An Assessment of a Proposed Method for Adjusting and Focusing Anvis Night Vision Goggles

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SUMMARY: Night vision goggles are becoming an increasingly important tool in military aviation. They provide superior visual capability over unaided night vision, but any reduction in goggle performance can have a serious effect on flight safety and operational effectiveness. This study shows that the use of a standard adjustment procedure in a night vision goggle (NVG) test lane, with a resolution chart, provides an effective method for aircrew to obtain better visual capability than is currently obtained by focusing on distant features of the landscape. Visual acuity (VA) was measured for 20 aircrew representing all crew positions, after using both the current adjustment method and the proposed method for adjusting ANVIS NVGs. The average visual acuity showed an improvement from 6/19 (s.d. = 3.9) with the current method to 6/13 (s.d. = 2.8) with the proposed method. However, NVG test lanes cannot be used with goggles which have fixed infinity objective lenses eg Night Vision Goggles (NVG).

Introduction

Night operations are playing an increasing role in military operations. Night vision goggles (NVGs) are widely used to enhance visual capabilities at night and as such have become an essential component of military aviation (1). Night vision goggles provide an amplified image of the ambient light, and although this is superior to unaided night vision, it is still inferior to daylight vision (2).

NVGs are a binocular assembly of two image intensifier tubes. Each of these has an objective lens which focuses an image onto a photo-cathode and then produces an amplified image using a microchannel plate. The amplified image is then viewed through the eyepiece (dioptré) lens (3). ANVIS type goggles are designed in such a way that the objective and eyepiece lenses can be adjusted (see Table 1). NVGs are a valuable aid to night flight, but there are inherent limitations on them. These limitations can be split into three groups: visual limitations and spatial disorientation (related to field of view, visual contrast and acuity); crew performance (affected by fatigue, endurance and crew co-ordination); and systems/hardware problems such as the inability to see wires and dimming of the image (by automatic gain control) due to bright lights (4).

Student pilots at the School of Army Aviation are given instruction on the use of NVGs as well as a briefing from a specialist in Aviation Medicine on the medical aspects of night vision and NVGs. They undergo 8 hours in-flight training with goggles during the Army pilot course. As part of their training they are taught how to focus and adjust the goggles prior to flying. Observations of the pre-flight routines of Army Air Corps pilots revealed that pre-flight adjustment and focusing procedures are inadequate. These errors are enough to cause a significant reduction in visual acuity.

Table 1

<table>
<thead>
<tr>
<th>The binocular assembly</th>
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<tr>
<td>a. Fore and aft adjustment knob – moves the entire binocular assembly toward or away from the eyes.</td>
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<tr>
<td>b. Tilt adjustment knob – allows wearer to rotate the binocular assembly.</td>
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<tr>
<td>c. Interpupillary distance (eyespan) adjustment knob – allows wearer to adjust for the distance between the eyes.</td>
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<td>d. Objective focus ring – focuses the goggles for distance (adjustment range is from 10 inches to infinity.</td>
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<td>e. Diopter focus ring – compensates for individual refraction error.</td>
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Common methods currently used to focus and adjust NVGs include focusing on a nearby hill or other landscape features around the airfield. In-flight adjustment of goggles is often found to be necessary, and qualified helicopter instructors (QHI) were often unsure of the visual acuity levels achieved by their students. The individual lenses are focused randomly and alignment of the goggles is haphazard.
The use of an NVG test lane (see Table 2) and a method of accurately adjusting and focusing ANVIS type NVGs provide the goggle user with a standard measure of his (and his/her students) goggle performance. It also allows the NVG novice to learn what should be seen through the goggles when they are properly adjusted and focused, which will be remembered when goggle adjustment 'in the field' is necessary. It is hoped that deterioration in tube performance will be noticed earlier than with current routines used, allowing defective tubes to be replaced before problems are noted in flight.

**Subjects**

Data were collected at the School of Army Aviation (a training situation) and in Northern Ireland (an operational situation). Twenty-two helicopter aircrew were studied of which: 3 qualified helicopter instructors, 9 helicopter pilots, 5 student pilots and 5 door gunners. All of the subjects had undergone ground-based NVG training and the NVG experience ranged from 0 to 155 NVG flying hours.

**Table 2**

NVG Test Lane Set Up

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<tr>
<th>Equipment</th>
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<tr>
<td>1. 7½-10 watt light bulb.</td>
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<tr>
<td>2. Lamp and shade with the opening covered by a card (black) with a 5mm diameter (20mm is recommended by the USAF) circular hole positioned centrally in front of the bulb and 40mm from it.</td>
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<tr>
<td>3. Snellen visual acuity letter chart.</td>
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<td>4. Light tight room at least 4m x 3m.</td>
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**Method of set-up**

5. Select a room which can be made light tight.

6. Hang the visual acuity chart on the wall slightly lower than eye height (when seated).

7. Attach a light source to the ceiling 3m away from and no more than 2m above the chart, pointing at the chart.

8. Mark a viewing distance of 3m and position a chair at this point directly facing the chart.

**Method**

Visual acuity was measured using each tube independently after the subject had focused the goggles using his/her usual techniques. Adjustments of the objective lens (only) were allowed at this stage as the measurements were done at 3m, and the usual technique involves focusing the objective lens to infinity. The subject was asked to read the letters on a Snellen Visual Acuity Chart line by line. If a mistake was made on a particular line, the line above was taken as the best visual acuity (see Table 3). The measurements were taken at 3m, but results were calculated to give a 6m visual acuity for ease of interpretation. This was done by simply doubling the figures eg. 3/6 becomes 6/12. The subject was then asked to refocus and adjust the goggles following the proposed technique and the visual acuity was re-measured for each tube as before. The illumination of the chart was constant, as described later in the text.
Proposed pre-flight procedure

The adjustment and focusing procedure was carried out in an NVG Test Line, using the visual acuity chart as a focusing aid. After donning the NVGs with all of the lenses set to zero the following adjustments were made:

**Align vertical**
- adjust the vertical position of the binocular assembly until it is directly in front of the eyes.

**Adjust tilt**
- adjust the tilt until the binocular assembly is perfectly aligned with the visual axis.

**Check IPD**
- adjust IPD (interpupillary distance) until a circular field of view is obtained.

**Adjust eye relief**
- adjust the fore/aft setting until it is possible to see underneath and around the goggles to view instruments (NB: if the eye relief is more than 30mm, the field of view will be reduced).

**Objective lenses**
- focus the objective ring, one tube at a time (whilst covering the other tube) until the chart is as clear as possible.

**Diopter lenses**
- adjust the diopter lenses one tube at a time (whilst covering the other tube) by rotating the diopter ring anticlockwise until the picture is slightly blurred. Slowly rotate the lens clockwise until the image just becomes sharp.

**Focus check**
- check the performance at 3 metres ensuring that the 6/6 line of the Snellen visual acuity chart is clear.

Note settings
- note the setting of the IPD and diopter lens for rechecking at the goggling up point in the aircraft.

Refocus to infinity
- refocus the objective lens to infinity using standard aircraft lettering at a distance of at least 30m in a dark area of the airfield.

Results

The visual acuity measurements obtained for each eye using the current and proposed pre-flight adjustment procedure are shown in Table 4. The means for each method are shown as averages for the two eyes and the improvement is the current method versus proposed method. There is a mean improvement in visual acuity from 6/19 (s.d. = 3.9) to 6/13 (s.d. = 2.8) and none of the 18 subjects showed a decrease in visual acuity. By applying the Bonferroni test the proposed method is shown to result in significantly better visual acuity than the current method (p<0.01).

This test also showed that with the current method, visual acuity of the right eye is better than that of the left eye (p<0.05). However, using the proposed method there is no significant difference between the two eyes. There is no evidence for crew position or NVG experience having an effect on visual acuity.

Discussion

The use of the proposed pre-flight procedure resulted in better visual acuity than using the current technique of focusing. This indicates better visual performance.
should lead to a greater operational effectiveness and safety during night missions. This may also help alleviate eye fatigue problems, caused by poor focusing and alignment of goggles.

It was found that the visual acuity of the right eye is superior to that of the left eye when using the current method of NVG adjustment. Even slight differences in focus between the eyes are thought to result in eye fatigue and this observation may explain some of the current problems of headaches and visual discomfort currently being experienced by aircrew after NVG sorties (5). This is the subject of ongoing research at the School of Army Aviation. Using the proposed method, no significant differences in the visual acuity were found between the eyes and this adds support to the argument for the introduction of test lanes and standardised focusing techniques.

The Armstrong Laboratory and USAF recommend the use of a square grating NVG resolution chart (see Table 2) instead of a letter chart (6). The main advantage is that the user cannot guess the orientation of the gratings and merely needs to count the number of resolvable squares to calculate visual acuity. Also, the user cannot learn the order of patterns, because the chart is periodically rotated through to 90°. However, this degree of accuracy in visual acuity assessment is not required for pre flight adjustment. Furthermore, the grating charts are expensive and so letter charts have been chosen in preference.

NVG test lanes (see Table 3) are relatively easy to set up in a permanent location, such as an Army Air Corps Camp. However, in the field this may be more difficult, though not impossible. Furthermore, although they are useful for assessing the visual capability of ANVIS NVG users, they cannot be used with Nite-op NVGs. This is because ANVIS can be focused on a chart at a distance of 3 metres (using the objective lens), but Nite-op have a fixed infinity focus objective lens and so they cannot be focused to 3 metres as required.

NVG test lanes are inexpensive and provide a standard procedure to assess NVG tube performance and properly adjust and focus the NVGs. However, they can only be practically be used for focusing ANVIS type NVGs.

The proposed method of focusing and alignment has been incorporated into Army Aviation Standardisation Instruction H21 NVG as a result of this study.

REFERENCES