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**Visual Evoked Potential Through  
Night Vision Goggles  
(Reprint)**

**By**

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**Aircrew Health and Performance Division**

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## TECHNICAL NOTE

# Visual Evoked Potentials Through Night Vision Goggles

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Night vision goggles (NVG's) have widespread use in military and civilian environments. NVG's amplify ambient illumination making performance possible when there is insufficient illumination for normal vision. While visual performance through NVG's is commonly assessed by measuring threshold functions such as visual acuity, few attempts have been made to assess vision through NVG's at suprathreshold levels of stimulation. Such information would be useful to better understand vision through NVG's across a range of stimulus conditions. In this study visual evoked potentials (VEP's) were used to evaluate vision through NVG's across a range of stimulus contrasts. The amplitude and latency of the VEP varied linearly with log contrast. A comparison of VEP's recorded with and without NVG's was used to estimate contrast attenuation through the device. VEP's offer an objective, electrophysiological tool to assess visual performance through NVG's at both threshold and suprathreshold levels of visual stimulation.

NIGHT VISION goggles (NVG's) amplify ambient illumination making performance possible when there is insufficient light for normal vision. While visual performance with NVG's is often assessed by measuring threshold visual functions such as the smallest detectable size or contrast (5,6,9,10,11), few attempts have been made to assess vision at suprathreshold levels of stimulation. Such information would be useful, since the visual world consists of a myriad of contrasts and intensities spanning threshold and suprathreshold levels. Understanding visual performance above threshold is important, since it can differ from that observed at threshold levels of stimulation (4).

One problem with measuring vision at suprathreshold levels is developing a performance index which continues to vary with stimulation above threshold. For example, visual acuity entails recognizing the smallest let-

ter possible at maximum contrast. If larger letters are presented, they are readily identified. Hence, there are no simple procedures to assess visibility of objects presented above threshold. One objective approach which provides information at suprathreshold levels involves recording the cortical, visual evoked potential (VEP) in response to repetitive patterned stimulation. Both the amplitude and latency of the VEP continue to vary at suprathreshold levels of stimulation. A response versus contrast function can be generated to provide an objective index of threshold and suprathreshold processing (1,2,3,8). Meaningful information can be obtained in brief periods with little participation from the observer other than vigilance (8).

In this study VEP's were recorded from observers viewing through third generation NVG's contained in the Aviator's Night Vision Imaging System (ANVIS). The amplitude and latency of the VEP were measured as a function of stimulus contrast. A comparison of VEP's recorded with and without ANVIS was used to estimate contrast attenuation through the device.

## METHODS

The stimulus for VEP's was vertical square wave gratings generated on a color monitor. Only the red phosphor was used to limit the spectral composition of the stimuli to the spectral range of ANVIS. While ANVIS has peak sensitivity in the near infrared (750 nm), little infrared radiation is emitted by the red phosphor of the monitor such that its output between 600-720 nm formed the primary stimulus for ANVIS. Additional attenuation was achieved by placing neutral density (ND) filters directly in front of the ANVIS objective. A grating spatial frequency of 2 cycles/degree was used since it is a dimension known to produce well-defined VEP's, and is also near the peak of the human contrast sensitivity function (8). Grating contrast was varied by software control of gun intensity. Four contrast levels (8%, 16%, 32%, and 64%) were presented at a mean intensity corresponding to a level between ¼ moon and starlight illumination. At this level of stimulation the ANVIS display luminance was 0.65 fL. VEP's

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VEP'S THROUGH NVG'S—RABIN

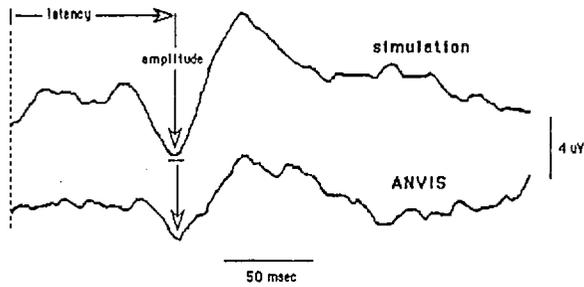


Fig. 1. VEP's from one subject are shown for ANVIS and simulated ANVIS viewing conditions. Each response is the time-averaged waveform to 100 pattern onsets. Amplitude and latency of the VEP are indicated. Grating contrast was 32%.

were also recorded under conditions which simulated the luminance and color of the ANVIS display. This simulation consisted of gratings modulated with the green gun of the color monitor to simulate the green ANVIS display. The green gratings were viewed through ND filters to make the luminance the same as the ANVIS display (0.65 fL). Spatial frequency and contrasts were also the same as in the ANVIS condition.

Subjects viewed the gratings through a binocular ANVIS mounted on an adjustable table 40 cm from the monitor such that the display nearly filled the ANVIS field. VEP's were recorded monocularly from the subject's right eye, while the left ANVIS tube was occluded. The active electrode was placed 2 cm above the inion, the reference electrode on the forehead, and the ground electrode on the right earlobe. The gratings were presented in pattern-onset mode 2x/s and recorded 100x in 300-ms epochs on an averaging computer (Nicolet Instruments, Madison, WI). The contrasts were presented in ascending order to minimize successive adaptation effects. Each subject was tested with ANVIS first followed by the simulation. Five subjects with visual acuity corrected to 20/20 and normal ocular health participated in this study. Prior to giving their informed consent, subjects were briefed on all procedures. They were told they could withdraw at any time.

RESULTS

Fig. 1 shows typical VEP waveforms for both ANVIS and simulation conditions. The ANVIS condition represents measurements through the device, while the simulation represents VEP's recorded without ANVIS,

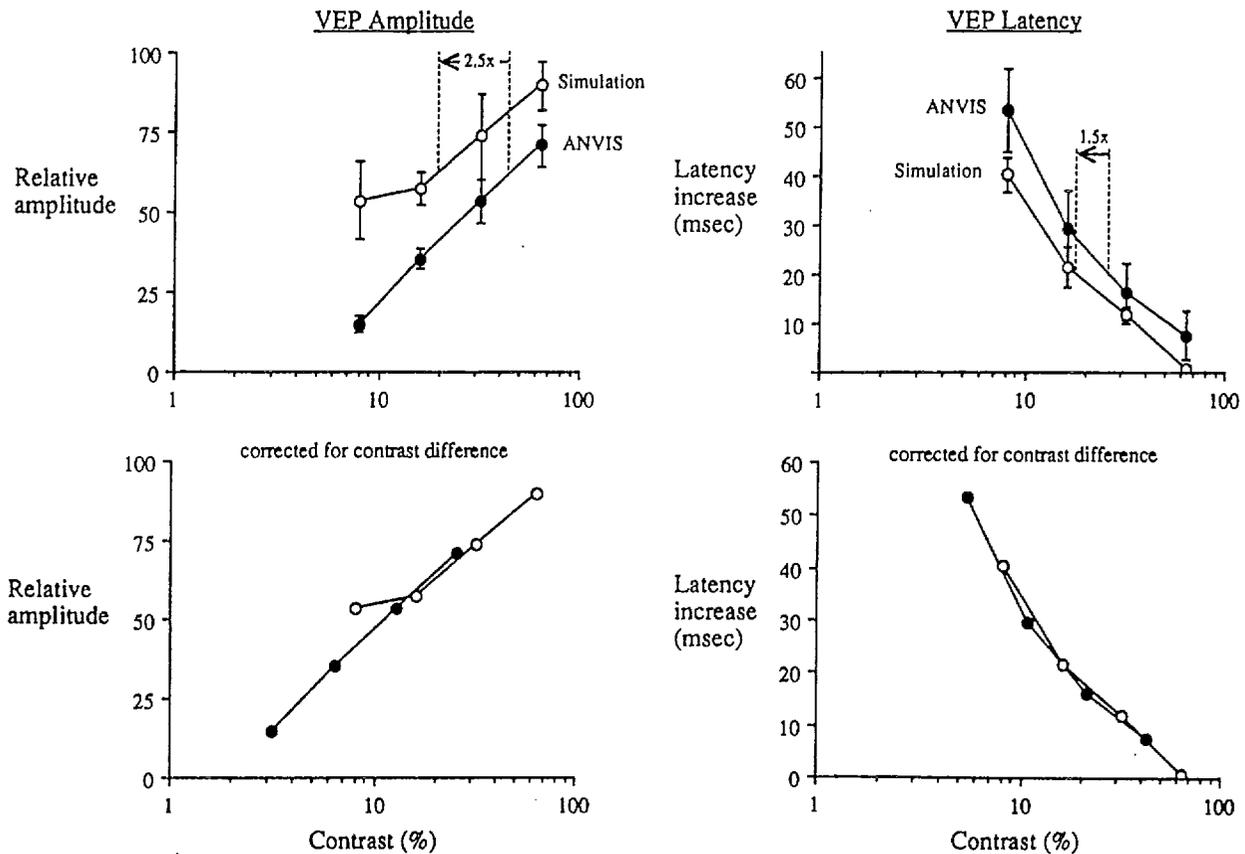


Fig. 2. Mean VEP amplitude and latency from five subjects are plotted against grating contrast. Amplitudes are normalized relative to the maximum amplitude for each subject. Latencies are expressed as increases relative to the minimum value for each subject across all contrasts and the two viewing conditions. The horizontal arrows in the top graphs indicate the contrast reduction through ANVIS necessary to make all data conform to common functions. The bottom graphs show the same data corrected for this contrast reduction.

but at the same display luminance and approximate color. Note that VEP amplitude is smaller and latency slightly longer in the ANVIS condition. These differences were found despite the equivalence of luminance and color in the two conditions. Thus, other factors, such as contrast reduction through ANVIS, are responsible for this difference.

Fig. 2 shows mean VEP amplitudes and latencies from five subjects plotted against grating contrast for ANVIS and simulation conditions. To reduce effects of inter-subject variability, amplitudes are expressed relative to the maximum for each subject, while latencies are shown as increases relative to the minimum for each subject across all contrasts and viewing conditions. As in previous studies (1-3,8), VEP amplitude increases and latency decreases with increasing stimulus contrast, and these functions are approximately linear with log contrast. Note also that amplitudes are smaller and latencies slightly longer in the ANVIS condition across the range of contrasts tested. Two-way repeated measures ANOVA revealed significant effects of contrast on VEP amplitude ( $F_{3,32} = 12.33$ ;  $p < 0.0001$ ) and latency ( $F_{3,32} = 22.84$ ;  $p < 0.0001$ ), and a significant difference between ANVIS and simulation for amplitude ( $F_{1,32} = 19.13$ ;  $p < 0.001$ ), while this difference approached significance for latency ( $F_{1,32} = 4.04$ ;  $p = 0.053$ ).

The VEP differences between ANVIS and simulation conditions are relatively constant across a range of suprathreshold contrasts increasing somewhat at low contrasts. These differences cannot be readily attributed to the luminance or color of the ANVIS display. While it is possible that inappropriate accommodation through ANVIS contributed to the attenuated VEP's, substantial errors ( $\geq 2D$ ) would have been required to significantly demodulate the low spatial frequency grating stimulus. It seems more likely that VEP differences between ANVIS and the simulation reflect contrast attenuation through the device. The amount of contrast attenuation can be estimated from the difference between ANVIS and simulation functions along the contrast axis. These contrast differences, computed from best-fit regression lines, are indicated by the horizontal arrows in the upper plots of Fig. 2. Shifting the VEP amplitude function leftward 0.4 log units ( $2.5\times$ ) and the latency function 0.17 log units ( $1.5\times$ ) makes all data better conform to common functions, as shown in the bottom graphs of Fig. 2. Since the latency difference between ANVIS and simulation only approached statistical significance, VEP amplitude may be a more useful tool for gauging contrast loss through NVG's. The amount of contrast attenuation predicted by amplitude is also comparable to the amount estimated from contrast sensitiv-

ity measurements through ANVIS using a similar mode of stimulation (7).

## DISCUSSION

This study demonstrates that VEP's can be used as an objective electrophysiological tool to assess visual processing through image intensifying devices. Contrast-dependent changes in the amplitude and latency of the VEP provide a continuous metric of vision, spanning threshold and suprathreshold levels of visual stimulation. Comparison of VEP's with and without image intensifiers can be used to estimate contrast attenuation through the device.

While VEP's provide an estimate of visual function at various levels of stimulation, the specific relation between VEP's and performance with image intensifiers is unclear. The results reported herein underscore the utility of VEP's as an adjunctive tool to complement more definitive techniques such as psychophysical measurement and the modulation transfer function of the image intensifying device.

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