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PAINTED HELICOPTER MAIN ROTOR BLADES

AND

FLICKER-INDUCED VERTIGO

By

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APPROVED: Robert W. Bailey

ROBERT W. BAILEY
LTC, MSC
Commanding

FOREWORD

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Table 1 was used with the permission of L. M. N. Bach and this permission is gratefully acknowledged.

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PAINTED HELICOPTER MAIN ROTOR BLADES

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I. INTRODUCTION

Recently, the U. S. Army Aeromedical Research Unit was asked to participate in a program of reducing mid-air collisions. A review of the problem resulted in the hypothesis that the most profitable research effort would be to increase the helicopter conspicuity. Subsequent research[1, 2] by this Unit on the visibility problem led to the recommendation that paint be applied to the upper surface of the main rotor blades of helicopters to enhance their conspicuousness.

Since this paint program would involve all training helicopters at the Aviation Center, the question was raised as to the possibility of adverse effects resulting from flicker in formation flights involving helicopters with painted blades. To this point, research involving flicker in fixed wing aircraft and helicopters[3, 4, 5, 6] has dealt with flicker disturbances as a function of interrupted light coming through either the blade or the propeller, but none was found indicating concern with flicker from sources away from the aircraft in which the pilot was flying. The situations dealt with so far have involved investigations of various light-dark ratios caused by the rotor blade or propeller of the aircraft in which the pilot was flying.

The apprehension expressed regarding the present problem was couched in terms of "flicker vertigo" being produced by observation of painted rotor blades. Vertigo, of course, has several connotations. It may result from vestibular stimulations, visual stimulations, or both. The technical definition of the sensation of vertigo indicates that there is more than one cause for vertigo, and more than one kind of vertigo. Consequently, it was necessary to define the phenomenon in question in order to plan the experimental design.

The problem of concern here was obviously visual in nature since it was expressed in terms of the possibility that a painted rotor system could stimulate the pilot in such a way as to cause spatial disorientation or other dysphoric sensations. This research, therefore, operationally defined vertigo as a flicker-induced phenomenon which causes some adverse effect as a result of viewing painted main rotor blades from above in formation flights.

In order to investigate this problem, a design was conceived which would relate certain psychophysiological responses to photic stimulations under the assumption that the effects (flicker vertigo) would be indicated by recordings of these parameters. Other research[3,7,8,9,10,11], has centered on the relationship of flicker to electroencephalographic (EEG) changes and suggested the utility of this measure in this regard.

It was implicit in this approach that there was some relationship between photic stimulations and flicker-induced vertigo such that an individual who demonstrated susceptibility to photic stimulations in the laboratory should be a good candidate to test for the possibility of flicker-induced vertigo in a helicopter. Consequently, two experiments were designed to answer the question of whether the viewing of painted blades produces sensations of vertigo.

In the first experiment, subjective data were gathered from a random sample of instructor and student pilots. This sample was divided so that one group of aviators was administered photic stimulations in the laboratory and the second group was not. Then both groups were flight-tested and information was compared, both with the subject as his own control and between subjects.

The second experiment incorporated the more objective psychophysiological data as well as some subjective data. The overall design for this experiment was to administer photic stimulation to a random sample of student pilots and record their EEG and EOG responses. Then a select number of these Ss were flown in helicopter formations containing painted rotor blades and comparisons in performance were made, again with subject as his own control and between Ss.

EXPERIMENT 1

METHOD.

Subjects. Thirty student pilots and eight instructor pilots were randomly chosen as Ss. From this sample, six student pilots and four instructor pilots were given a laboratory orientation to flicker and advised of the problem. Collectively, these ten Ss were designated Group E (experienced). The remaining twenty-eight Ss were designated Group N (naive) because they were neither briefed nor told that they were Ss until after their flight in a formation with painted rotors.

Apparatus. The laboratory apparatus consisted of a Polaroid Model 610 slide projector with an episcotister attached and a translucent plastic screen which served as a diffusion screen.

Procedure. Each S in Group E reported to the laboratory, individually, and was briefed about the problem to be investigated. Each was specifically asked about his concept of vertigo. (A significant agreement among Ss was noted and each response was along the line of spatial disorientation.) The S was then seated in a dimly lit room and the diffusion screen was placed 12 - 18 inches in front of his face and he was instructed to look at the center of the screen. He was told to expect a flickering light and was asked to verbally relate his sensations as they were experienced.

Frequencies of flicker were set at 7 cps, 10 cps, and 14 cps to correspond with the rate of the UH-1 helicopter which turns at approximately 10 cps (both blades considered), and Ss were stimulated with flashing light for a two-minute duration at each frequency in an ascending order.

After stimulations, Ss were debriefed and asked specifically about dysphoria, experience of colors, nausea and other symptoms of illness. Each S reported sensations ranging from dizziness to dysphoria and each S was sure he would be able to recognize such sensations, should similar photic stimulations occur.

The orientation period for Group E took place the last two duty days of the week preceding the week in which Groups N and E were scheduled to receive their first instructional periods in formation flying in the helicopter. Thus, none of the student pilots in Groups N or E had experienced formation flying in the UH-1 helicopter, and none had flown in formations which included painted blades although most Ss had seen the painted blades on solo helicopters.

For the flight test, Ss flew in both "V of Vs" and "Staggered Trail" formations. They were randomly positioned throughout the formations and were thus stimulated by the blades at a variety of positions and angles.

Upon completion of the flight period, each S was interviewed and debriefed. The following questions were asked and answers were recorded verbatim:

1. What did you think about the flight?

2. As you watched the rotors, did you notice any sensations that were peculiar?

3. Did you have any unusual difficulties with your eyes? In other words, were there any unusual problems with your eyes that you have never had before?

4. Did you notice any unusual muscle activity around your head or any part of your body?

5. What about any general symptoms of illness? Did you notice any problems there?

6. What is your personal opinion of painting the rotor blades? Do you think it helps you see the aircraft any better?

7. How did you like the blades when you first saw them? What do you think of them now that you have flown in formations with them? Why?

In addition, each S in Group E was asked if he noted any sensations similar to those he experienced in the laboratory.

RESULTS AND DISCUSSION.

Table 1 indicates the technique by which responses were judged. This table, abstracted from a comprehensive report on flicker[7], seemed a promising way to assess results.

On the basis of the table, each response was scored as zero which indicates no adverse responses. None of the thirty-eight Ss interviewed reported any sensations that were peculiar. There were no reports of unusual difficulties with the eye nor were there any reports of unusual muscle activity. No S reported any symptoms of general illness.

All Ss indicated a favorable opinion in response to Question 6. Each S was of the opinion that the paint did make the aircraft easier to see.

Question 7 was aimed at obtaining Ss' impressions on seeing the painted blades as compared with their first notice of the blades. All Ss reported favorable impressions on first seeing the blades and further contact did nothing to alter these impressions.

Several related comments should be noted. Ss indicated that, in some instances, the painted blades were perceived as an asset in formation flights. These comments were based on opinions that attitudes of the lead helicopters were more easily detected, especially rolling in and out of turns, because of a noticeable change in the plane of the rotor disc.

Student pilots are instructed as to proper sight picture in formations and one of the questions of concern was whether pilots would be forced to stare at the paint patterns. There were no reports of such incidents.

Special reference should be made to the responses of Ss in Group E. None reported any sensations similar to or remotely resembling those reported in the laboratory.

Dichotomizing responses into those from instructors versus those from students yielded essentially the same information, that is, there were no indications of adverse effects as a result of painted rotor induced "photic stimulation" while flying in formations.

Table 1

CLASSIFICATION OF EFFECTS

A Effects: Hypnotized - strange - panic - disturbing - dizzy - hazy - woozy - pass out - head heavy - mind blank - can't concentrate - drowsy - loss of orientation - balance - paralyzed - eyes functionless.

B Effects: Eye fatigue - eye sting - watery - eyes hurt - pressure on eyes - eyes wandering - pain.

C Effects: Blinking - face and eyes twitching - violent or driven blinking - jumping (with light) - hard to keep eyes open - head and jaw muscles pulsating with light.

D Effects: Headache - tense - nausea - queasy - chills up and down spine - turning in pit of stomach - muscles tense in back of neck.

	0 = No adverse response				
	1	2	3	4	5
	Antici-patory	Slight effect	Moderate effect	Moderate large effect	Extreme effect
A Effect	"	mind blank can't concen-trate drowsy	strange head heavy disturbing	panic loss of ori-entation balance enclosure	hazy pass out hypnotized dizzy woozy paralyzed eyes func-tionless
B Effect	"	slight eye fatigue	eye fatigue pressure on eyes eyes wander-ing	eyes sting sore irritated pain	eyes watering
C Effect	"	blinking eyes twitch-ing	fast blinking hard to keep eyes open	driven blinking jaw muscles pulsating with light (head)	violent jumping face twitch-ing
D Effect	"		bad feeling queasy turning in pit of stomach	headache muscles tense in back of neck	nausea chills up and down spine

CONCLUSIONS AND RECOMMENDATIONS.

As a result of the subjective data, the following conclusions were reached:

1. There were no adverse effects from flying in formations of helicopters that had painted main rotor blades.

2. Subjects given a pre-test orientation to photic stimulation performed no differently than Ss who were naive with regard to the painted blades.

3. The painting of helicopter main rotor blades has some values secondary to conspicuousness. Painted blades appear to serve as an aid in judging accelerations, decelerations, flight attitude and relative position.

EXPERIMENT 2

METHOD.

Subject. Thirty-seven student pilots were randomly selected to serve as subjects for the laboratory recordings. On the basis of their EEG activity and subjective responses to photic stimulation, ten of these were then selected to participate in the flight phase.

Apparatus. The same photic stimulation apparatus described in Experiment 1 was used in this experiment. A Grass Model 5 Polygraph was used to record two channels of EEG, one channel of EOG, one channel of eye blinks, one channel of photic stimulation and one channel of time code information. An Ampex DAS 100 data acquisition system was coupled with the Grass recorder so that magnetic tape recordings were made concurrently with the ink tracings. Calibration signals for the EEG recordings were provided by a Wavetek multi-purpose VCG 116 signal generator. A photocell was used to monitor frequency of photic stimulation. During the airborne phase of the experiment, a specially fabricated amplifier system was used, and the output from the amplifier system fed into an Ampex AR 200 airborne tape recorder system.

During the laboratory recording sessions, standard silver disc electrodes were used for all leads and during the airborne recording sessions silver disc electrodes were used for EEG signals and Beckman Bio-Potential electrodes were used for EOG and eye blink recording.

Subsequent to data recording, the EEG data were edited and one channel was then processed through a computer system consisting of a series of twenty bandpass filters with output of each filter integrated over a ten-second period. Integrated data were then converted from analog to digital form and further processed on a PDP-5 digital computer.

Procedure. Subjects reported to the laboratory, individually, and were given a short orientation to the problem and the role each would play. Each subject was then prepared for the recording session by having the skin cleansed with alcohol and the various leads attached. Parietal-to-occipital left and right placement was used for EEG leads and leads were attached to the outer canthus of each eye and above and below the orbit of the right eye. An ohmmeter was used to insure that resistance was 10 K ohms or less on each channel and a gold clip lead was attached to the left ear lobe to serve as ground.

After preparation, each subject was seated in a dimly lit room and the plastic screen was placed before the subject in the same manner as in Experiment 1.

EOG and eye blink recordings were made, using the Grass 5P1C low level DC preamplifier. A time constant setting of 0.8 was used and sensitivity was set at 0.2 millivolts per centimeter. EEG recordings were made with a Grass Model 5P5E EEG preamplifier. Sensitivity was set at 30 microvolts per centimeter with 60 cycle filters in.

After eye movement direction had been established and the subject was seated and comfortable, he was asked to close his eyes and relax. A calibration signal of 10 cycles per second was fed into the EEG leads for a 45-second period prior to the actual test run. All calibrations and eye movements were recorded both on the ink written tracing and the magnetic tape.

The actual test run was conducted in the following manner. Two minutes of eyes closed resting recordings were made. After the two minutes, S was directed to open his eyes and two minutes of eyes open rests were recorded. At the end of this two-minute period, the photic stimulation was introduced. Two minutes of stimulation at each of four frequencies was recorded. Frequencies were 7, 10, 14 and 28 cps and were controlled by voltage to the episcotister. The output of the photocell was recorded on the ink written tracing as a check on frequency. Following each two-minute period of photic stimulation, the light was turned off and the experimenter entered the room and asked the subject what he experienced at that time. Subject's responses were recorded verbatim on an IBM Executary dictating unit. Following the 28-cycle stimulation, the photic stimulator was turned off and S was directed to sit with eyes open and two minutes of eyes open resting recordings were made. Following this, two minutes of eyes closed resting recordings were made and then another 45-second calibration signal was fed into the EEG leads.

The two prime considerations for selecting ten subjects from the original group of thirty-seven were EEG activity and subjective responses. Five subjects were selected from the group because they demonstrated clearly defined EEG alpha rhythm photic driving activity and five subjects were selected because they reported dysphoric sensations when subjected to the photic stimulations. This group of ten subjects was further tested in the flight phase. Further discussion of these results is contained in the Results and Discussion section.

Because of certain administrative problems, three of the ten Ss were eliminated from the testing. This left seven Ss for the flight tests. The testing procedure consisted of a period of time during which the EOG leads were placed in the same manner as in the laboratory setting. However, the EEG leads were placed on the scalp with Grass electrode paste and collodion to allow the pilot to wear his flying helmet during data collection procedures.

The airborne recordings were made during actual tactical training maneuvers in formation flights with student pilots at the controls. There was, of course, no opportunity to manipulate variables and the only manipulation allowed was whether the pilot was in the formation with the other aircraft or was withdrawn from the formation and therefore flying single ship maneuvers. Each flight lasted approximately 50 minutes and contained both formation flying and solo flying. Data reduction techniques for both the laboratory and the airborne phases were outlined in the Apparatus section.

RESULTS AND DISCUSSION.

The incidence of dominant alpha activity was unusually high in this population. Under eyes closed conditions, 88 percent of the subjects demonstrated good alpha (defined as energy in any one band in the alpha range being greater than 10 percent of the total energy in the bandpass filter system). Such a high amount of alpha activity is unusual, especially on the first recordings of EEGs.

Under both eyes open and eyes closed conditions, we found subjects who developed drowsiness as measured by reduction in alpha frequency from the pre to the post photic stimulation run. What is, at first glance, surprising is the complete lack of overlap between those who demonstrate this phenomenon under eyes open conditions as compared to eyes closed conditions. An explanation for this discrepancy is not readily forthcoming. Utilizing either condition, we find approximately 25 percent of our subjects developing some signs of sleep inhibition.

If we utilize a more stringent criterion of sleep inhibition, namely, a decrease in the dominant alpha frequency coupled with a general shift downward of total energy, we find that seven out of eight subjects identified by the previous criteria are still so identified. The four frequencies below the alpha band, 4, 5, 6 and 7, and the four adjacent frequencies above the alpha band, 13, 14, 15 and 16, were evaluated with respect to shift and the percent of energy at each of the above center frequencies. Since we are concerned with the evaluation of drowsiness or fatigue as a function of exposure to photic stimulation, it was predicted that drowsiness would be accompanied by an increase in percent of energy found in the low frequency bands and a decrease in percent of energy in the beta one band (13 to 16 cps). Evaluation of the data demonstrated that three things could occur, a decrease in percent energy at a given frequency when comparing the post to the pre photic stimulation record, an increase in percent energy, or no change in percent energy. Using as a crude criterion of "drowsiness" that the number of frequencies at which the predicted change exceeded changes in the direction of greater alertness by at least two (out of a total of eight), we find that under the eyes closed condition eight out of seventeen subjects demonstrated an increase in drowsiness while three became more alert. Under eyes open condition, five out of fourteen subjects demonstrated an increase in drowsiness and three an increase in alertness. We thus have suggested evidence that photic stimulation produces more of a shift toward drowsiness than toward alertness.

Of the thirty-seven subjects evaluated, fifteen experienced no discomfort or unusual experience in response to photic stimulation. Nine experienced hypnagogic effect such as a feeling of sleep and drowsiness, relaxation, daydreaming and feeling of euphoria. Fifteen subjects experienced discomfort of one type or another. Specifically, they reported sensations of annoyance, irritation, eyes hurt, headache and soreness of eyes, difficulty keeping eyes open, loss of depth perception, distractions, sensation of feeling themselves moving or floating, and sensations of vertigo, nausea and dizziness. Thus more than half the subjects experienced some type of dysphoric sensation.

Whether the experiencing of dysphoric sensations with photic stimulation can be generalized to other situations such as helicopter flying seems a distinct possibility. If dysphoric sensations such as vertigo are experienced frequently enough by helicopter pilot trainees to be a source for disqualifying them from further flight training, a study relating these two phenomena - vertigo while flying and dysphoric sensations produced by photic stimulations - should be conducted with the aim of using the response to photic stimulation as a prediction of sensing disturbances during flight training.

An analysis of the data collected in flight showed a considerable artifact of the EEGs recorded. The major contribution to this artifact was believed to be the helicopter vibration producing electrical noise in the EEG amplifiers. Where data was adequate for evaluation, no signs of any abnormal EEG activity was detected. Eye movement and eye blink recordings were collected on six subjects. For four subjects, adequate signals for the concurrent analysis of both eye movement and eye blinks were obtained. Though we have no external criteria, we were impressed by a number of aspects of the data. These were:

(1) The lack of visual scanning by the pilot;

(2) The reduction in scanning rate as a function of time on task;

(3) Reduction in degree of movement with a given saccad;

(4) Reduction in blink rate as a function of time on task; and

(5) Impaiment in visual activity as measured by the relationship between saccadic movement and eye blinks.

CC ICLUSIONS AND RECOMMENDATIONS.

On the basis of this experiment and Experiment 1, the following conclusions, recommendations and observations are relevant:

1. Photic stimulation effects, as experienced in the helicopter, do not constitute a major problem with respect to the development of flicker-induced vertigo. Dysphoric sensations due to photic stimulation occur only under special conditions in the aircraft.

2. The EEGs of our subjects demonstrate markedly more alpha activity than is characteristic of similar groups of young men not on flying status.

3. The effect of photic stimulation on resting EEG activity is such that:

    (a) Subjects seemed to demonstrate one or more signs of a decrease in alertness when comparing the pre and post photic stimulation recordings;

(b) Some subjects demonstrate either no change in alertness or a post photic stimulation increase in alertness; and

(c) It thus appears that pilots are differentially affected by photic stimulation.

Interestingly, those reporting sensations of drowsiness or sleep in response to photic stimulation were not necessarily the subjects who demonstrated electroencephalographic evidence of drowsiness.

4. Subjective sensations in response to photic stimulation identified that nine out of thirty-seven experienced hypnagogic phenomenon and fifteen discomfort while being stimulated in the laboratory.

5. Eye movement and eye blink data collected in flight suggest that these measures may have considerable utility in evaluating adequacy of flight performance as well as a measure of task-induced fatigue. When appropriate amplifiers for in-flight recording become available, data will be collected on a series of pilot instructors and student pilots to further investigate the relationships between time on task and fatigue and the question of whether student pilots should engage in less visual searching than is desirable (using an instructor pilot as a criteria measure).

6. Helicopters with a symmetrical paint design on the upper surface of the main rotor blade did not interrupt the normal operations of the student pilots. Psychophysiological data and subjective data did not indicate the paint to be a source of flicker-vertigo.

LITERATURE CITED

1. Bynum, J. A., Bailey, R. W., Crosley, J. K., and Nix, M. S. Development of a paint scheme for increasing helicopter conspicuity. USAARU Report 68-1, September, 1967.

2. Crosley, J. K., Bailey, R. W., and Nix, M. S. Improving helicopter conspicuity through the use of painted main rotor blades. USAARU Report 68-2, October, 1967.

3. Stern, J. A. Photic Stimulation - The activation response simulated helicopter photic stimulation - EEG activation and subjective sensation. Final Report, U. S. Army Medical Research and Development Command Contract DA-49-193-MD-2179, September, 1965.

4. Johnson, L. C. Flicker as a helicopter pilot problem. Aerospace Medicine, 1963, 34, 306-310.

5. Carpenter, R. Flicker Vertigo. Flight Safety Foundation Pilots Safety Exchange Bulletin 55-110. November 30, 1955.

6. Ulett, G. A. Flicker Sickness. AMA Arch Opthalmology. 1953, 50, 685-687.

7. Bach, L. M. N. (Ed.) ERDL - Tulane Symposium on Flicker. ASTIA AD 155440, April, 1957.

8. Bach, L. M. N., Sperry, C. J., Jr., and Ray, J. T. Tulane Studies on the effects of flickering light on human subjects. In L.M.N. Bach (Ed.) ERDL - Tulane Symposium on Flicker. ASTIA AD 155440, April, 1957.

9. Johnson, L. C., Ulett, G. A., and Gleser, G. C. Studies of the photically stimulated EEG - Quantification and stability of photic driving patterns. School Aviation Medicine USAF Report 57-54, 1957.

10. Ulett, G. A., and Johnson, L. C. Pattern, stability and correlates of photic-electroencephalographic activation. J. Nervous & Mental Diseases. 1958, 126, 153-168.

11. Ulett, G. A., and Gleser, G. The effect of experimental stress upon the photically activated EEG. Science, 1952, 115, 678-682.