Functionally Relevant Illumination Levels For Evaluation Of A New Night Vision Device

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ABSTRACT

Purpose: We are collaborating with MicroOpical Engineering Corp on the development of a new type of night vision device (incorporating a novel vision display) to aid outdoor night mobility, specifically for patients with night blindness but good daylight visual acuity. As part of our preliminary evaluations, we determined the functionally relevant range of lighting levels at which the device should operate to provide maximum benefit for outdoor mobility in a range of environments and at which visual function, mobility and device performance should then be evaluated during clinical trials.

Methods: Detailed surveys of lighting levels on busy and quiet city center, residential and rural streets were carried out in the Boston area. Visual performance of 3 retinitis pigmentosa (RP) subjects and 2 control subjects was assessed with and without a commercially available night vision device (Visys) at a range of illumination levels found in the street lighting surveys. Independent night-time outdoor mobility with habitual mobility aids (long canes) was assessed for 3 RP subjects under a range of street lighting conditions with and without the Visys device.

Results: Street lighting ranged from a median of 13 (range 1.0 - 694) lux on busy city center streets to a median of 3.2 (range 0.3 – 22) lux on quiet residential streets and a median of 0.3 (range 0 – 17) lux on rural streets. Two of the RP subjects had good VA (20/50 or better in daylight). For these 2 subjects, visual functions, walking speed and subjective confidence to carry out independent night-time mobility were reduced when outdoor illumination levels were less than 5 lux; there was a marked improvement in visual function and walking speed with the Visys device at these light levels. The third RP subject had reduced VA (20/400). His mobility performance showed less illuminance dependence than the 2 RP subjects with good daylight VA.

Conclusions: Although our survey indicated that a night vision device should operate across a wide illuminance range, particular attention should be given to device performance below 5 lux as this was the illuminance level below which our target population (night blindness, but good visual acuity) felt unsafe to undertake independent outdoor night mobility

ILLUMINANCE LEVELS FOR NIGHT VISION DEVICES

- Surveys of street lighting confirmed that a night vision device should operate across a wide illuminance range (Fig 1 and Table 1).

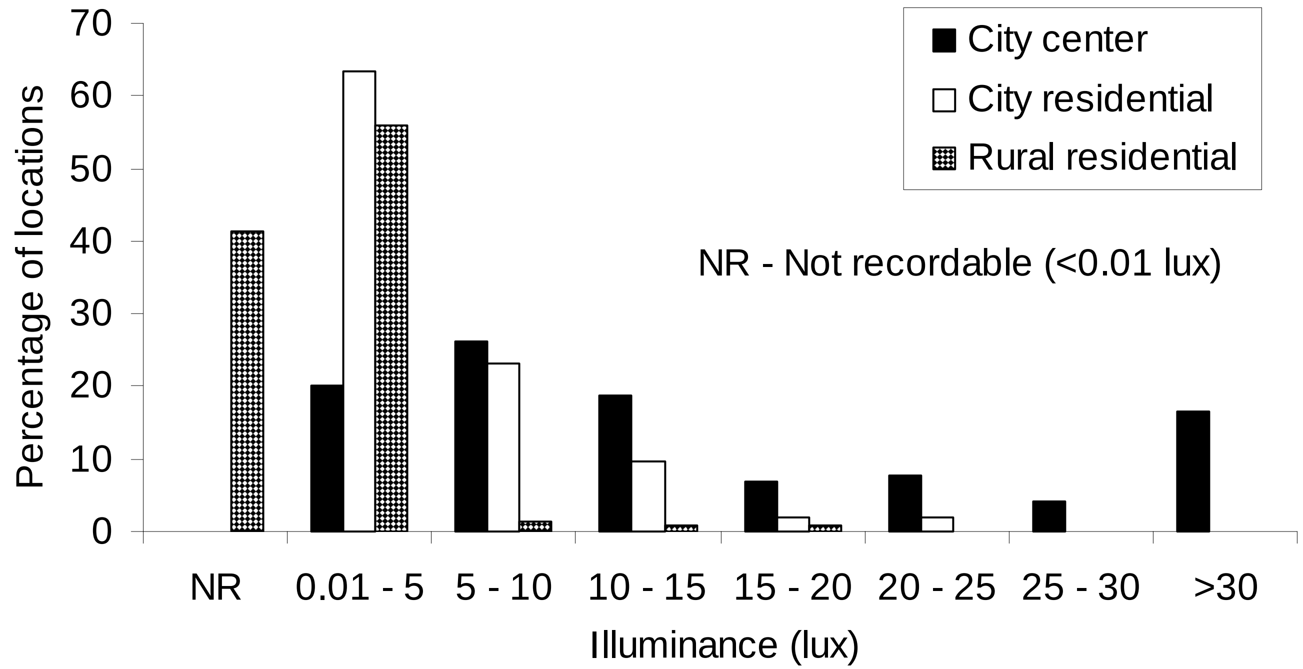

Fig 1: Illuminance levels in 3 outdoor areas

Table 1: Summary statistics for the three areas

Area	Illuminance (lux)	
	Median	Interquartile range
City center (n = 145)	13.1	6.5 – 22.4
City residential (n = 52)	3.3	1.5 – 6.9
Rural residential (n = 145)	0.32	0.01 – 0.54

EVALUATION OF NIGHT VISION DEVICES

- Performance of prototype MicroOptical device was compared to that of the Visys device at functionally relevant illumination levels through:
    1. Vision function measurements
    2. Outdoor evaluation (subjective ratings of amount of “help” provided by the device)
    3. *Indoor obstacle course assessment – data collection on going and not reported here*

Subjects

- Four subjects with night blindness, with daylight visual acuity of 20/40 or better, who currently undertake independent night mobility with long cane

Subject	Visual Acuity (logMAR)	Letter Contrast Sensitivity (log units)	Horizontal visual field diameter (degrees)
NV01	0.32	1.35	7.5
NV02	0.02	1.65	10.5
NV03	0.16	1.60	10.0
NV04	0.04	1.85	20.0

Table 2: Visual function (binocular) of subjects in standard room lighting with habitual distance correction

NEW NIGHT VISION DEVICE: MICROOPTICAL

- Under development with MicroOptical Engineering Corp.
- Monocular see-through display
- Provides field expansion and image from low--light sensitive camera
- Image and natural view available simultaneously (possible to alternate between views by eye or head movement)
- Miniature video camera with wide field of view (about 4x the field of the 16° display) mounted on one temple of spectacle frame
- LCD situated below other temple
- Image relayed to eyepiece embedded within the eyeglass lens.
- The virtual image seen by the user is minified, thus providing field expansion

New night vision device developed with MicroOptical is cosmetically more attractive with better ergonomic design than other night vision devices

MicroOptical Engineering Corporation, 33 Southwest Park, Westwood MA 02090; www.microoptical.net

Comparison Night Vision Device: Visys

- Head mounted binocular goggles with opaque display
- Natural view of the scene not available whilst wearing goggles

- IR camera mounted on front of goggles
- Image presented on LCDs within the goggles.
- No minification of image (1:1 representation), therefore no field expansion
- Field of view about 40°

Visys night vision device is cosmetically less attractive with poorer ergonomic design than MicroOptical device, but camera sensitivity and autogain control are superior

Visys AG 61350 Bad Homburg, Germany; www.visys.net

Subjects' Comments About the Devices

MicroOptical		**ViSys**
Positive		Negative
Light in weight	→	Heavy and does not fit well over glasses
Liked open design	→	Enclosed with restricted field
No delay in display on head movement	→	Delay in display with quick head movement
Pedestrian signal lights can be seen on see-through	→	Red pedestrian signal lights appear white
Negative		Positive
Poor contrast image	→	"Makes night look like day"
Not good for distant objects	→	Good for distant objects
Poor performance at lower light levels	→	Good performance at all light levels
		Copes well with headlight glare

VISION MEASUREMENTS WITHOUT DEVICE

Visual function was assessed without night vision devices at room illumination (360 lux) and illumination levels representative of city center streets (15 lux) and residential streets (2 lux).

Effect of reduced illumination on visual function of night-blind subjects

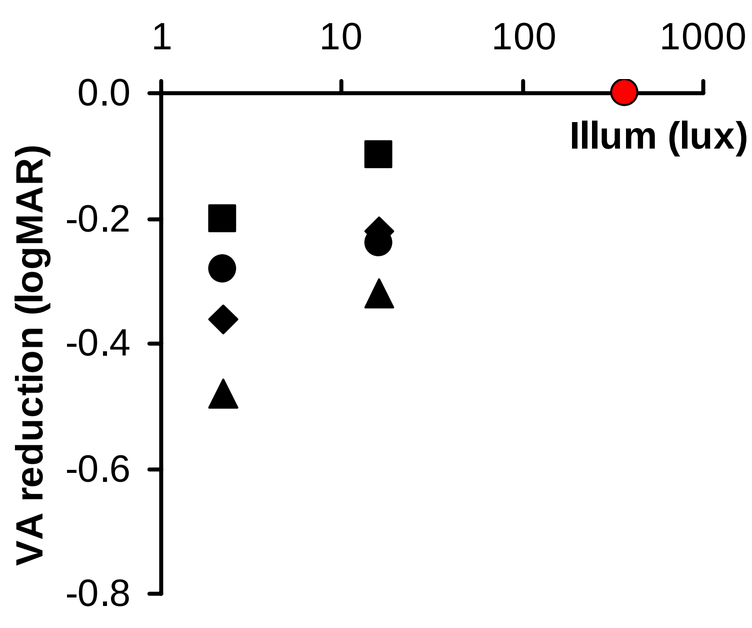

Fig 4: Reduction in visual acuity from standard lighting

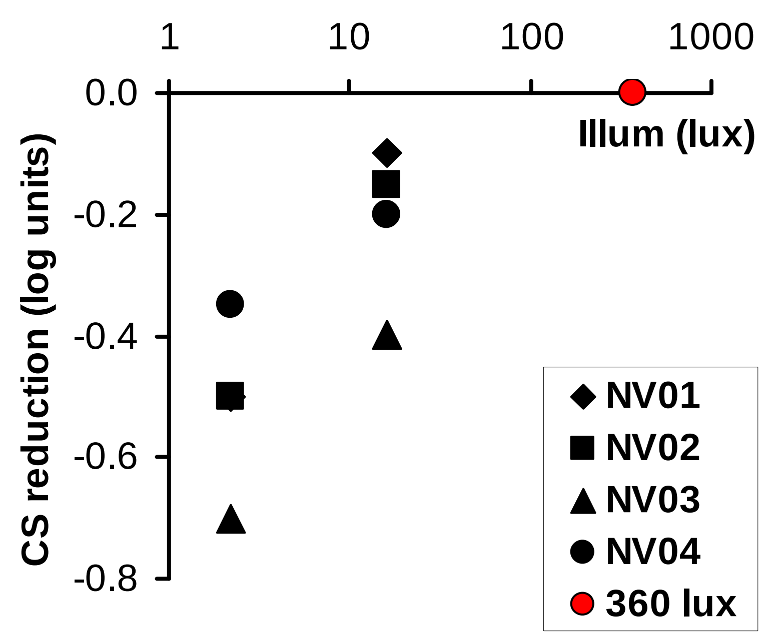

Fig 5: Reduction in letter contrast sensitivity from standard lighting

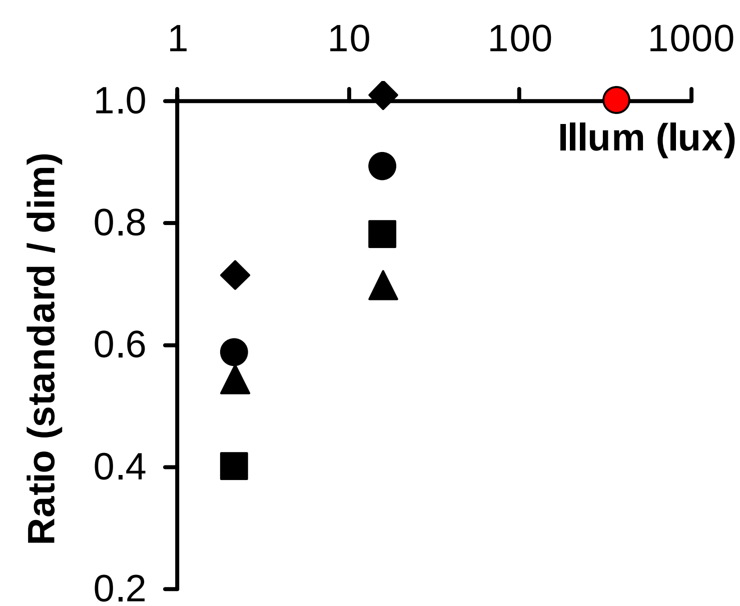

Fig 6: Reduction in horizontal field extent (ratio)

VISION MEASUREMENTS WITH NIGHT VISION DEVICES

Visual function was assessed with night vision devices at 15 lux and 2 lux

Difference in visual function at street lighting levels with and without each device

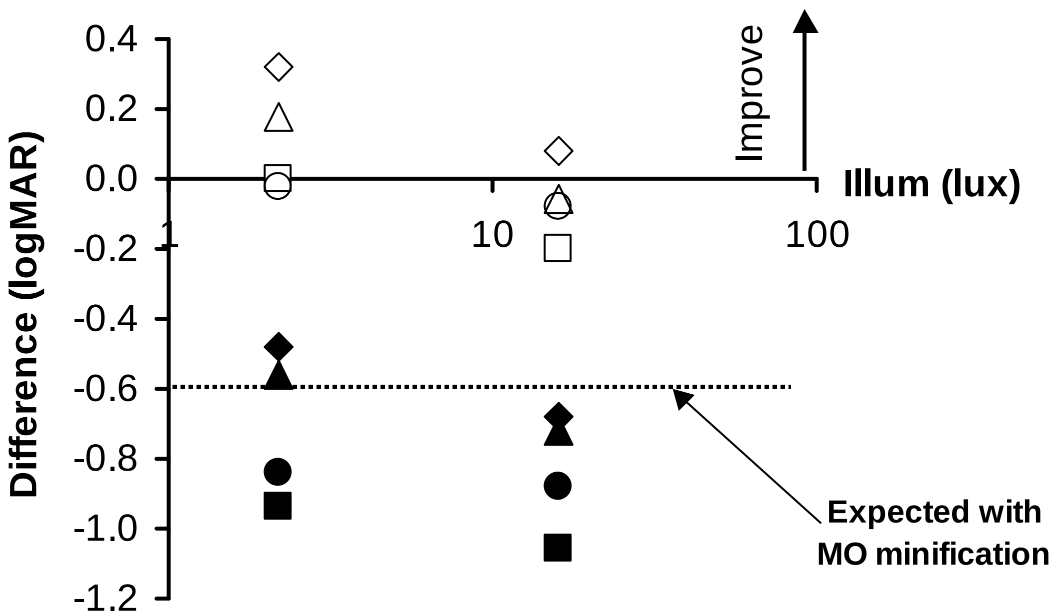

Fig 7: Difference in visual acuity

- Improvement in VA with Visys for 2 subjects at 2 lux
- Reduction in VA with MicroOptical due to minification and resolution limits of device

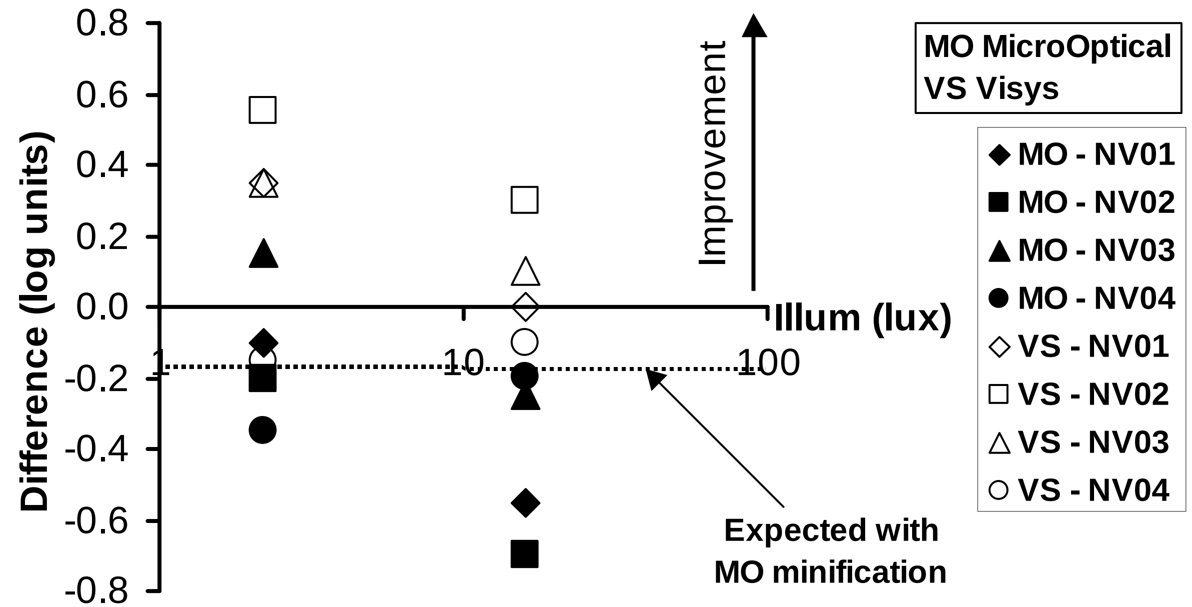

Fig 8: Difference in letter contrast sensitivity

- Improvement in CS with Visys at 2 lux
- Improvement in CS with MicroOptical for NV03 at 2 lux

VISION MEASUREMENTS WITH NIGHT VISION DEVICES

Effect of night vision devices on visual field extent

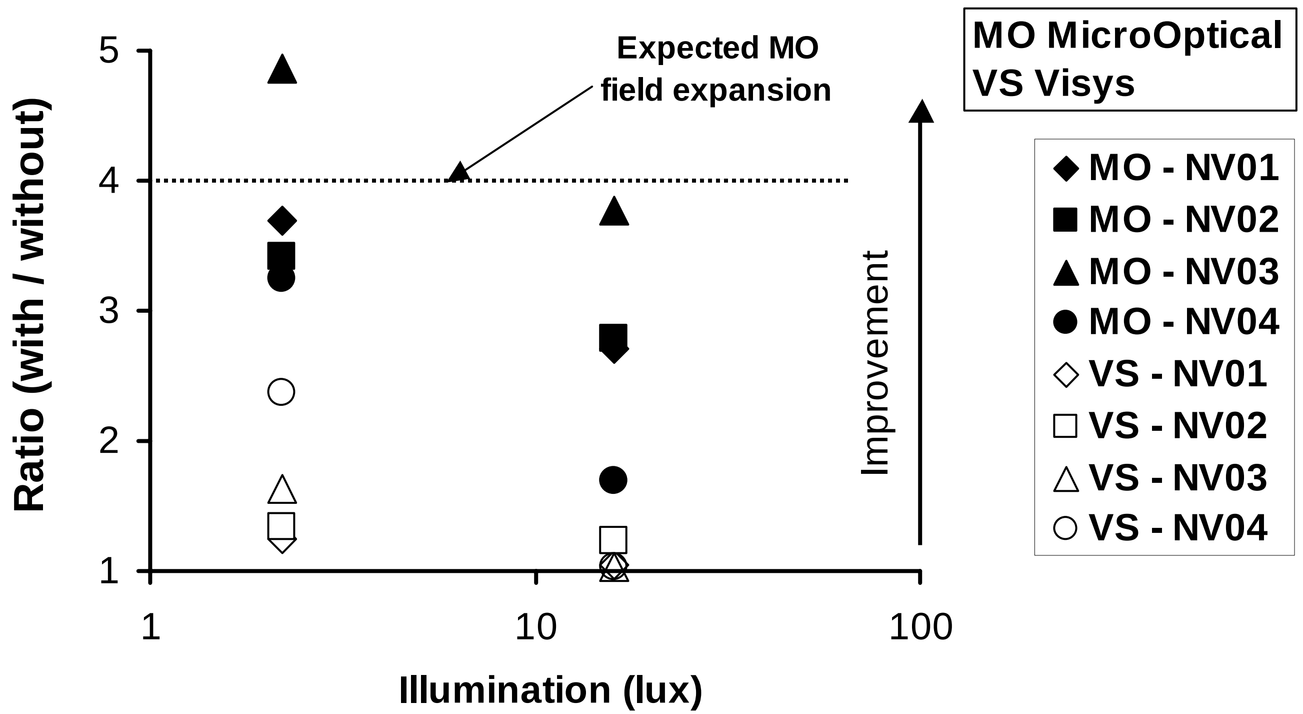

Fig 9: Increase in horizontal field extent with device (ratio) at street lighting levels

- Field expansion of MicroOptical device clearly evident
- Field extent with Visys at 2 lux was greater than field extent without device

OUTDOOR EVALUATION OF NIGHT VISION DEVICES

Devices evaluated at street locations with median illuminance levels of <1, 2, 6 and 15 lux
Subjects rated, on a 5-point scale, difficulty in seeing without device & amount of help provided by each device

Do night vision devices help subjects see street objects at night?

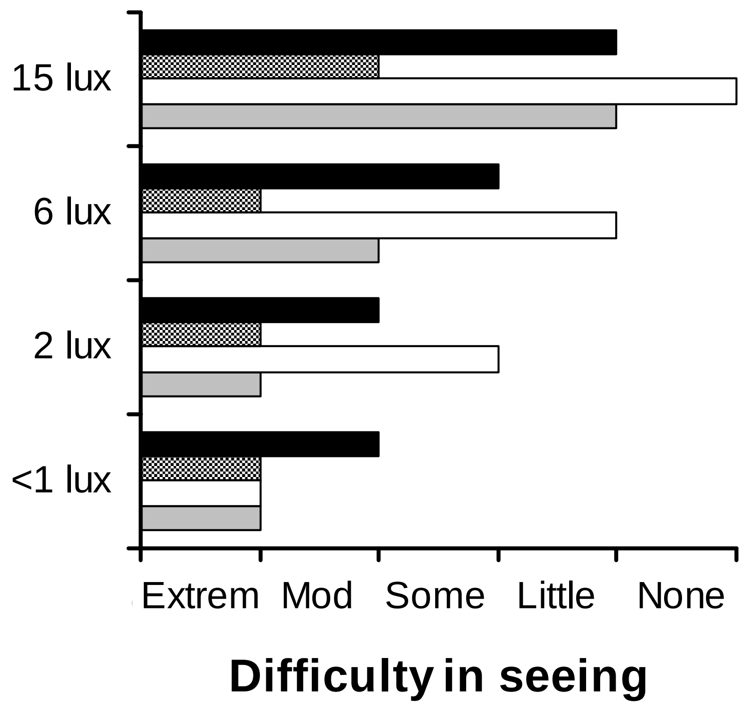

Fig 10: Without device

Extreme difficulty seeing at < 1 lux

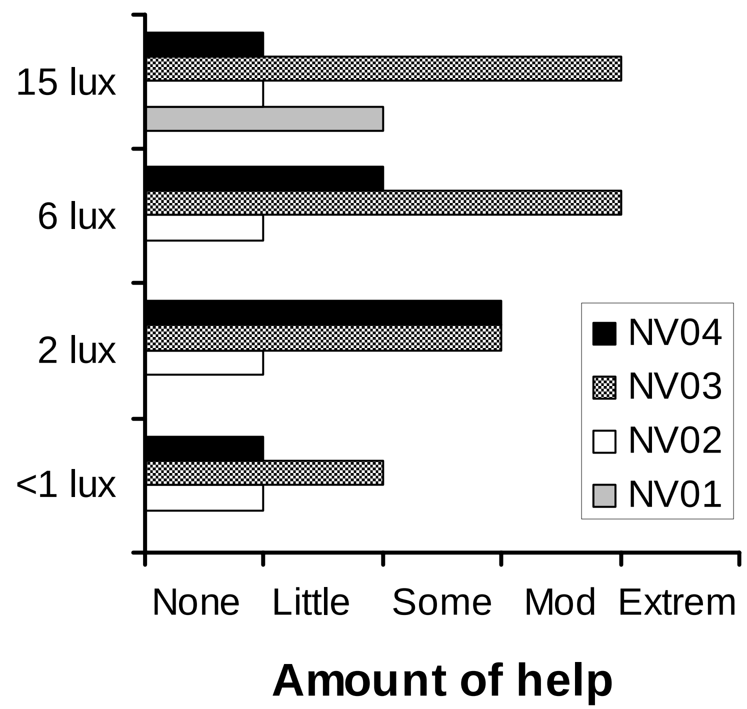

Fig 11: With MicroOptical

MO device helpful for NV04 & NV03

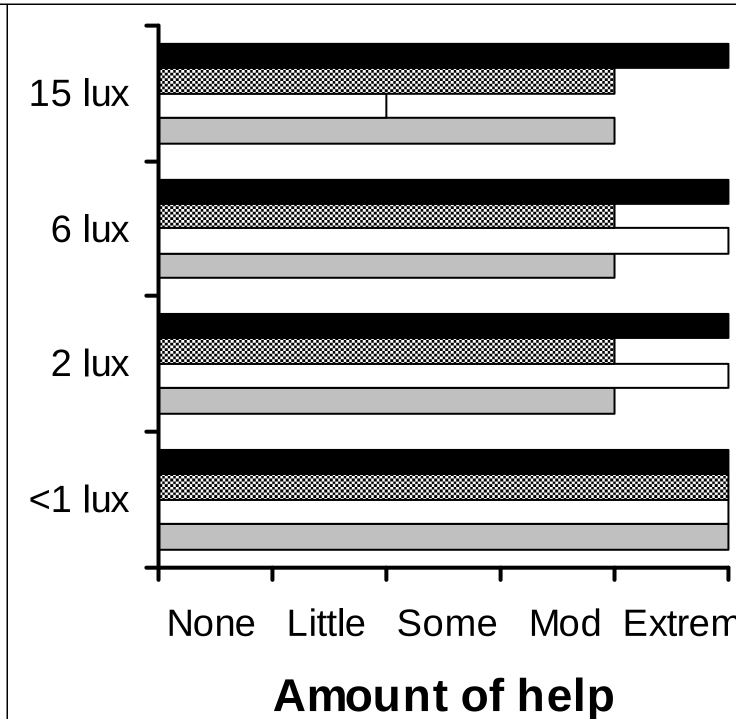

Fig 12: With ViSys

ViSys was extremely helpful

OUTDOOR EVALUATION OF NIGHT VISION DEVICES

Subjects rated, on a 5-point scale, confidence to undertake independent mobility without a night device and improvement in confidence with each device

Do the night vision devices improve confidence to undertake independent mobility?

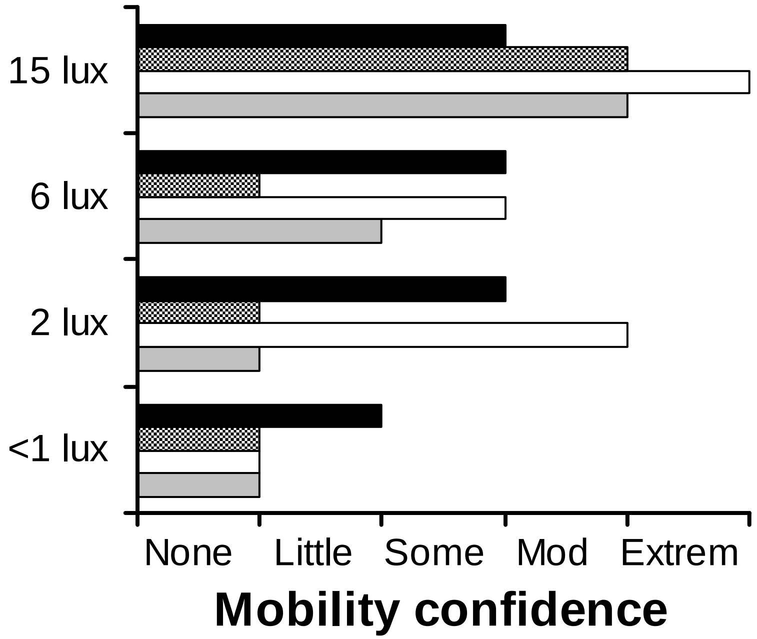

Fig 13: Without night device

Confidence without device varied across subjects and was strongly illuminance dependent

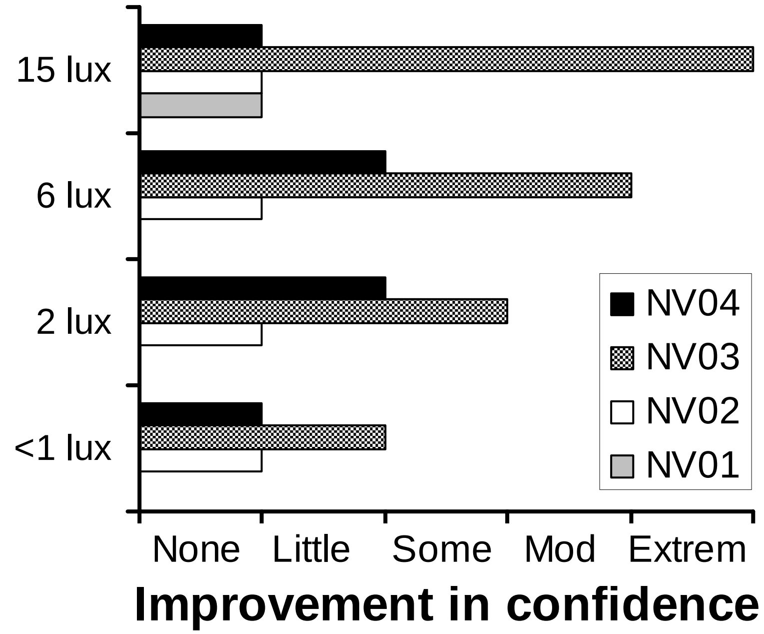

Fig 14: With MicroOptical

NV03 - very positive about device
NV04 - small improvement 2 & 6 lux
NV02 - very negative about device

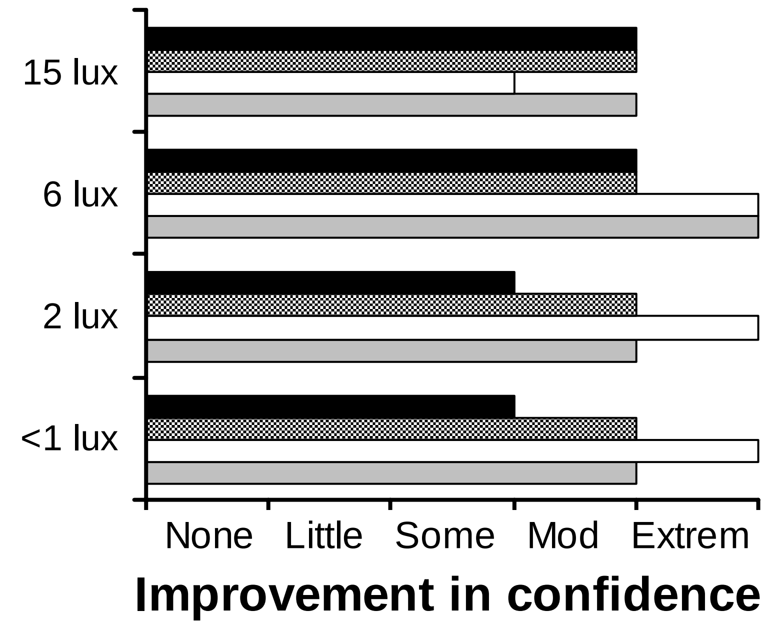

Fig 15: With ViSys

ViSys improved confidence of all subjects to undertake independent mobility at all illuminance levels

CONCLUSIONS

- The performance of the MicroOptical device was inadequate at low light levels, but subjects liked the open design
- Although subjects were very positive about the ability of the Visys device to improve vision and mobility confidence, they did not like the weight and enclosed design.
- Our results reinforce the importance of:
  - ergonomic and cosmetic considerations in the design of visual aids
  - evaluating device performance across a representative range of outdoor illumination levels

Future developments

- Second generation MicroOptical night vision device:
  - improved frame design
  - improved image quality and contrast, especially at low light levels
  - “cartoon” image using edge contours (rather than solid image) – vision multiplexing
- Subjects take device home for 2 weeks; full outdoor mobility assessment

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