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Methods of Visual Scanning with Night Vision Goggles

By

John C. Kotulak

Sensory Research Division

February 1992

United States Army Aeromedical Research Laboratory
Fort Rucker, Alabama 36362-5292

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Reviewed:

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LTC, MS
Director, Sensory Research Division

ROGER W. WILEY, O.D., Ph.D.
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DAVID H. KARNEY
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Commanding

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This report describes recommended methods for scanning the flight path and cockpit instruments for pilots wearing night vision goggles (NVGs) while flying Army helicopters. The impetus for this report was a task force sponsored by the Office of the Deputy Chief of Staff of the Army for Plans and Operations, which determined that the development of scanning methods was the Army's top training priority for night helicopter operations. The recommended methods of scanning were derived from published scientific works, interviews with scientists, and interviews with aviators from field tactical units, training units, and from the resea~ch and development community. The proposed scanning methods recommend free

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search as opposed to formalized scan patterns. In addition, they place equal weight on crew coordination and individual technique. The proposed methods stress actions taken before flight, such as premission planning and NVG preflight adjustments. Furthermore, the proposed methods are intended to build an awareness of: NVG performance limits, and how to maximize performance; common problems encountered while scanning with NVGs, and the conditions which elicit them; and the scientific basis for scanning. Separate scanning methods were developed for individuals and for crews. In addition, the relevant scientific literature was reviewed.

Preface

A preliminary version of this report was conveyed to the Commander, Aviation Training Brigade, Fort Rucker, Alabama, by means of a formal memorandum on 2 April 1991. That memorandum, after substantial revision, is published herein as a technical report to facilitate the widest possible dissemination of its content, which is relevant to flight safety and mission effectiveness with night vision goggles.

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CW4 G. Arnold, Aviation Training Brigade, Fort Rucker, Alabama

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COL W. Berkley, U.S. Air Force Human Resources Laboratory, Williams AFB, Arizona

Mr. A. Boyd, U.S. Army Safety Center, Fort Rucker, Alabama

MW4 R. Brooks, Aviation Training Brigade, Fort Rucker, Alabama

CW4 C. Brown, 160th Special Operations Aviation Regiment, Fort Campbell, Kentucky

Ms. T. Bui, Center for Night Vision and Electro-Optics, Fort Belvoir, Virginia

Dr. J. Caldwell, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama

CW3 W. Campbell, 1/14th Aviation Regiment, Fort Rucker, Alabama

Ms. C. Ecker, Department of Tactics and Simulation, Fort Rucker, Alabama

Mr. T. Evans, 160th Special Operations Aviation Regiment, Fort Campbell, Kentucky

CPT T. Fox, U.S. Army School of Aviation Medicine, Fort Rucker, Alabama

LTC T. Frezell, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama

Mr. J. Galushka, U.S. Army Safety Center, Fort Rucker, Alabama

CW2 C. Greely, 4/17th Cavalry, Fort Bragg, North Carolina

Mr. E. Hill, 160th Special Operations Aviation Regiment, Fort Campbell, Kentucky

Dr. W. Howse, U.S. Army Research Institute, Fort Rucker, Alabama

Dr. G. Intano, U.S. Army Research Institute, Fort Rucker, Alabama

Dr. R. Karsh, U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland

MAJ J. Kimberly, Airborne Electronics Research Detachment, Fort Belvoir, Virginia

Mr. W. Komulainen, 160th Special Operations Aviation Regiment, Fort Campbell, Kentucky

CW3 R. Lageman, 1/14th Aviation Regiment, Fort Rucker, Alabama

Mr. K. Lanam, Airborne Electronics Research Detachment, Fort Belvoir, Virginia

Mr. B. Lavallee, 160th Special Operations Aviation Regiment, Fort Campbell, Kentucky

Dr. D. Leedom, U.S. Army Research Institute, Fort Rucker, Alabama

CW3 R. Littleton, Directorate of Evaluation and Standardization, Fort Rucker, Alabama

CW4 M. McIntosh, Aviation Training Brigade, Fort Rucker, Alabama

CW3 D. Mauss, 1/223rd Aviation Regiment, Fort Rucker, Alabama

Dr. W. McLean, U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland

CW3 N. Messer, 7/6th Cavalry, U.S. Army Reserve

LTC R. Miller, U.S. Air Force School of Aerospace Medicine, Brooks Air Force Base, Texas

CW4 R. Morse, 1/14th Aviation Regiment, Fort Rucker, Alabama

CW3 W. Mullen, Directorate of Evaluation and Standardization, Fort Rucker, Alabama

Mr. G. Nowack, Office of Project Manager, Night Vision and Electro-Optics Devices, Fort Belvoir, Virginia

Dr. L. Oatman, U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland

CW4 R. Osterlund, Aviation Training Brigade, Fort Rucker, Alabama

CW4 B. Partridge, 1/212th Aviation Regiment, Fort Rucker, Alabama

Mr. Philip Perconte, Center for Night Vision and Electro-Optics, Fort Belvoir, Virginia

Mr. R. Portman, 1/112th Aviation Regiment, Fort Rucker, Alabama

Dr. R. Remmel, Boston University. Boston, Massachusetts

Mr. D. Ricketson, U.S. Army Safety Center, Fort Rucker, Alabama

Mr. W. Riley, 1/14th Aviation Regiment, Fort Rucker, Alabama

CPT J. Robertson, Department of Tactics and Simulation, Fort Rucker, Alabama

CW3 R. San Gil, 1/14th Aviation Regiment, Fort Rucker, Alabama

Dr. C. Schor, University of California, Berkeley, California

Mr. J. Stark, 160th Special Operations Aviation Regiment, Fort Campbell, Kentucky

Mr. R. Vollmerhausen, Center for Night Vision and Electro-Optics, Fort Belvoir, Virginia

CW2 J. Wade, 3/4th Aviation Regiment, Mainz, Germany

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Introduction

A task force organized by the Office of the Deputy Chief of Staff of the Army for Operations and Plans has identified several training and materiel development actions which were deemed essential to improving the safety of night helicopter operations (Department of the Army, 1990). One of the training priorities was the development of methods for proper scanning of the flight path and cockpit instruments during flights with night vision goggles (NVGs). This Laboratory was asked to assist in the development of these methods.

The urgency with which the methods were required did not allow time for new research. Therefore, the recommended methods were derived from published scientific works, interviews with scientists, and interviews with aviators from field tactical units, the U.S. Army Aviation Center (USAAVNC), and the research and development community. Much of the information upon which the methods were based came from two conferences on scanning. The first was hosted by the USAAVNC Aviation Training Brigade, and was held at Fort Rucker, Alabama from 29-31 October 1990. Participants in this conference were drawn from USAAVNC, the U.S. Army Safety Center (USASC), the U.S. Army School of Aviation Medicine, the U.S. Army Research Institute, the 160th Special Operations Aviation Regiment, and this Laboratory. The second meeting was hosted by the 160th Special Operations Aviation Regiment at the request of this Laboratory. It was held at Fort Campbell, Kentucky on 8 January 1991, and participation was limited to personnel from the regiment and this Laboratory.

The report that follows has three major sections. The first lays the scientific foundation for the sections on scanning methods which follow. The latter two sections provide individual and crew scanning methods respectively.

Scientific foundation

Two fundamentally different bodies of scientific knowledge that relate to scanning with NVGs are surveyed below. One deals with scanning but not with NVGs, while the other deals with visual functions through NVGs but not with scanning. There have been no investigations of visual scanning with NVGs, and due to technical limitations, none are anticipated in the near future. The absence of direct measurements of visual scanning with NVGs is not considered to be an unsurmountable impediment to the development of scanning methods.

Visual scanning without night vision goggles

For the purposes of this report, visual scanning includes motor functions, such as eye and head movements, and sensory functions, such as visual attention and target detection.

Visual scanning during instrument flight

In-flight studies of pilots flying on instruments in Air Force fixed-wing aircraft (Fitts, Jones, and Milton, 1950) and Army rotary-wing aircraft (Simmons, Kimball, and Diaz, 1976; Simmons, Lees, and Kimball, 1978) demonstrated that the pilot's eyes were constantly in motion. Dwell time on any instrument was generally less than 1 second. These studies also showed that the eyes did not move in an orderly pattern from instrument to adjacent instrument, but that the eye movements were highly selective, virtually ignoring some instruments while returning to others frequently.

Visual scanning during nap-of-the-earth flight

A USASC study concluded that improper scanning is the leading crew error in Army helicopter accidents at night, and that tactical low-altitude NVG flight is the most common profile for such accidents (Boyd, 1990). Another USASC investigation found that crew errors in nap-of-the-earth (NOE) flight were significantly more common with NVGs than in unaided night or day NOE flight (Crowley, 1990). Therefore, in the development of the proposed methods for scanning, particular attention was devoted to NOE flight. However, the methods apply as well to other NVG profiles.

Flight path scanning

Irregular eye movements were also recorded during daylight NOE flights in an Army helicopter when the visibility was good (Harker and Jones, 1981). During these flights, the pilots almost exclusively looked at potential terrain hazards, foregoing a formalized scan pattern in favor of a problem-oriented approach. When the flight path was above the tree line, the pilots tended to look at taller trees in or near the line of flight at about two thirds of the distance to the horizon. The pilots made periodic close-in looks at trees that were previously spotted to ensure clearance. When the flight path was below the tree line (i.e., along the course of a river), visual attention shifted laterally to trees which protruded toward the line of flight from both banks of the river. During the transition from above the tree line to below, there was no characteristic scan pattern. However, during the transition out of the river course, the pilots did not scan but steadfastly maintained their gaze on the top of the tallest tree in the flight path until clearance.

Cockpit instrument scanning

In addition, Harker and Jones (1981) noted that during NOE flight, pilots generally did not monitor cockpit instruments, which implies that flight control information was obtained from cues external to the aircraft. This is consistent with laboratory studies which showed that visual cues, such as changes in apparent terrain texture, can be used to sense absolute altitude (De Maio and Brooks, 1985), changes in altitude (Johnson et al., 1989), deceleration (Owen et al., 1985), and acceleration (Warren, Owen, and Hettinger, 1982).

Differences between flight path and instrument scanning

Although instrument scanning and flight path scanning are similar in some respects, there is evidence of at least one important difference. Liu and Wickens (1989) discovered that scanning with spatial uncertainty (e.g., flight path scanning) causes more difficulties in performing concurrent spatial tasks than does scanning with spatial certainty (e.g., instrument scanning). This suggests that pilots who are primarily engaged in flight path scanning should anticipate more difficulty with navigation and flight control than those engaged in instrument scanning.

Visual search failure

From the above it is clear that eye movements contribute greatly to object detection; however, alignment of the eyes with the target is no guarantee of target detection (Nodine, Carmody, and Kundel, 1978). Nodine and his associates showed in a laboratory experiment that the vast majority of search failures are not due to failure to scan the target area, but to the inability to discriminate the target from its surround. These scientists suggested that successful search depends not only on knowing where to look, but on knowing what aspects of a target become distinctive in a particular surround. A laboratory study on scanning visual displays suggests that extensive training can improve target detection reaction time (Hoffman, Nelson, and Houck, 1983).

Formalized scan patterns

Gale and Worthington (1983) investigated whether formalized scan patterns could improve visual search performance by providing uniform coverage of the target area. They found two significant problems with scan patterns: (1) search performance was poor without extensive training, and (2) as performance improved with training, the rate of false positives increased, i.e., the subjects falsely "detected" targets that were not present. They concluded that even with extensive training, formalized scan patterns were not beneficial. A similar study by Clare (1979) reached the same conclusion.

Adjustments due to speed

There is evidence that the rapidity of scanning is related to the velocity that the individual is travelling. McDowell and Rockwell (1978) discovered that the eye movements of drivers of ground vehicles tended to slow down as vehicle speed increased. Their explanation was that at higher speeds finer discriminations were required, and these took more time.

Effectiveness of peripheral vision

During scanning, objects of interest may appear in both central and peripheral vision. Some scientists maintain that attending to objects in central vision causes "cognitive tunnel vision," i.e., a shrinkage in the effective visual field (Mackworth, 1965; Ikeda and Takeuchi, 1975; Williams, 1985). Williams and Lefton (1981) found that simple visual tasks (e.g., physical matches) can be performed up to 7° from the object of regard, while performance of complex tasks is limited to separations of 4° or less. Similarly, Wickens (1984) showed that stress leads to a reduction in the amount of visual information that can be sampled simultaneously.

Visual functions with night vision goggles

Visual acuity

Figures 1 and 2 demonstrate that, for a given NVG generation, visual acuity (VA) worsens with decreasing night sky irradiance and with decreasing target contrast (Kotulak and Rash, 1991). In these figures and the ones that follow, the second generation device is the AN/PVS-5 NVG, while the third generation device is

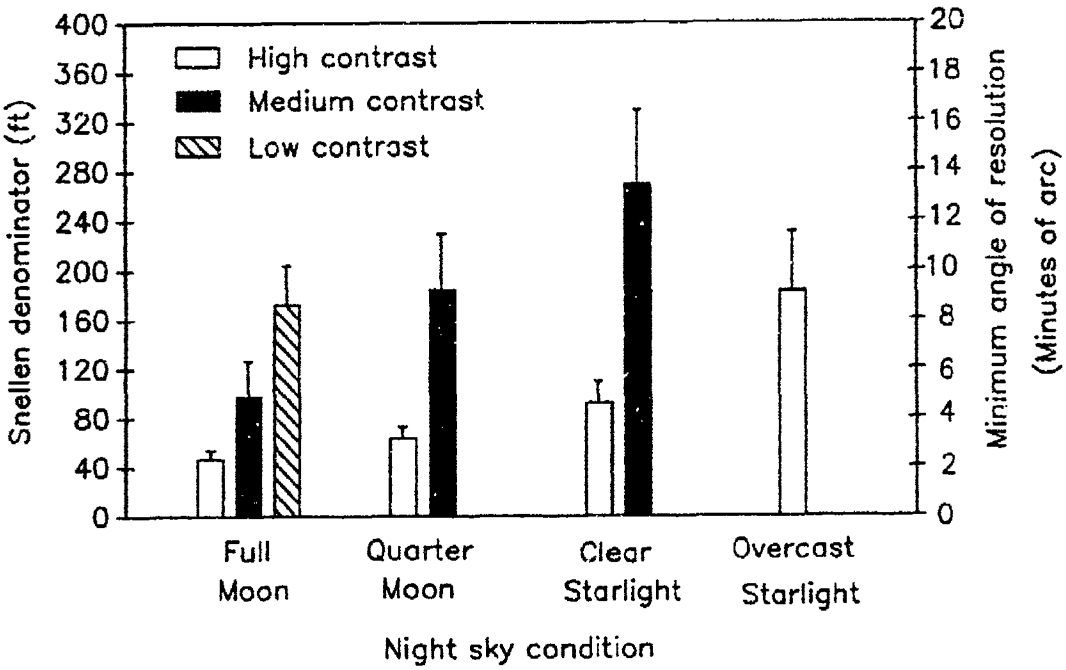

Figure 1. Visual acuity with generation II devices.

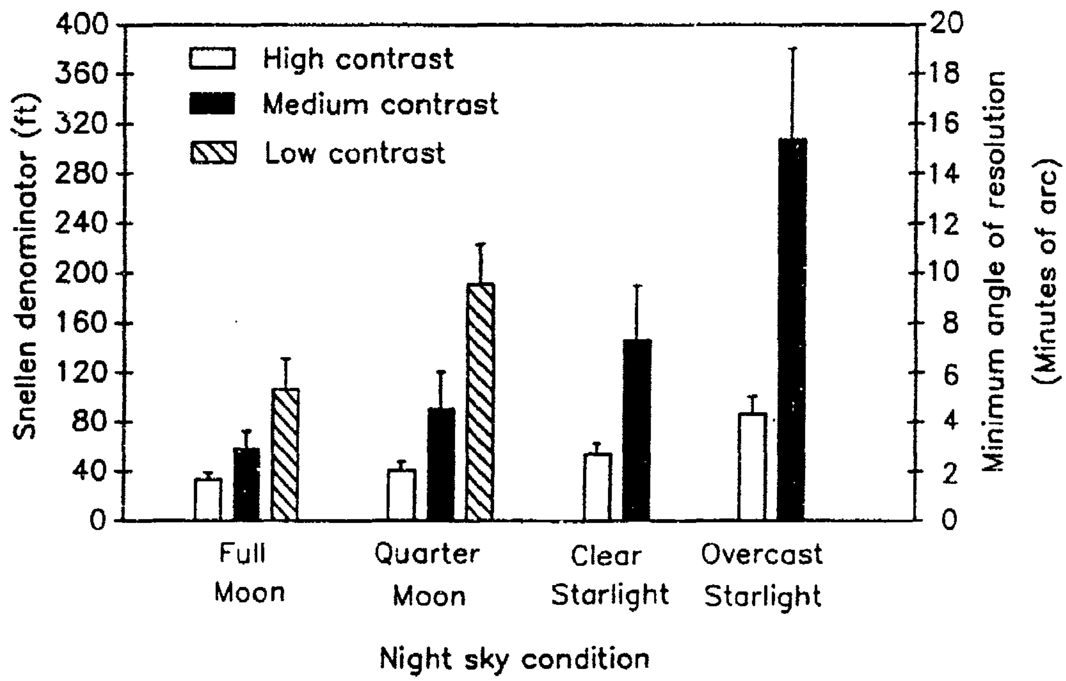

Figure 2. Visual acuity with generation III devices.

the AN/AVS-6 Aviator Night Vision Imaging System (ANVIS). It is significant that extremely reduced VA can occur under realistic operating conditions, e.g., Figure 2 shows that VA is worse than 20/300 when a medium (12 percent) contrast target is viewed with ANVIS during simulated overcast starlight. Figures 3 and 4 show that the difference in VA between NVG generations is relatively small under optimum conditions, i.e., full moon and high target contrast (Kotulak and Rash, 1991). However, VA with the AN/PVS-5 falls off more rapidly with decreasing night sky irradiance (Figure 3) and with decreasing target contrast (Figure 4) than does VA under corresponding conditions with ANVIS. Finally, as night sky irradiance decreases, VA declines faster when viewing a low contrast target than when viewing a high contrast target, regardless of NVG generation (Figure 5) (Kotulak and Rash, 1991).

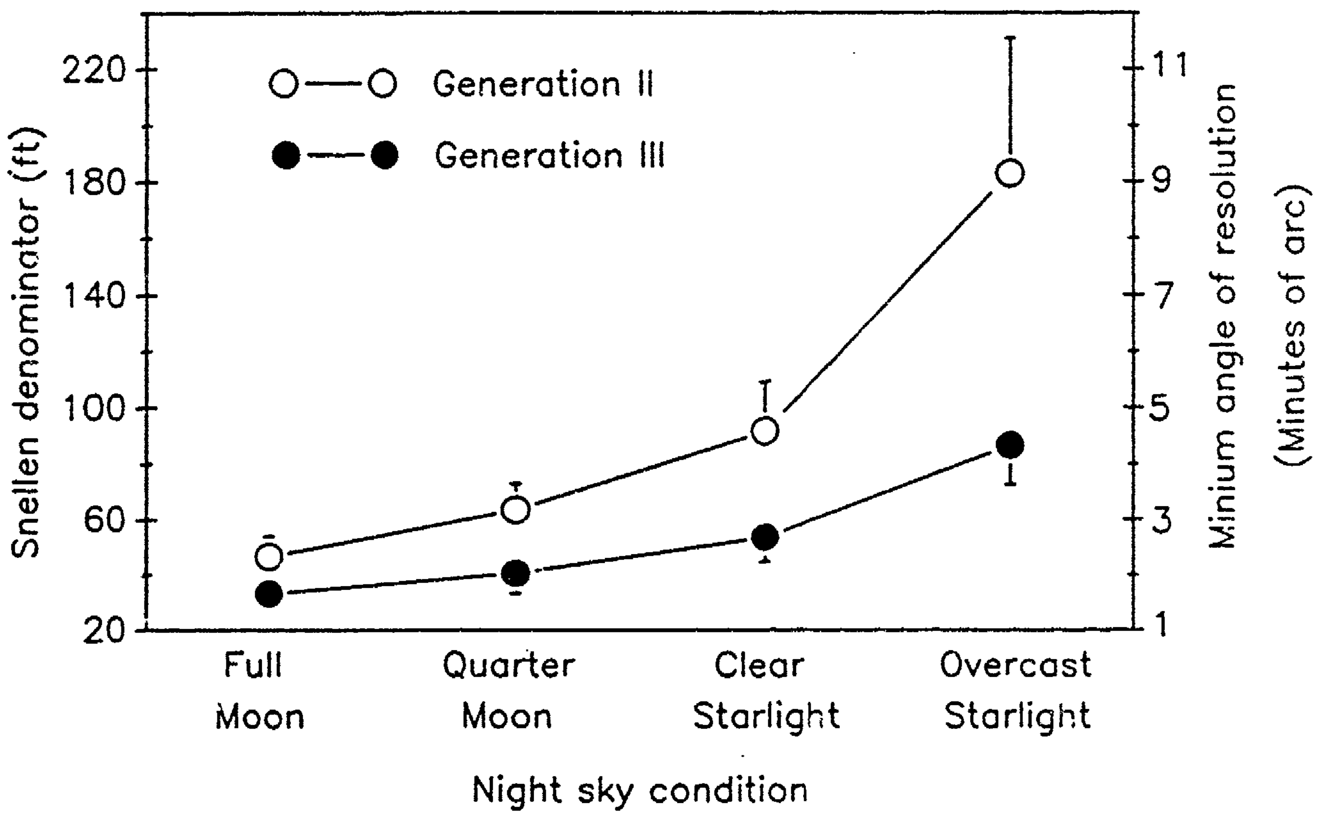

Figure 3. Visual acuity as a function of night sky condition and night vision goggle generation with high contrast targets.

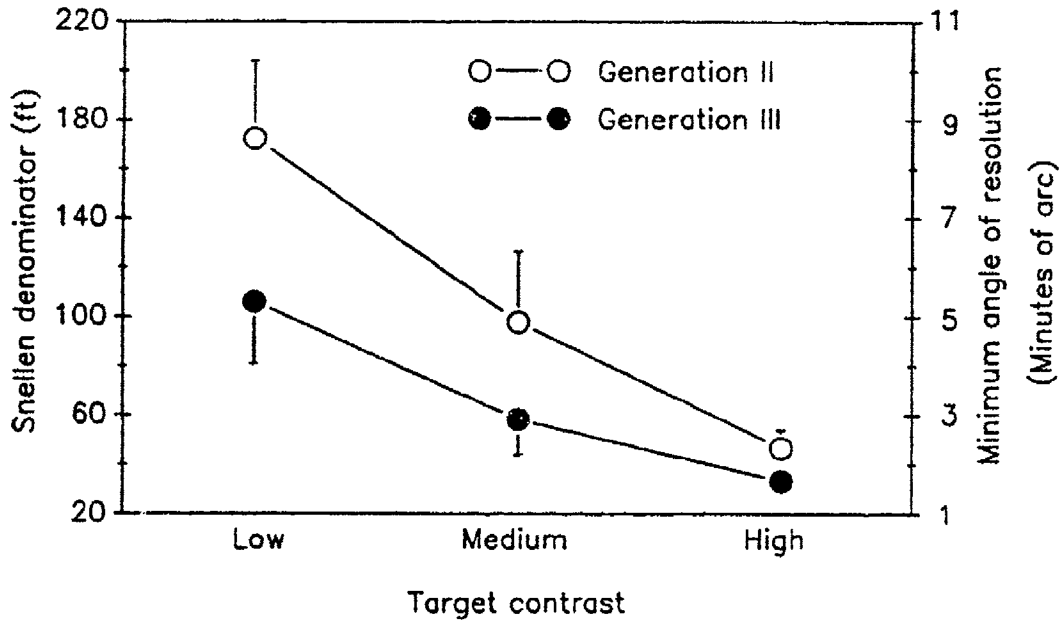

Figure 4. Visual acuity as a function of contrast and night vision goggle generation under simulated full moon irradiance.

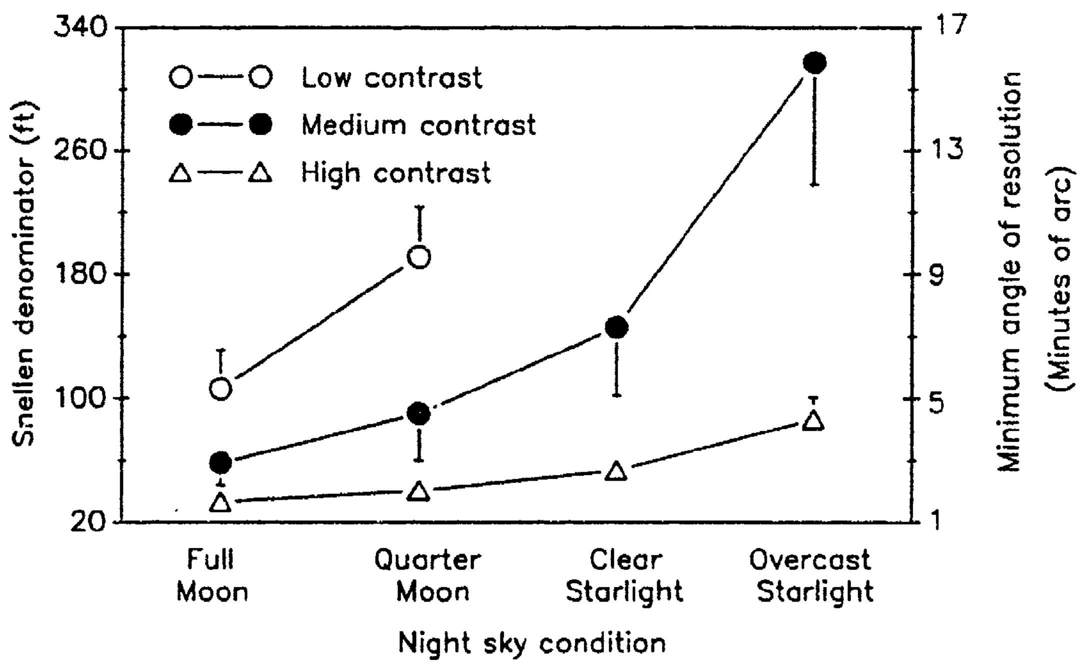

Figure 5. Visual acuity as a function of night sky condition and target contrast with generation III night vision goggles.

Hazard detection distances

Using a reductionist approach which assumes detection is determined by acuity, the VA thresholds in Figures 1 and 2 can be used to predict hazard detection distances. Figures 6 and 7 are mathematically-derived predictions of such distances for 6-inch diameter tree branches with contrasts of 95 and 12 percent respectively (corresponding to high and medium contrast in Figures 1 and 2). For the medium contrast tree branch viewed with ANVIS during simulated overcast starlight (as in the preceding paragraph), the predicted detection distance is 108 feet. For a helicopter travelling at the 40 knot NVG NOE limit (68 feet/second), the time to impact is less than 2 seconds. This is far less than the minimum time necessary for hazard avoidance, which was estimated at 4-6 seconds by Hart (1991) and 8 seconds by Branigan (1991). In order to avoid the hazard, the helicopter would have to be travelling 8 knots (14 feet/second) or less. During actual flights, hazard detection distances could vary. Figures 6 and 7 are provided only as rough guides.

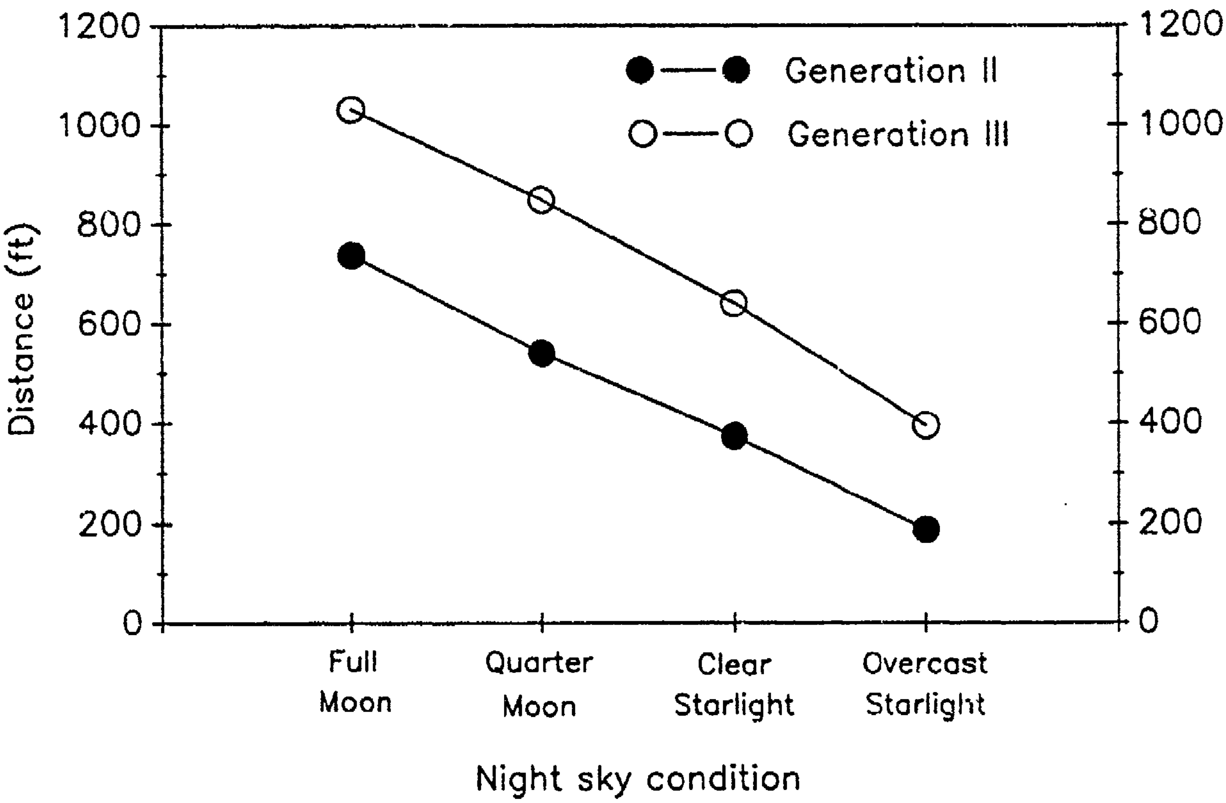

Figure 6. Night vision goggle hazard detection distances for a 6-inch diameter tree branch with 98 percent contrast.

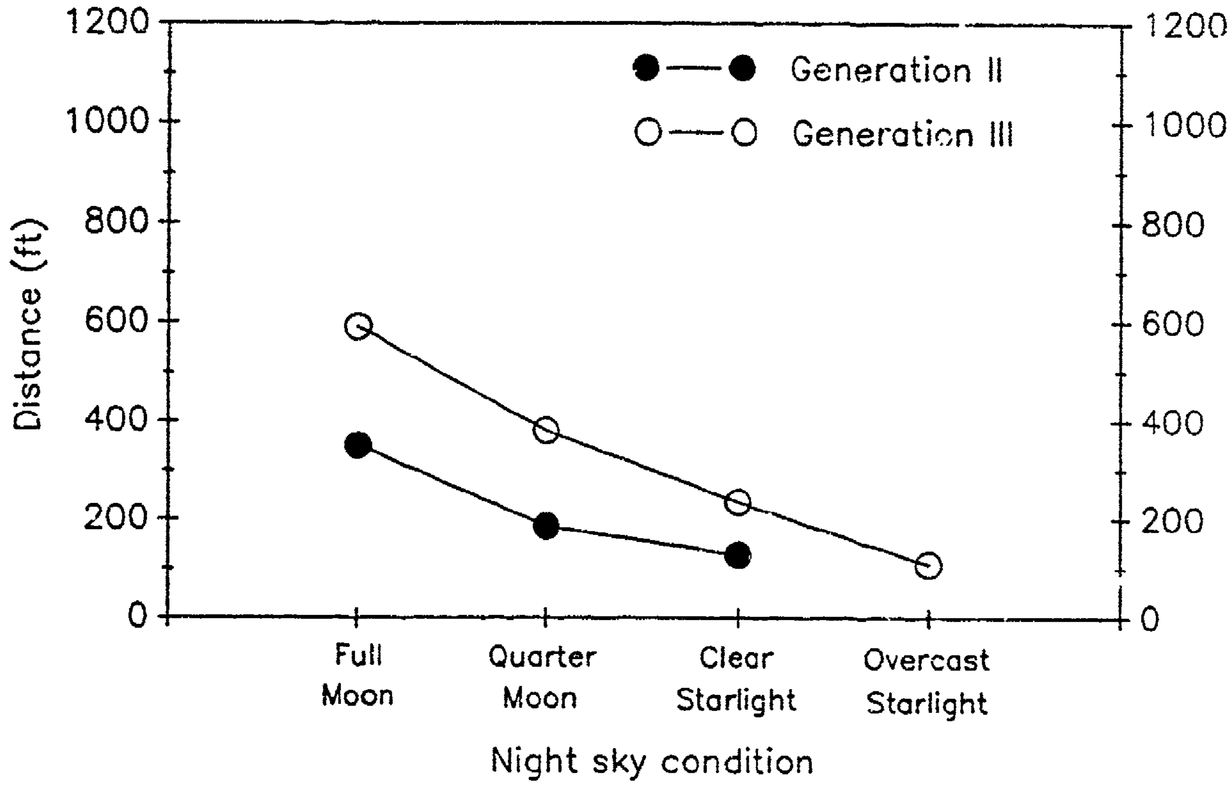

Figure 7. Night vision goggle hazard detection distances for a 6-inch diameter tree branch with 12 percent contrast.

Central versus peripheral viewing of display screen

Walsh (1988) showed that viewing through the periphery of an NVG display screen leads to a loss of resolution of approximately 16 percent compared with viewing through the center. This effect was independent of night sky condition and target contrast.

Field-of-view

The nominal field-of-view (FOV) of current NVGs is 40°. This is obtainable if the eyes are positioned within the 18 mm eye relief distance of the NVG eyepiece lenses. There is evidence that the best case FOV of ANVIS is less than 40° for at least some aviators because of mechanical limitations in the helmet mount (Kotulak and Frezell, 1991). Deliberate adjustments of the fore-aft distance to maximize look-under capability would further decrease the FOV. Figure 8 shows the relationship between eye to eyepiece lens distance (vertex distance) and FOV with ANVIS (Kotulak and Frezell, 1991).

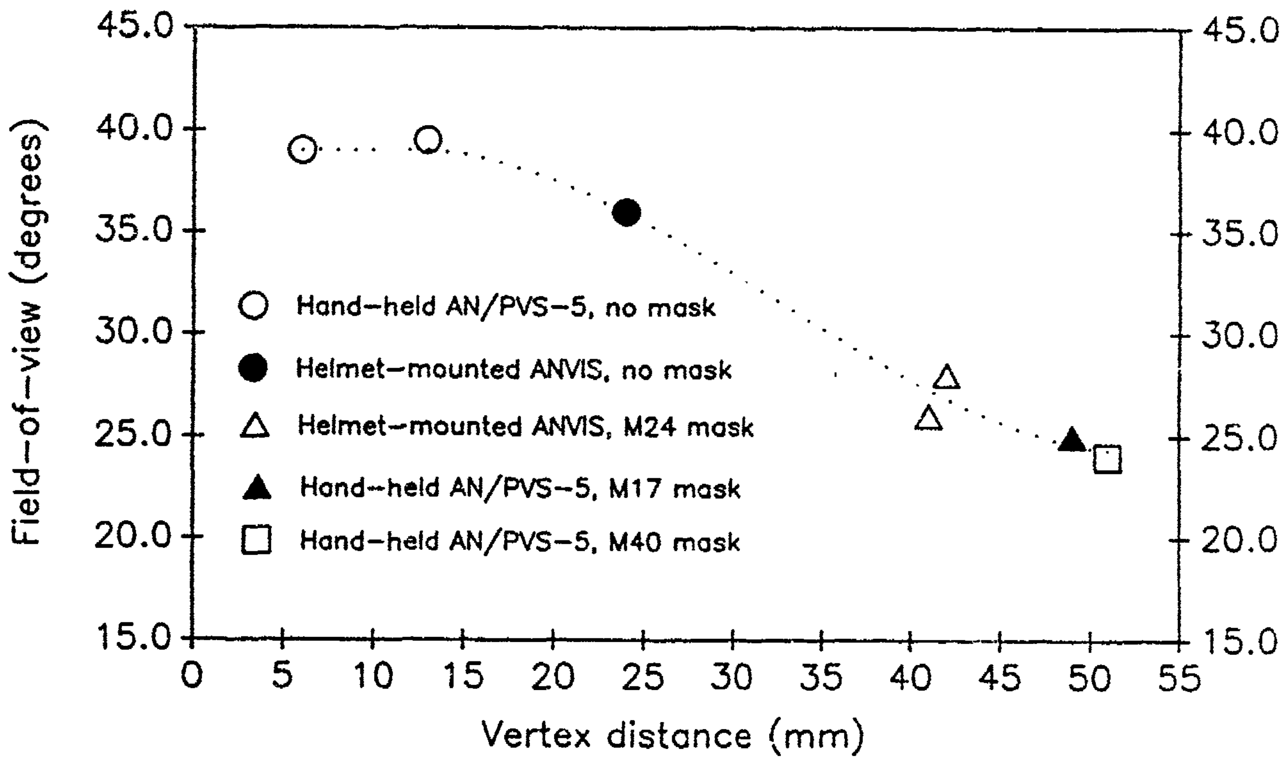

Figure 8. Effects of vertex distance on night vision goggle field-of-view.

Head movements

Greene (1988) reported that the velocity of head movements of pilots in flight tends to increase as the FOV of NVGs decreases (wi h resolution constant). Also, he found that the velocity of head movements tends to decrease as the resolution of NVGs decreases (with FOV constant). The latter may be a reflection of the need for increased processing time to interpret a degraded image.

Scanning methods for individuals

1. Be thorough in your premission planning. Learn as much as possible about:

• Natural and manmade terrain features along your route, especially hazards.

• Weather and other atmospheric conditions which affect visibility, e.g., dust or smoke.

• Lunar conditions, especially percent illumination, elevation above the horizon, and angle of incidence of moonlight with respect to the flight path.

• Expected air traffic.

2. Conduct an exacting preflight NVG check, especially:

• Clean all lenses with lens paper.

• Set the interpupillary distance (IPD) and vertical height adjustment to center the eyepiece lenses on the eyes. Do not try to increase your FOV by misadjusting the IPD, because this will decrease your vision.

• Adjust the objective lenses for infinity and the eyepiece lenses for best vision. These adjustments must be made one eye at a time. The eyepiece lenses require considerable care to adjust. Start with the knobs in the full counterclockwise position. Rotate clockwise and stop immediately when the image clears. Do not "overminus," because this may lead to problems later, e.g., eyestrain, blurred vision, and headache.

• Using the fore-aft adjustment, position the eyepiece lenses as close to the eyes as possible, while still maintaining adequate look-under capability. Be aware that even when the fore-aft adjustment is in the maximum aft position (which brings the eyepiece lenses as close to the eyes as possible), many aviators will have less than a 40° FOV.

3. Make sure that you understand your specific scanning duties and those assigned to other crewmen. Examples of scan duties include the sector to be scanned and the circumstances under which you may "come inside."

4. Know and use your unit's conventions for voice communications that pertain to scanning, e.g., "Wires, dead ahead, 250 feet," or "I'm coming in, you've got the scan" or "Traffic, 10 o'clock low, slow moving."

5. Scan specific objects of interest in and around the flight path as opposed to general areas.

6. Look directly at objects as opposed to "off-center viewing." The central blind spot, which is present during unaided night viewing, is not present with NVGs. This method of viewing is called central fixation.

7. Do not dwell on any object for more than a second or two. Make frequent glances at difficult to interpret objects if necessary. Request the assistance of other crew members to help identify an object so that you can maintain an uninterrupted scan.

8. Use a free search scan strategy as opposed to a stylized method of repetitive eye and head movements. Use a combination of eye and head movements that comes natural to you.

9. Your first priority in deciding where to scan is hazard detection and clearance. Your goal is to detect the hazard as far away as possible and to monitor it periodically until clearance is assured.

10. For positive identification of a difficult to see object, move your head to center the object within the NVG FOV. The best resolution is near the center of the screen.

11. Know the risk factors for poor scanning. These are conditions under which scanning either stops or becomes less effective, such as emergencies, unfamiliar situations, visually-demanding procedures, fatigue, or emotional duress.

12. Watch for warning signs of NVG performance degradation (due to reductions in ambient illumination and/or weather). The best clues are: increased visual noise (scintillations), increased size of halos around lights, loss of shadows from moonlight, decreased NVG screen brightness, and loss of sharpness and contrast of objects.

13. Scan with caution around artificial lights, e.g., flares, pink lights, non-NVG compatible cockpit lighting, the AH-1 head-up display, etc. These reduce the NVG gain and could prevent you from seeing an object that would otherwise be visible. In addition, pink lights may cause some aviators to restrict their scan to the illuminated area. Take care to avoid pink-light channelization.

14. Be alert for illusions. The false horizon illusion and others that affect judgement of altitude, distance, and speed are fairly common with NVGs. Get a second opinion when in doubt.

15. During transitions from NOE to other modes of terrain flight, adjust your scan distance outward away from the aircraft as your speed increases. This allows you to identify hazards far enough away so that you still have time to react.

16. During transitions to NOE or contour from low level flight, scan for clues of excessive airspeed. A brief lateral glance (45 to 60°) may provide a better sense of speed than straight ahead viewing.

Scanning methods for crews

1. If you are the pilot in command:

- Enforce all individual methods for scanning, but in particular those that pertain to:

  - Premission planning.

  - Preflight NVG checks.

  - Specific scan duties of each crew member.

  - Standardized crew voice communications procedures.

- Make maximal use of all available personnel for scanning, to include non-rated crew members. Some aircraft require considerable scanning support by non-rated crew members, e.g., the CH-47. Some maneuvers are likewise dependent to a high degree on scanning support by all crew members, e.g., confined area hover.

- Carefully consider the degree of navigation workload in deciding whether to assign a scan sector to the pilot not on the controls. When navigation is accomplished primarily with a map, scanning for hazards (i.e., scanning with spatial uncertainty) may predispose the pilot not on the controls to navigation errors.

- Monitor the scanning of all crew members, using head movements as an index of scanning effectiveness.

  - Be particularly watchful under circumstances that degrade scanning effectiveness, e.g., emergencies, unfamiliar situations, visually demanding procedures, fatigue, or emotional duress.

  - Ensure that the entire crew is not visually fixated on the same object.

  - Assign scan sectors that overlap.

Harker, G. S., and Jones, P. D. 1981. Analysis of pilots' eye movements during helicopter flight. Naval Training Center, Orlando, FL: Project Manager for Training Devices. Technical Report No. PMT-ET-0015-81.

Hart, S. G. 1991. Human factors aspects of night flight. Paper presented at U.S. Army Safety Center, 7 March, Fort Rucker, AL.

Hoffman, J. E., Nelson, B., and Houck, M. R. 1983. The role of attentional resources in automatic detection. Cognitive psychology. 15: 379-410.

Ikeda, M., and Takeuchi, T. 1975. Influence of foveal load on the functional visual field. Perception and psychophysics. 18: 255-260.

Johnson, W. W., Tsang, P. S., Bennett, C. T., and Phatak, A. V., 1989. The visually guided control of simulated altitude. Aviation, space, and environmental medicine. 60: 152-156.

Kotulak, J. C., and Frezell, T. L. 1991. Field-of-view with night vision goggles. Paper presented at 6th Annual Joint Services Night Vision Conference, 13 June, Phoenix, AZ.

Kotulak, J. C., and Rash, C. E. 1991. Visual acuity with second and third generation night vision goggles, obtained from a new method of night sky simulation, across a wide range of target contrasts. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. In press.

Liu, Y., and Wickens, C. D. 1989. Visual scanning with or without spatial uncertainty and time-sharing performance. Proceedings of the Human Factors Society 33rd annual meeting. 1: 76-80.

Mackworth, N. H. 1965. Visual noise causes tunnel vision. Psychonomic science. 3: 67-68.

McDowell, E. D., and Rockwell, T. H. 1978. An exploratory investigation of the stochastic nature of the drivers' eye movements and their relationship to the roadway geometry. In J. W. Senders, D. F. Fisher, and R. A. Monty (eds.), Eye movements and the higher psychological functions. New York: Lawrence Erlbaum Associates.

Nodine, C. F., Carmody, D. P., and Kundel, H. L. 1978. Searching for Nina. In R. Groner, C. Menz, D. E. Fisher, and R. A. Monty (eds.), Eye movements and psychological functions: international views. New York: Lawrence Erlbaum Associates.

Owen, D. H., Pallos, I. E., Hettinger, L. J., and Fogt, J. C. 1985. The influence of preview period and global optical flow rate on sensitivity to loss in speed of self motion. In R. S. Jensen and J. Adrion (eds.), Proceedings of the third symposium on aviation psychology. Columbus, OH: Ohio State University.

Simmons, R. R., Kimball, K. A., and Diaz, J. J. 1976. Measurement of aviator visual performance and workload during helicopter operations. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 77-4.

Simmons, R. R., Lees, M. A., and Kimball, K. A. 1978. Visual performance/workload of helicopter pilots during instrument flight. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 78-6.

Walsh, D. J. 1988. Evaluation of the Aviator's Night Vision Imaging System (ANVIS) with 25 mm eyepieces. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. Unpublished data.

Warren, R., Owen, D. H., and Hettinger, L. J. 1982. Separation of the contributions of optical flow rate and edge rate on the perception of egospeed acceleration. In D. H. Owen (ed.), Optical flow and texture variables useful in simulating self motion (II). Columbus, OH: Ohio State University.

Wickens, C. D. 1984. Processing resources in attention. In R. Parasuraman and D. R. Davies (eds.), Varieties of attention. New York: Academic Press.

Williams, L. J. 1985. Tunnel vision induced by a foveal load manipulation. Human factors. 27: 221-227.

Williams, L. J., and Lefton, L. A. 1981. Processing of alphabetic information presented in the fovea or the periphery: functional visual field and cognitive load. Perception. 10: 645-650.

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