10 sec preceding a stimulus and the first complete respiration cycle during the stimulus were recorded for each trial.

Heart rate was recorded by a cardi tachometer coupler. It was qualified in terms of mean beat per minute change from the mean of the 10-sec period before stimulation compared to the 10 sec during stimulation.

Results

All trials effect comparisons were based on the nonparametric Friedman analyses of variance pre-during stimulus comparisons and specific trial comparisons were based on correlated difference between means t-tests. The $p < .05$ two tailed rejection region was adopted throughout.

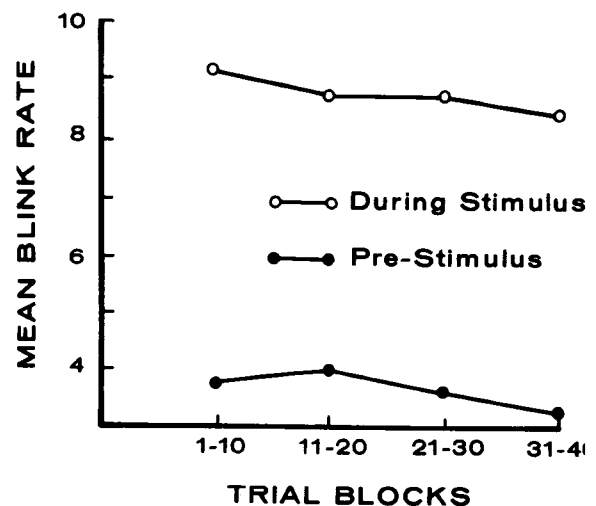


FIGURE 1. Mean number of eye blinks in 10 trial blocks pre- and during- light flash stimulation.

Figure 1 summarizes the results for the eye blink data. Both the mean pre-stimulus blink rate and the mean rate of blinking during photostimulation are presented in 10 trial blocks. Several results are evident from this figure. First, collapsing the data across trials, there is

a highly significant increase in blinking to the light flashes when compared with the pre-stimulus blink rate ($t=8.30$, $df=12$, $p<.001$). Second, the blinking rate to the flashing lights did not habituate as indicated by a nonsignificant Friedman nonparametric analysis of variance for trend across trials. Third, no significant changes in basal blink rate occurred over trials as indicated by a second Friedman analysis of variance.

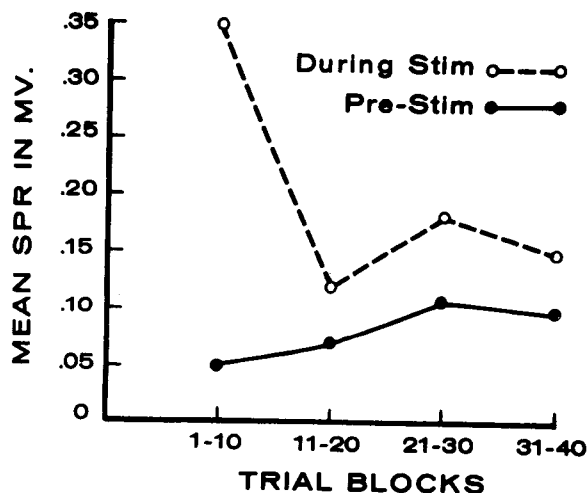


FIGURE 2. Mean magnitude of skin potential responses in millivolts for 10 trial blocks pre- and during-light flash stimulation.

Figure 2 summarizes the results for the skin potential data. A Friedman nonparametric analysis of variance indicated that the decrement in responding across trial blocks was significant ($C=12.15$, $df=3$, $p<.01$). Further testing indicated that a significant decrement occurred between the first and second trial blocks ($t=2.51$, $df=9$, $p<.05$). None of the other comparisons was significant. Thus, most of the decrement occurred in the first 10 trials with no consistent change occurring thereafter.

Figure 3 summarizes the results for respiration data in 10 trial blocks. Collapsing across trials, significant difference in respiration rate was found with rate increasing during photic stimulation when compared to the rate just preceding photic stimulation ($t=2.83$, $df=9$, $p<.02$). The respiration changes across trial blocks were not significant for either the pre- or during-stimulus tests.

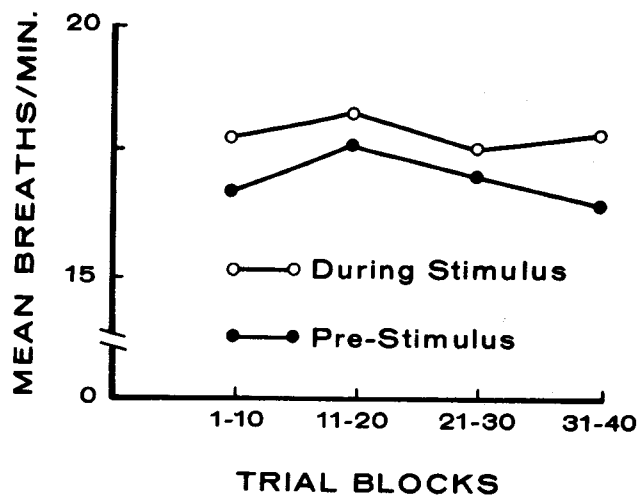


FIGURE 3. Mean rate of respiration in 10 trial blocks pre- and during- light flash stimulation.

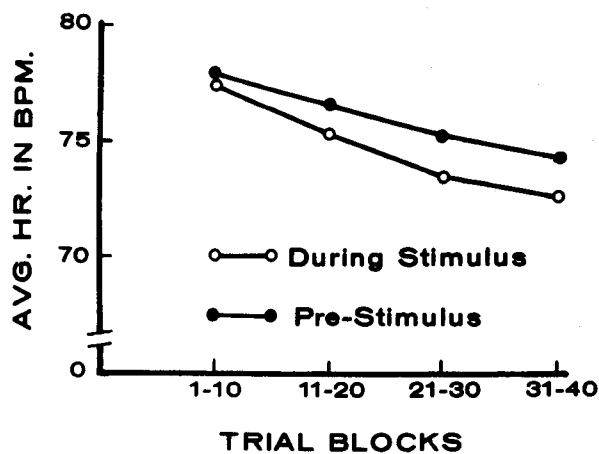


FIGURE 4. Mean heart rate over 10 trial blocks pre- and during- light flash stimulation.

Figure 4 summarizes the results for heart rate data over trial blocks. Collapsing across trials, a small but highly reliable heart rate deceleration was found when comparing pre- with during-stimulus heart rate ($t=5.65$, $df=12$, $p<.001$). The decrease in basal heart rate as measured over trial blocks in the pre-stimulus interval was not significant ($C=4.88$, $df=3$, $p<.05$). However, the heart rate decrease across trial blocks during light stimulation was significant ($C=13.3$, $df=3$, $p<.01$).

EXPERIMENT II

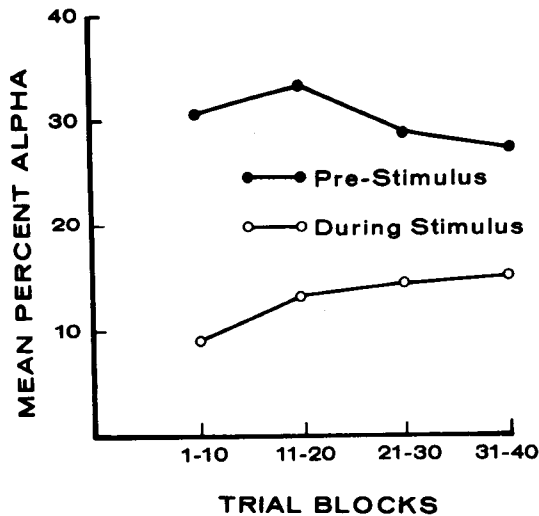


FIGURE 5. Mean percent brain wave activity in the alpha range (8-12 Hertz) for 10 trial blocks in the pre- and during- light flash periods.

Figure 5 presents the mean percent brain wave activity in the alpha range (8-12 Hertz) in the pre-stimulus period and in the light stimulus period across trial blocks. As is evident from Figure 5, there was a highly reliable reduction in alpha activity while the light was flashing when compared to the pre-stimulus alpha baseline ($t=3.68$, $df=12$, $p<.001$). Although Figure 5 shows an increase in percent alpha over trial blocks in response to the light stimulus, the trend was not significant ($C=2.82$, $df=3$, $p>.05$). Similarly, the changes in percent baseline alpha over trial blocks were also nonsignificant ($C=1.2$, $df=3$, $p>.05$). In summary, these tests indicate that habituation of alpha blocking to light stimulation did not occur.

Questionnaire data indicated that none of the subjects became nauseated during the experiment. A majority found the light flashes irritating or annoying. A couple of subjects claim that they experienced "eye strain" or "eye fatigue" from exposure to the light flashes. Several reported that for about 1-2 seconds after photic stimulus offset the room background illumination seemed to dim and the room and everything in it appeared subjectively darker. Most of the subjects reported drowsiness toward the end of the experiment.

Since the subjects in the first experiment were not pilots and the possibility exists that pilots may respond differently to flashing lights than non-pilots, the first experiment was repeated, but it utilized instrument-rated pilots as subjects as well as an age-matched control group of non-pilots. Secondly, the actual back-scatter conditions were simulated more closely by using back scatter from man-made fog as the stimulus.

Methods

Subjects. A group of 12 instrument-rated pilots from the Oklahoma City area and a group of 14 non-pilot professional men from the University of Oklahoma Medical School served as subjects in the experiment. The average age of the subjects was 40 years. Pilots and non-pilot did not differ significantly on average age. Each session lasted about 80 minutes. At the end of the experiment subjects were administered post-experimental questionnaire. Post-experimental verbal reports and ratings were also obtained from the subjects. Subjects were paid for participation in the experiment.

Procedure. Upon arriving at the laboratory subjects were told that they would be a part of visual stimulation experiment and that a variety of physiological responses would be monitored. Electrode placements and data quantification were the same as in Experiment I except that the pulse train duration in Experiment II was extended to 40 seconds for pre- and during stimulus measures. For eye blinks, skin potential responses, and alpha EEG activity, data were quantified over 40-second intervals instead of the 10-second intervals of Experiment I. For heart rate the data were scored over the 10 seconds preceding a stimulus and the first ten seconds during the stimulus because preliminary data indicated that that is where the changes were taking place. Respiration was not scored in the second experiment because of recording difficulties with the transducer.

Experiment II was performed in the fog chamber of the Civil Aeromedical Institute, the FAA Center in Oklahoma City. After being instrumented, the subject, clad in a surgical gown, was placed in a semi-reclining position in a plastic lawn chair in the fog chamber. Temperature was $72^{\circ}\text{F} \pm 2^{\circ}$ and the humid

was 100%. A flashing Grimes airplane anti-collision strobe light was placed below and behind the subject. The fog density was such that neither the experimenters nor the subject could see more than five feet in the fog chamber. On two occasions the fog generator iced up and the data from the subjects were not used because the fog density thinned visibly.

Design. The experiment was designed to provide 20 trials, each 40 seconds in duration, of repetitive high intensity condenser discharge light stimulation. The light source was a Grimes model no. 30-360-1 high intensity condenser discharge airplane anticollision light. Flash rate was constant at 1.27 flashes per second and flash duration was $\approx 10 \mu\text{sec}$. The intertrial interval was 30-90 seconds, varying randomly in 15-second steps as determined by a table of random numbers. A Gerbrands tape programmer operated Hunter 111C timer for 40-second periods at the randomly prescribed intervals. The Hunter timer, in turn, controlled the power source to the Grimes light. Sound masking was provided by a Grason-tadler 901B white noise generator via a Koss ro 4A headphone set. The white noise generator was set to provide 80 db re: 0.0002 dyne/ cm^2 white noise at the earphones.

Both instrument-rated pilots and the control group of non-pilots received the same sequence of 20 trials of flashing light stimulation. For the pilot group a 100-watt overhead light was on in the fog chamber at all times during the experiment.

The non-pilot matched control subjects received the flashing light under two conditions. For one-half of the control subjects the overhead light was on for the first half of the experiment and was turned off for the second half of the experiment. For the second half of the control subjects, these conditions were reversed. This procedure tested the hypothesis that the physiological and subjective effects of the flashing light stimulus are determined, in part, by contrast or amount of light change.

For each response measure the data were analyzed by 3-factor repeated measures (Case 1) analyses of variance.²¹ Factor one was the instrument-rated pilot versus non-pilot dimension. Factor two was the pre-stimulus basal measure compared with the during-stimulus measure. Factor three was repetition, i.e., response change

over 4 trial blocks. In all cases two-tailed tests were used and the criterion for rejection of the null hypothesis was set up at $p < .05$ or better.

Results

Figure 6 summarizes the results for the eye-blink data. Both the mean pre-stimulus blink rate and the mean rate during light flash stimulation are presented for the four trial blocks. The instrument-rated pilots did not differ significantly in overall blink rate from the age-matched non-pilot group ($F < 1$, $df = 1$, 22, $p > .05$) indicating that the blink rate between groups was nondifferential. There was a significant groups-by-stimulus interaction ($F = 11.46$, $df = 1$, 22, $p < .01$), with the instrument-rated pilot group having a higher pre-stimulus blink rate than stimulus rate, whereas the group of non-pilot showed increased blinking during the flashing light stimulus over their pre-stimulus rate.

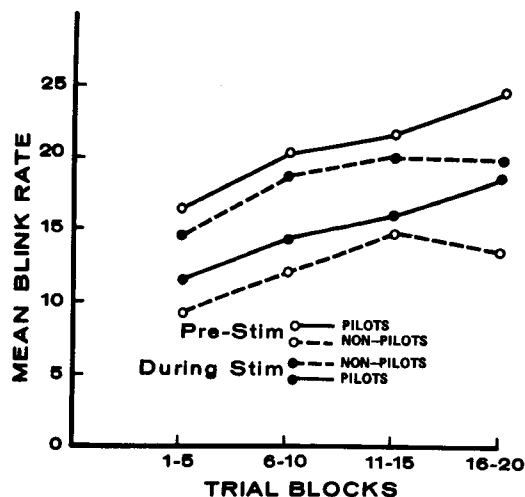


FIGURE 6. Mean number of eye blinks in 5 trial blocks pre- and during- light flash stimulation.

There was a significant trials effect ($F = 4.64$, $df = 3, 66$, $p < .01$) indicating that blink rate increased over the course of the experiment. The groups-x-trials interaction was not significant, suggesting that both pilots and non-pilots contributed about equally to the significant trials effect.

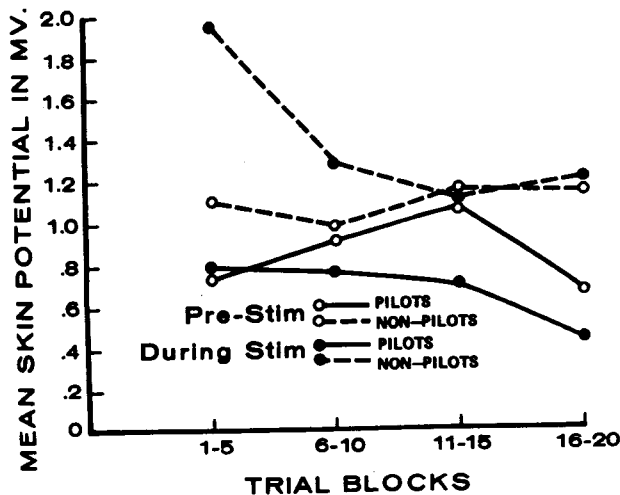


FIGURE 7. Mean magnitude of skin potential responses in millivolts for 5 trial blocks pre- and during- light flash stimulation.

Figure 7 presents the skin potential response data in summary form. The three-factor analysis of variance for the skin potential data indicates that (1) pilot and non-pilot groups did not differ in their overall level of skin potential responding ($F=1$, $df=1,22$, $p>.05$); (2) there was a significant groups-x-trials interaction ($F=3.48$, $df=3,66$, $p<.05$). The interaction was due to the fact that pilots did not differ in their pre-stimulus or during-stimulus responses nor did they change their responding over trials. The non-pilot group, on the other hand, had a stable pre-stimulus response rate over trials but their response to the flashing light stimulus was largest initially and showed steady decrement (habituation) over trials.

Figure 8 summarizes the heart rate data. The analysis of variance of the heart rate data did not disclose any significant differences between groups in either basal heart rate or in pre-during stimulus heart rate changes, although there was a non-significant decrease in rate from pre-stimulus base to stimulus for both groups. There was a significant trials effect ($F=4.5$, $df=3,66$, $p<.01$) indicating that for both groups heart rate decreased over trial blocks.

Figure 9 summarizes the EEG data. Figure 9, inconjunction with a three-factor analysis of variance, indicates that neither groups, nor stimulus, nor trials had any significant effect on percent alpha rhythm.

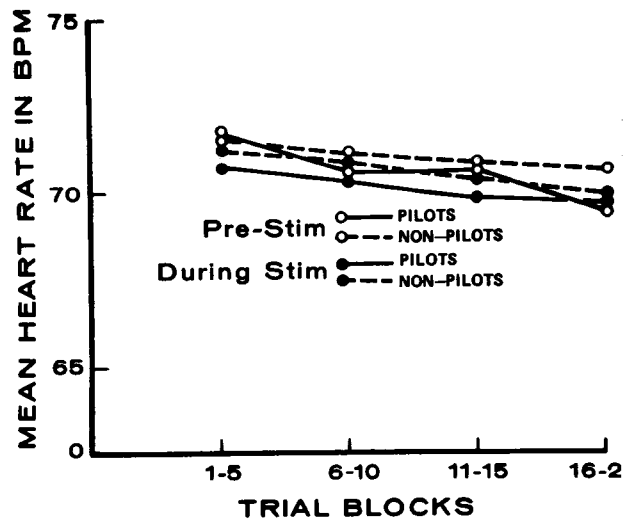


FIGURE 8. Mean heart rate in 5 trials blocks pre- and during- light flash stimulation.

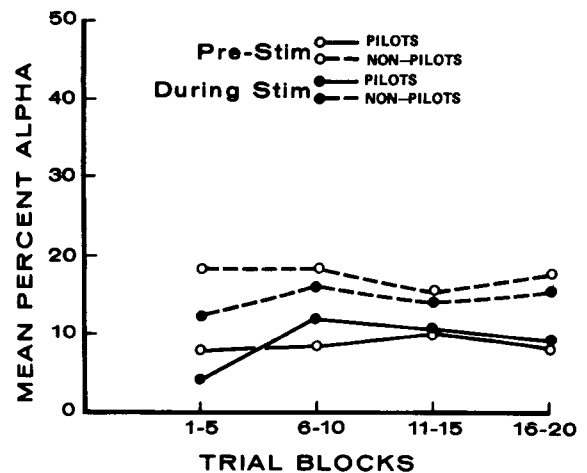


FIGURE 9. Mean percent brain wave activity in the alpha range (8-12 Hertz) for 5 trial blocks in the pre- and during- light flash periods.

In the control group there was suggestive evidence with the physiological measures that the degree of change or contrast determines the amount of physiological responding to the flashing light. The control subjects who received the flashing lights with the overhead light off responded with larger responses than did subjects who received the flashing light with the overhead lights on. The effect was not statistically significant because there was one reversal and the sample size was too small to tolerate such reversal.

The post-experimental questionnaire results indicated that none of the subjects in either pilot or non-pilot groups experienced any subjective feelings of nausea. Eight out of 12 pilots and seven out of 12 non-pilots developed severe drowsiness over the course of the experiment. Some felt that had the experiment continued longer they could not have stayed awake. There was no difference in the noxiousness rating assigned to the flashing light by pilots or non-pilots. The non-pilot controls who received the flashing light under overhead light-on and overhead light-off conditions, rated the flashing light significantly more noxious when the overhead light was off ($t=5.05$, $df=11$, $p<.001$).

DISCUSSION

In Experiment I, 13 young adult males ranging from 17-25 years of age were exposed to very intense reflected intermittent light flashes from a Grimes condenser discharge airplane anticollision light. Their EEG, eye blinks, skin potential responses, heart rate, and respiration rate were monitored. Over a 40-trial session, habituation (response decrement) occurred only with the skin potential response.

In Experiment II, 26 adult males ranging from 31 to 51 years of age were exposed to very intense backscatter off man-made fog produced by a Grimes condenser discharge airplane anticollision light. Brain wave activity, eye blinks, in potential responses and heart rate were continuously monitored over the course of twenty-sec trains of light pulses. Heart rate and brain wave activity did not differentiate between groups, but significant differentiation occurred with eye blinks and skin potential measures.

In our sample of subjects neither photic driving nor EEG seizure activity occurred. These findings are in line with the results of previous experiments which indicate that for both photic driving and EEG seizure activity, the adequate stimulus is a light flashing at faster than 4 c/rtz.⁸

Data of the present experiment readily fit into a framework of the habituation literature.^{6, 14} Our finding that the skin potential response habituates sooner than does the occipital alpha blocking responses to intermittent light stimulation supports the findings of Sokolov^{12, 13} and his workers.

The fact the eye blinks to the anticollision light flashes showed no decrement over trial blocks in either Experiment I or II suggests that the reflected light may have been intense enough to elicit a protective reflex. None of the commercially made photic stimulators on the market puts out a light even approaching the intensity of the Grimes anticollision light. Thus, there is a scarcity of data with which to compare our findings on this point.

In Experiment II there was actually a significant increase in blinking in the pilot and non-pilot groups over trials. Since the increase occurred not only to the light stimulus but also during the pre-stimulus base level periods, it was probably not due to the effects of the light becoming more noxious over repeated presentations. A more parsimonious explanation would ascribe the increase to the humid environment. This interpretation is supported by statements of subjects from the post-experimental questionnaire.

The fact that pilots blinked less to the flashing light than during the pre-stimulus period can be ascribed to a combination of greater familiarity and possible adaptation to flashing light and to greater defensiveness by the pilots than non-pilots. Support for the latter interpretation comes from the post-experimental questionnaire. Several pilots volunteered the information that they actively resisted the effects of the flashing lights by concentrating on their great toe or on an imaginary instrument panel. Non-pilot subjects did not report engaging in such activities.

The skin potential data also offer support for the view that instrument-rated pilots were more defensive than non-pilot subjects. Whereas non-pilot subjects showed habituation of responding to the flashing light as had college students in Experiment I, the pilots by concentrating on something else while the light was flashing, were able to suppress their responses so that there was no difference in their pre-stimulus base versus during-stimulus response measures.

In our first experiment in which a younger, more responsive college student population was utilized for subjects, significant physiological changes to backscatter off a white wall from the Grimes light occurred in all measures (occipital EEG, skin potential, heart rate, respiration, eye blinks). In the second experiment, responses with occipital EEG and heart rate measures were

not significantly different although they were in the same direction as had been the case in the first experiment. A plausible explanation for this discrepancy is attributable to either (1) the fact that the intensity of backscatter from fog in the second experiment was much less than the backscatter from the white wall in the first experiment, or (2) the fact that young college-age subjects are more responsive than are older subjects.

Our finding, that none of the subjects in either experiment became nauseated, does not mean that under actual flying conditions pilots may not be affected. A potentially significant factor which was not present in our experiment but which is present under actual flying conditions is vestibular input and its interaction with visual phenomena.

Our finding that there was a consistent decrease in heart rate to the flashing light which did not habituate cannot be accounted for as an epi-phenomenon or by-product of respiration change. Since the first complete respiration cycle during light stimulation showed a consistent increase over the pre-stimulus respiration rate, then, if anything, heart rate during the light should have increased if it were positively related to respiration. Graham and Clifton⁵ in reviewing the literature on heart rate change to a variety of stimuli have concluded that the orienting response to stimuli is heart rate deceleration, a conclusion in line with our findings.

Subjects in other experiments⁹ as well as subjects in our experiments have noted that the experimental chamber appears appreciably darker just after light offset. This finding suggests that a marked degree of dark de-adaptation

occurs which may lead to a brief temporary interference with seeing the instrument panel under conditions of backscatter from clouds or fog.

Conclusion

The purpose of the experiments was to determine, under controlled conditions, the effects of short, high-intensity light pulses from an actual aircraft anticollision light flashing at 1.27 Hertz on a variety of physiological measures. Post-experimental verbal reports of the subjective experience were also obtained from the participants. Three groups of subjects composed of instrument-rated pilots, age matched non-pilot and medical students without flying experience were used for experiments in the laboratory of the University of Oklahoma Medical School and in the fog chamber of the FAA Civil Aeromedical Institute in Oklahoma City. The light source was a Grimes model No. 30-360-1 high-intensity condenser discharge flash tube. Heart, respiration and blink rates, EEG, and galvanic skin response were recorded. In general, heart rate and skin potential were slightly elevated in the early part but decreased in the later part of the experiments. The blink-rate responses were different for the three groups: the pilots showed decrease, and the non-pilots and medical students showed an increase in eye blinks in the course of exposure. None of the subjects demonstrated photic driving, seizure or theta-wave activity on his EEG, or nausea but experienced the backscattered light as noxious, and many became drowsy. The results bear directly on the problem of anticollision lights used during flight under backscatter conditions.

REFERENCES

1. Davidoff, R. A., and Johnson, L. C. Photic activation and photoconvulsive responses in a non-epileptic subject. *Neurology*, 13:617-621, 1963.
2. Gastaut, H. Combined photic and metrazol activation of the brain. *EEG Clin. Neurophysiol.*, 2:249, 1950.
3. Gastaut, H., and Hunter, J. An experimental study of the mechanisms of photic activation in idiopathic epilepsy. *EEG Clin. Neurophysiol.*, 2:263, 1950.
4. Gerathewohl, S. J., and Taylor, W. F. The effect of intermittent light on vision. USAF School of Aviation Medicine, Project No. 21-1205-0014, Report No. 1, 1953.
5. Graham, F. K., and Clifton, R. K. Heart rate change as a component of the orienting response. *Psychol. Bull.*, 65:305-320, 1966.
6. Harris, J. D. Habituation response decrement in the intact organism. *Psychol. Bull.*, 40:385-422, 1943.
7. Johnson, L. C. Flicker as a helicopter pilot problem. *Aerosp. Med.*, 34:306-310, 1963.
8. Johnson, L. C., Ulett, G. A., and Gleser, G. C. Studies of the photically stimulated EEG quantification and stability of photic driving patterns. SAM Report #57-54, 1957.
9. Melton, C. E., Higgins, E. A., Saldivar, J. T., and Wicks, S. M. Exposure of men to intermittent photic stimulation under simulated IFR conditions. OAM Report #66-39, 1966.
10. Mundy-Castle, A. C. An analysis of central responses to photic stimulation in normal adults. *EEG Clin. Neurophysiol.*, 5:1-22, 1953.
11. Orlansky, J. The use of flashing light to perturb human behavior. Research paper P-172, Inst. for Defense Analyses, Res. and Engr. Support Div., Contract DS-50.
12. Sokolov, E. N. *Perception and the conditioned reflex*. New York: Pergamon Press, 1963.
13. Sokolov, E. N. The orienting reflex, its structure and mechanisms. In L. G. Voronin, A. N. Leontiev, A. R. Luria, E. N. Sokolov, and O. S. Vinogradova (Eds), *Orienting reflex and exploratory behavior*. Baltimore: Garamond/Pridemark Press, 1965.
14. Thompson, R. F., and Spencer, W. A. Habituation: A model phenomenon for the study of neuronal substrates of behavior. *Psychol. Rev.*, 173:16-43, 1966.
15. Ulett, G. A. Flicker sickness. *Arch. Ophthalm.*, 50:687-695, 1953.
16. Ulett, G. A., Gleser, G., Winokur, G., and Lawler, A. The EEG and reaction to photic stimulation as an index of anxiety-proneness. *EEG Clin. Neurophysiol.*, 5:23-32, 1953.
17. Walter, W. G., Dovey, V. J., and Shipton, H. W. Analysis of the electrical response of the human cortex to photic stimulation. *Nature*, 158:540-541, 1946.
18. Walter, V. J., and Walter, W. G. The central effects of rhythmic sensory stimulation. *EEG Clin. Neurophysiol.*, 1:57-86, 1949.
19. Walter, W. G., and Walter, V. J. The electrical activity of the brain. *Annual Review of Physiology*, 11:199-230, 1949.
20. Watson, C. W., and Hunter, J. Detection of light-evoked cerebral electrical abnormalities among helicopter pilot trainees. Progress report to the Research and Development Division, Office of the Surgeon General.
21. Winer, B. J. *Statistical principles in experimental design*. New York: McGraw-Hill, 1962. P. 319.

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