[illegible] VISIBILITY AS A FUNCTION OF [illegible] [illegible]ANSMISSION THROUGH FIXED FILTER VISORS

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Target Visibility as a Function of Light
Transmission Through Fixed Filter Visors

This study was conducted to determine the effect of amount of light transmission through fixed filter visors on the visibility of targets. The maintenance of proper visual acuity is of utmost importance to a naval aviator. For safety of flight reasons, he must be able to detect the presence of other aircraft at the greatest possible distance. Any goggles or visors provided for the protection of his vision must not seriously degrade visual acuity.

Procedures

Visors allowing fifteen percent, three percent, and one percent transmission of visible energy were used in this evaluation. These were compared against vision with no visor. The fifteen percent visor, made of neutral gray acrylic material, is that used on the APH-5 and APH-6 aviator's protective helmet. The three percent and one percent filters are gold-plated visors contemplated for issue to naval aviators for protection against retinal burns or flash blindness when operating in a nuclear environment. The principle underlying the use of gold plating is that gold film typically has a relatively high transmissivity in the visible spectrum compared with that in the ultraviolet and infrared regions (Hill and Chisum, 1963).

Part I of this study measured visual acuity under field conditions. It was conducted using the taxiway of the local airport at West Point, Virginia. This taxiway is one mile in length, perfectly flat, and free of all obstructions. It serves as an excellent visual range for field evaluations of this type.

For each trial, a subject used one of the visors being evaluated. He sat in the right hand side of an automobile and was driven at a constant speed (25 mph) toward a target. The target consisted of a Landolt ring, i.e., a three and one-half inch wide black circle on a white background. The circle was nineteen inches in outer diameter with a twenty degree section removed. It thus looked like the letter "C" at a distance. The task of the subject was to specify whether the opening of the C was up, down, to the left, or to the right as soon as he was able. Target orientation was varied for each trial.

Each trial began at a fixed distance from the target. The run was timed until the subject correctly indicated the orientation of the target. This time was then transformed, knowing the speed of the vehicle, into a measure of the distance at which the subject could initially distinguish the target.

Two adult males served as subjects for Part I of this study. Each had 20/20 vision.

Since the level of ambient illumination is known to influence measures of visual acuity, the two subjects were tested under the extremes of daylight conditions. One was tested in the morning of a clear, sunny day when the sky was virtually cloudless. The other was tested in the late afternoon on a day when the sky was completely overcast. Results for the two subjects are presented in the appendix of this report. A third subject was tested but his results are not presented since shifting cloud conditions caused wide differences in ambient lighting during the course of his trials.

In Part II of this study, standard measures of visual acuity were obtained, using a Snellen chart, under four levels of illumination. As in the first part, the three visors were used and were again compared with normal vision. For this part of the evaluation, four subjects were used, each of whom had 20/20 vision with one being corrected to this level by glasses. Results of Part II also are presented in the appendix.

Discussion

It generally is agreed that the perception of a distant object can be differentiated into at least three stages, each with its own threshold and its own reaction time (Andrews, 1958). The first of these is detection, that point at which the subject recognizes that an object is present. The second is recognition, when the basic nature of the object becomes known. This stage requires some detail discrimination. The final stage is identification, that point at which the exact features of the object become known. This final stage requires virtually complete resolution of the stimulus pattern for a proper decision to be made. Both Part I and Part II of this study deal with identification decisions and in each instance the target-background complex provides virtually no contextual cues to aid in the identification. This means that visual acuity is being measured at a demanding level.

The most impressive feature of the data of Part I is the obvious fact that, un er normal daylight conditions, a target can be seen at virtually the same distance whether a visor is worn or not. The average detection distance, as shown for the first subject, differs by less than 100 feet when the one percent transmission visor is compared with normal vision. A comparison of the results for the four experimental conditions clearly indicates that this fluctuation, which is less than 10 percent of the detection distance, can be attributed to chance variation alone.

Results for the second subject of Part I, who was tested in the decreased lighting beneath a solid overcast, are quite different. Here there is a steady degradation of visual acuity as one progresses from normal vision to the one percent visor. Visibility distances for the one percent are only about one-half of those for unobstructed vision.

One of the principal interests of this study was to compare the one percent and three percent visors. The regular reduction in visual acuity from normal vision to the one percent visor, under the decreased illumination conditions, suggests that the difference shown between the one and three percent might be significant. The Sign Test (Tate and Clelland, 1957) provides a quick yet reasonably sensitive test of this difference. Of the 15 series of runs on which the one and three percent visors were compared, one yielded identical detection distances while 13 of the remaining 14 showed the three percent visor to be superior. A thirteen-to-one split such as this is significant at the .01 level of confidence. Thus, at least for this subject, there is a significant difference in the relative effectiveness of vision through the one and three percent visors, under conditions of low ambient illumination, with the three percent visor allowing greater detection distances.

The data of Part II bear out the results of Part I. In this case, however, some decrement is noted when low transmission visors are worn at all levels of illumination. At high levels, the decrement is very slight and does not differ for the three and one percent visors. At low levels of illumination there is a progressive decrement. At these levels, visibility through the one percent visor shows considerable degradation over visibility with no visor. It also may be noted that here again the one percent consistently impairs vision more than the three percent.

The results of this study affirm what has long been known.

Although the human eye will respond to an extremely wide band of light intensities, there is a limited band for optimum function. Results of this study indicate that when a high contrast target is illuminated by approximately fifty foot-candles to sixteen hundred foot-candles of visible energy, the use or non-use of visors of varying density, even down to one percent transmission, makes very little difference in detection capability. For lower illumination levels, six foot-candles or less, visual acuity is seriously degraded.

There is an interesting feature to the data of Part II. By sheer happenstance, illumination levels were shosen so that the light reaching the eye under a test condition in which no visor was worn (target background luminance of two foot-lamberts) was exactly equal to that in another test condition when the one percent visor was worn (target background luminance of 200 foot-lamberts). In each case the adapting luminance should be two foot-lamberts. The data of Part II show that for each of the four subjects visual acuity was measured at 20/13 under these two conditions. This is, of course, exactly what we should find. The fact that this perfect matching occurs, however, adds strength to the conclusion that target visibility, at least for targets of this type, is purely a matter of contrast and is not influenced by the use of a visor per se.

When using the results of this study for predicting the hazard which might be involved if fixed filter visors were worn by pilots, there is one caution which should be observed. This study deals exclusively with the detection of targets through use of foveal vision. Dynamic visual acuity and peripheral acuity were not examined. It is not known whether the same relationships would hold in these instances.

Conclusions

1. Results of this study indicate that, under normal daylight conditions, the use of any visor, even one allowing only one percent transmission of visible light, does not reduce the ability to detect high contrast targets.

2. At low levels of illumination, such as found at dusk or beneath a solid overcast, visibility is consistently degraded as visor density increases. For these conditions, a three percent visor definitely is preferable to a one percent.

References

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APPENDIX

Part 1: Target Visibility Under Field Lighting Conditions

Series 1

Date:	6 March 1964				
Weather:	Clear sunny day				
Time of Measurement:		0845	0940	1010	1045
Target Background (ft-L):		1600*	1400	1200	900

Run No.	No. Visor	15% Visor	3% Visor	1% Visor
1	777	887	887	997
2	1144	997	887	740
3	960	997	923	887
4	960	997	997	887
5	1070	960	960	887
6	923	960	997	960
7	1070	997	1034	1144
8	1070	813	997	1034
9	1144	1070	1217	960
10	1107	1107	1070	960
11	1217	1144	1144	1070
12	1290	1107	997	997
13	1180	1034	1180	1034
14	1180	1070	1070	1070
15	1217	630	1217	1254
Aver. dist. (ft.)	1087	985	1038	992

*Measured with Weston Model 735 Light Meter.

Series 2

Date:	3 March 1964			
Weather:	Solid Overcast			
Time of measurement:	1535	1620	1700	1740
Target Background (ft-L):	75	45	20	4

Run No.	No Visor	15% Visor	3% Visor	1% Visor
1	850	446	410	373
2	667	593	556	446
3	703	667	593	483
4	703	630	483	520
5	740	630	446	336
6	740	667	520	336
7	630	667	483	373
8	813	703	483	410
9	813	593	667	410
10	777	556	520	483
11	777	630	446	300
12	740	520	520	300
13	813	593	410	410
14	813	667	336	263
15	923	703	263	153
Aver. dist. (ft.)	767	618	476	373

Part 2: Measures of Visual Acuity (Snellen Chart)

		Target Background Luminance			
		2 ft-L	6 ft-L	60 ft-L	200 ft-L
Subject 1	No Visor	20/13	20/13	20/15	20/10
	15%	20/15	20/13	20/15	20/10
	3%	20/20	20/20	20/13	20/13
	1%	20/20	20/20	20/13	20/13
Subject 2	No Visor	20/13	20/13	20/13	20/10
	15%	20/15	20/13	20/13	20/10
	3%	20/20	20/15	20/13	20/13
	1%	20/25	20/20	20/15	20/13
Subject 3	No Visor	20/13	20/13	20/13	20/10
	15%	20/20	20/15	20/13	20/10
	3%	20/30	20/20	20/15	20/13
	1%	20/40	20/25	20/15	20/13
Subject 4	No Visor	20/13	20/13	20/10	20/10
	15%	20/15	20/13	20/13	20/13
	3%	20/25	20/20	20/13	20/13
	1%	20/30	20/20	20/13	20/13

Note:
- 2 ft-L: Dark, snowy day, no room lights
- 6 ft-L: Room lights, plus indirect 100W bulb
- 60 ft-L: Sylvania motion picture light, low setting
- 200 ft-L: Sylvania motion picture light, high setting