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Research Report

Establishing Mobility Measures to Assess the Effectiveness of Night Vision Devices: Results of a Pilot Study

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In addition to their restricted peripheral fields, persons with retinitis pigmentosa (RP) report significant problems seeing in low levels of illumination, which causes difficulty with night travel (Turano, Geruschat, Stahl, & Massof, 1999). Several devices have been developed to support the visual needs of persons who have night blindness. These devices include wide-angle flashlights (Morrissette, Marmor, & Goodrich, 1983), adapted military light-intensifier devices (Berson, Mehaffey, & Rabin, 1974), and systems that use high-sensitivity (or infrared-sensitive) video cameras (Friedburg, Serey, Sharpe, Trauzettel-Klosinski, & Zrenner, 1999; Hartong, Jorritsma, Neve, Melis-Dankers, & Kooijman, 2004; Spandau, Wechsler, & Blankenagel, 2002). New devices are also in development, including the Minified Augmented-View device, which incorporates expansion of the visual field, along with the enhancement of night vision, to address both the field and night vision needs of persons with RP (Bowers, Luo, Rensing, & Peli, 2004; Peli, 2001).

To guide the development of new night vision devices and provide accurate information to potential consumers of such devices, it is important to evaluate their usefulness in supporting efficient and safe mobility in outdoor areas of low illumination. An evaluation of night vision devices that provides sufficient details about mobility performance in actual night situations would also benefit orientation and mobility (O&M) instructors who may be involved in introducing and training clients to use such devices effectively for safe and independent travel.

Methods of evaluating mobility performance while using night vision devices have varied, ranging from subjective decisions by trained specialists about a person's travel abilities while performing functional tasks (Spandau et al., 2002) to designs that used a more objective set of measures, including recorded occurrences of mobility behaviors, total time to walk a course, or preferred walking speed (Hartong et al., 2004; Morrissette et al., 1983; Robinson, Story, & Kuyk, 1990).

This pilot study included mobility measures that were used in previous studies of night vision devices, as well as two new measures (cane contacts and object-recognition distances), to gain an initial impression about these measures' sensitivity to changes in mobility with night vision devices. In addition, in preparation for future studies, the study was conducted to provide information about any difficulties in assessing outdoor night mobility in a real-world environment. The results are reported to open an avenue for discussion among professionals in the field.

Method

Design of the course and mobility measures

The assessment was conducted in Boston, Massachusetts, and included two main outdoor sections: a mobility course and an object-recognition task (similar to the daylight object-detection task used by Goodrich and Ludt [2003]). An earlier study (Bowers et al., 2004) reported differences in mobility performance and perceived visual difficulty without a night vision device at lighting levels that were equivalent to those found on well-lit and poorly lit streets (about 16 lux and 2 lux, respectively). On the basis of this finding, the mobility course used in the current study was divided into a high-light section (median: 15 lux) and a low-light section (median: 2.5 lux), each consisting of approximately 8-9 short city blocks and naturally occurring obstacles. The object-recognition section was situated in a low-light area (median: 1.5 lux). The participants' mobility performance was scored by a certified O&M instructor. Another O&M instructor was present to monitor the participants' safety and to give instructions about the route.

The participants were instructed to walk at a natural pace along the high- and low-light sections of the course and to attempt to avoid body contact with all obstacles. They were scored for the occurrence of three main categories of mobility behaviors: cane contacts, body contacts, and mobility errors (see Box 1). Other than cane contacts, these measures were consistent with those that were used in other studies of night vision. The time it took to complete each route was also recorded. Since many potential users of night vision devices are likely to use the device in conjunction with a long cane, the number of cane contacts was tallied. The inclusion of this additional measure was based on the premise that a change in the number of cane contacts when walking the routes with a device and without a device might provide an indication of the extent to which the participants used vision versus tactile information to navigate the environment in these two conditions.

Along the section of the course that dealt with the object-recognition task, the participants were asked to find five objects of various sizes and contrast that had previously been shown to them indoors: a large, black plastic garbage bin; a large, orange traffic cone; a small, orange pumpkin basket; a yellow "caution wet floor" sign; and a navy umbrella in the open position. The objects were placed on the right or left side of the sidewalk from the ground to hip level. The participants were asked to search for these objects visually and to stop each time they could first identify an object. An ultrasound measure or standard tape measure was used to measure the distance at which the objects were recognized. The location of the objects was varied between the participants. The inclusion of this task was considered important for two reasons. First, an increase in the detection distance of obstacles at night, which may occur when using a night vision device, could improve safety and ease of movement. Second, a night vision device could be used for the visual detection of specific landmarks for navigation; therefore, some measure of a person's ability to recognize objects using the device is important.

The device

Each participant used the MultiVision night vision device (manufactured by Trivisio, Switzerland) and received 40 minutes of training with the device before the mobility assessment started. The MultiVision provides a video image of the environment, gathered through a high-sensitivity camera that is mounted on the front of a pair of goggles. The image is displayed on two small video screens that are enclosed in the goggles. The user wears the goggles, watching the video screens to see where she or he is going. The field of view of the system was 32 degrees horizontal by 24 degrees vertical.

Participants

The participants were two adults who had RP and reported that they had difficulty in outdoor night travel because of reduced vision. Participant 1 was a 44-year-old woman who did not use a cane for mobility, and Participant 2 was a 35-year-old man who used a long cane. Table 1 summarizes their visual characteristics. Under dim illumination conditions, the device improved contrast sensitivity for both participants to the levels attained at normal (standard) room lighting without the device. However, visual acuity with the device was restricted by the limited resolutions of the display and camera, such that visual acuity at low light levels did not improve with the device; similar results were reported by Bowers et al. (2004).

Both participants completed the entire course with and without a night vision device. For the mobility course, the order of the route sections (high and low light) and the starting direction of each section were reversed between the device and no-device conditions to reduce any effects of learning. For the with-device assessments, the device was used continuously.

Results

Mobility measures

As is indicated by the low number of body contacts and mobility errors that the participants made, neither participant had difficulty traveling with or without the device in the high-light section of the course. The low-light section, with lower illumination levels and a greater concentration of obstacles, was more challenging, and both participants made more contacts and mobility errors than in the high-light section (see Table 2). Furthermore, Participant 2, who used a long cane, showed an increase in cane contacts at the low light level. For both participants, the most frequently recorded mobility errors were shuffling or hesitations, followed by sudden stops and a loss of balance. High-stepping and curb-approach errors were rarely recorded, and veers and spotter interventions did not occur (see Box 1 for definitions of these terms).

The impact of the night vision device on mobility performance was different for the two participants in the high-light section of the course: Participant 1 took longer to complete the section and made a few more mobility errors with the device than without, whereas Participant 2 took just 5 seconds less to complete the section and made fewer cane contacts with the device than without it (see Table 2). For the low-light section, there were clear differences in the participants' mobility performance with and without the night vision device. Participant 1 demonstrated worse mobility performance (she made more body contacts and mobility errors) and took 45 seconds longer to walk the section with the device than without it. In contrast, Participant 2 took about the same time to walk the section and made more body contacts but fewer mobility errors and far fewer cane contacts when using the device than without it.

For Participant 2, the increase in body contacts and reduction in cane contacts was partly a result of a change in the cane technique that he adopted when using the device. Without the device, he used the touch technique, but he changed to the diagonal technique when using the device. For comparison purposes, Participant 2 was asked to walk half of the low-light section of the route (four blocks) again with the device, using the touch technique. Cane contacts using both techniques decreased when he used the device, but less dramatically when he maintained the touch technique (a decrease of 35 contacts compared to 45 for the four-block section). Also, the same pattern of increased body contacts and decreased mobility errors was present along this portion of the route, but at different ratios, depending on the cane technique that he used: less of an increase in body contacts (3 versus 9) and more of a decrease in mobility errors (4 versus 1) with the touch technique and the device. The potential confound of having the participant walk the same section twice should be noted.

Object-recognition task

In general, both participants' object-recognition performances were better with than without the night vision device, especially the performance of Participant 2 (see Table 3). There was an overall increase in the distance at which objects were recognized when using the device; Participant 2 missed two objects without the device, but saw them with the device.

Discussion

Mobility errors

In the low-light section of the course, Participant 1 made more mobility errors with the device than without it, whereas

Participant 2 made fewer errors with the device than without it (see Table 2). The opposite effect for the two participants could be due to insufficient training in using the device, but may also be related to differences in the participants' visual characteristics, a finding that is consistent with previous studies (Morrissette et al., 1983; Rohrschneider, Spandau, Wechsler, & Blankenagel, 2000; Spandau et al., 2002). Participant 1, with a larger visual field and better contrast sensitivity at low light levels (see Table 1), did not find the device useful and reported that it limited her natural eye scanning and blocked the view of her feet (similar comments were previously reported for the MultiVision device; Hartong et al., 2004; Spandau et al., 2002). By comparison, Participant 2, with a much narrower visual field and poorer contrast sensitivity at low light levels, found the device to be useful in the low-light section of the course in providing visual information about objects that he otherwise would not have seen and made fewer mobility errors with the device.

Despite the low number of overall errors in the high-light section, both participants had a slight increase in mobility errors when using the device. It is likely that their slightly poorer mobility performance with the device at this light level was due to insufficient training in using the device and the limitation on natural eye scanning imposed by the restricted field of the device.

Body contacts

The increase in body contacts with the use of the night vision device for both participants is inconsistent with previous studies (Hartong et al., 2004; Morrissette et al., 1983). This finding may be due to a combination of factors. First, the definition that was used for counting body contacts in this study was strict and even included brushing against plants in window boxes (which were a common feature in the neighborhood that was used). For both participants, most of the increase in body contacts with the device occurred at the middle/vertical level because they brushed against street lamps with the arm or shoulder or against plants in window boxes. Second, for both participants, most of these harmless "to the side" contacts occurred in one extremely cluttered part of the low-light route where the sidewalk was narrow. Since the night vision goggles limit the extent of the field that can be scanned with eye movements alone, it appears that the need to switch to full head scanning affected the participants, particularly in cluttered areas. More training, including head-scanning techniques, may help alleviate this problem (Hartong et al., 2004).

Cane contacts and use of a cane

For the cane user (Participant 2), the total time he took to walk the course was similar in both conditions. However, the reduction of cane contacts when he wore the night vision device shows promise as a measure of the increase in the use of vision to navigate the environment. A similar pattern was also shown by another cane user in the prepilot phase, a 58-year-old man with a restricted peripheral field of 7 degrees in daylight conditions. In the low-light section, the total time it took to walk the course was similar with and without the device, but a 50% reduction in cane contacts was observed when the device was used. Since the implication of the utility of the cane-contacts measure is based on patterns that were observed in only two individuals (Participant 2 and the prepilot participant), further investigation is warranted. It is also necessary to refine the measure and recording procedures to make counting cane contacts less cumbersome.

The approach taken in this study (and in Robinson et al., 1990) was to allow the use of a cane during all mobility assessments. Although this approach does not allow for the direct assessment of the extent to which the night vision device alone may improve mobility, it is nevertheless a valid approach that measures how much the device improves mobility in the habitual situation of cane use. We suggest that cane users may use night vision devices as a supplementary aid, not as a replacement for the cane. In particular, for the MultiVision device that was used in this study, the limited field of view of the device (32 degrees horizontal field) and the challenges it thus poses for eye scanning (especially when a person is not fully adapted to the device) suggest that a cane should be used.

Object-recognition task

The object-recognition task could be accomplished only by using visual information and provided a direct measurement of the visual benefits of the night vision device in an actual environment. As expected, overall object-recognition distances increased when the night vision device was used, especially for Participant 2, who had more impaired vision at low light levels than did Participant 1. However, this task presented some difficulties, which have to be overcome, including variation in lighting conditions at different locations of objects, items being stolen, and items on the sidewalk that could be mistaken for an intended target. The task could also be improved by the inclusion of more functional objects in the natural environment (which are likely to be low contrast) to simulate better the real landmarks that participants may be trying to recognize.

Conclusion

The ultimate goal of an evaluation of a night vision device in a real-world setting is to gain as much functional information about the device's benefits and limitations to users with night blindness. To provide specific details that will assist O&M specialists in creating training protocols for their clients on the devices, reporting on a wide variety of measures may be useful. The preliminary results of this exploratory study suggest that both cane contacts and object-recognition distances--measures that were not previously used in such studies--may be sensitive to changes in mobility behavior resulting from increased visual information when using the device. Our findings invite discussion from the field.

References

Berson, E. L., Mehaffey, L., & Rabin, A. R. (1974). A night vision device as an aid for patients with retinitis pigmentosa. *Archives of Ophthalmology, 91,* 495-500.

Bowers, A. R., Luo, G., Rensing, N. M., & Peli, E. (2004). Evaluation of a prototype minified augmented-view device for patients with impaired night vision. *Ophthalmic and Physiological Optics, 24,* 296-312.

Friedburg, C., Serey, L., Sharpe, L. T., Trauzettel-Klosinski, S., & Zrenner, E. (1999). Evaluation of the night vision spectacles on patients with impaired night vision. *Graefe's Archive of Clinical and Experimental Ophthalmology*, *237*, 125-136.

Goodrich, G. L., & Ludt, R. (2003). Assessing visual detection ability for mobility in individuals with low vision. *Visual Impairment Research*, *5*(2), 57-71.

Hartong, D. T., Jorritsma, F. F., Neve, J. J., Melis-Dankers, B. J. M., & Kooijman, A. C. (2004). Improved mobility and independence of night-blind people using night-vision goggles. *Investigative Ophthalmology & Visual Science*, *45*, 1725-1731.

Morrissette, D. L., Marmor, M. F., & Goodrich, G. L. (1983). An evaluation of night vision mobility aids. *Ophthalmology*, *90*, 1226-1230.

Peli, E. (2001). Vision multiplexing: An engineering approach to vision rehabilitation device development. *Optometry and Vision Science, 78,* 304-315.

Robinson, J., Story, S. M., & Kuyk, T. (1990). Evaluation of two night-vision devices. *Journal of Visual Impairment & Blindness, 84,* 539-541.

Rohrschneider, K., Spandau, U., Wechsler, S., & Blankenagel, A. (2000). Utilization of a new night vision enhancement device (DAVIS). *Klinische Monatsblatter Augenheilkunde, 217,* 88-93.

Spandau, U. H. M., Wechsler, S., & Blankenagel, A. (2002). Testing night vision goggles in a dark outside environment. *Optometry and Vision Science*, *79*, 39-44.

Turano, K. A., Geruschat, D. R., Stahl, J. W., & Massof, R. W. (1999). Perceived visual ability for independent mobility in persons with retinitis pigmentosa. *Investigative Ophthalmology & Visual Science*, *40*, 865-877.

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