Development and Testing of Trifield Glasses for People with Severely Restricted Visual Fields

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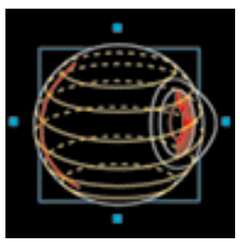

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ABSTRACT

PURPOSE: "Tunnel vision" (e.g. <10° visual field) impairs mobility and searching for objects. Peli (1999, 2001) proposed a novel spectacle-based prism device that expands the visual field. Here we describe the development of the Trifield glasses and preliminary testing with two subjects.
METHODS: Trifield glasses, two prisms separated by a vertical junction, provide visual field expansion. In extended testing, two pilot subjects evaluated a variety of designs. Adaptation to Trifield glasses was evaluated using a pointing task. We have commenced a trial in which twelve subjects are fitted and evaluated over a six-week period.
RESULTS: Fresnel prisms produced a reduction in vision that was greater than found for normally-sighted subjects. Collaboration with local manufacturers allowed us to provide ground prisms. Insufficient prism power caused diplopia, when visual fields overlapped. Phoria correction usually necessitated asymmetric prism powers. Objects seen through a prism were detected, but direction was not correctly determined. We tinted the prisms to provide spectral information that may be associated with direction. The two subjects did not demonstrate adaptation of visual direction, a perceptual integration of Trifield glasses, even with the tints.
CONCLUSIONS: Trifield lenses provided some benefit to subjects, by giving warning of nearby objects. However, subjects did not demonstrate adaptation to the field expansion with altered perception of visual direction. The extended wearing trial will provide objective evaluation of the impact on walking, visual direction and quality of life.
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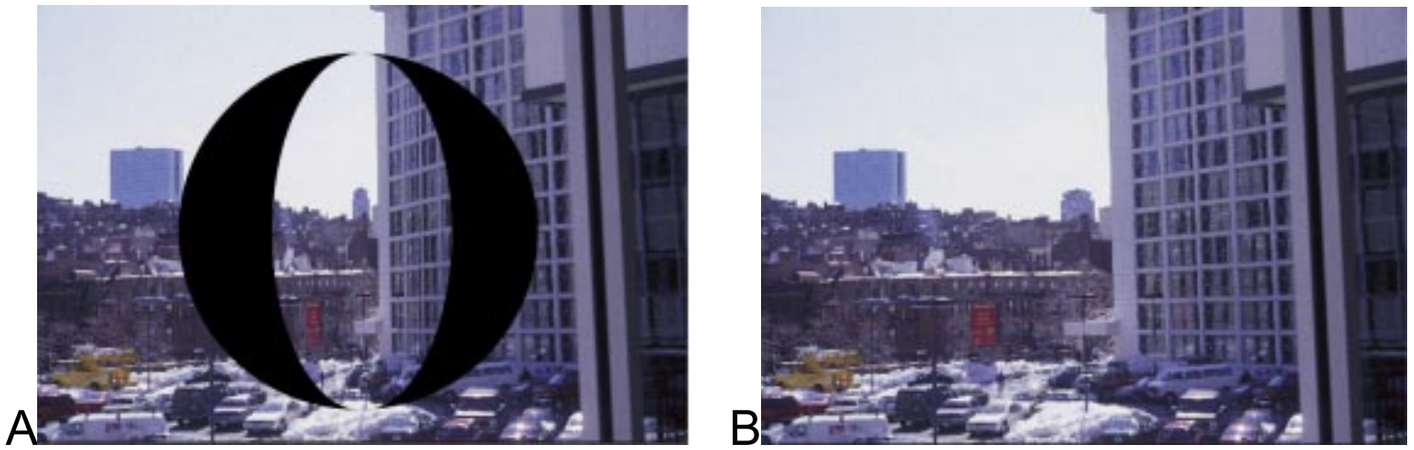
BACKGROUND

- A visual field of 10° or less impairs mobility (e.g. walking).
- Existing visual aids have not been widely successful.
- Peli (1999, 2001) proposed a novel spectacle-based prism device that horizontally expands the visual field – the Trifield lens.
- We describe the concept, the development of the Trifield lens, pilot testing with two subjects and preliminary results of an extended study with five subjects enrolled.

The Trifield lens provides an expanded visual field for all directions of gaze.

EXISTING VISUAL AIDS

- Minifying lens/ telescope, e.g. the amorphic lens (Figure 1)
- Prisms, e.g. InWave™ lens (Figure 2)



A B

Figure 1. (A) Simulated view through amorphic lenses. (B) Compare to the original view. Note that amorphic lenses are worn binocularly.

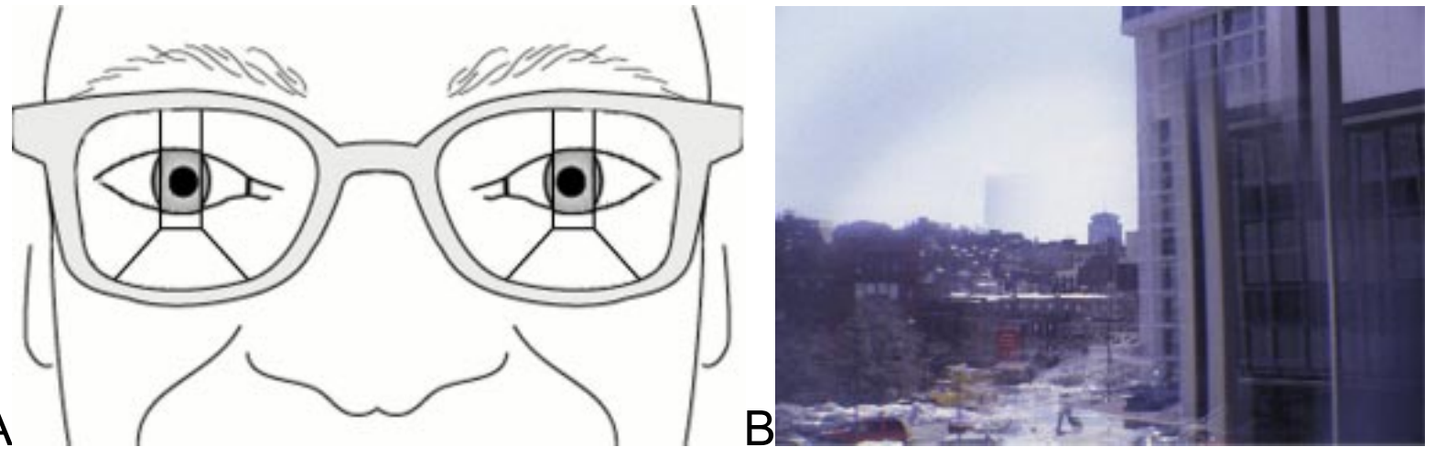


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Figure 2. (A) InWave™ lenses are fitted binocularly. (B) Optical scotomata at the prism apices are shown in a photograph through an InWave™ lens, that can be compared to figure 1B, the original view.

TRIFIELD GLASSES

- Dominant eye has unmodified (i.e. normal) view; other eye wears Trifield lens (figure 3). Note that the Trifield lens is only worn over one eye (monocular).
- Trifield lens: Two prisms, separated by a vertical junction, fitted apex to apex.
- Each prism expands the visual field (figure 4).
- Only on primary gaze are both prisms used. Due to eye movements, usually only one prism is effective at a time.

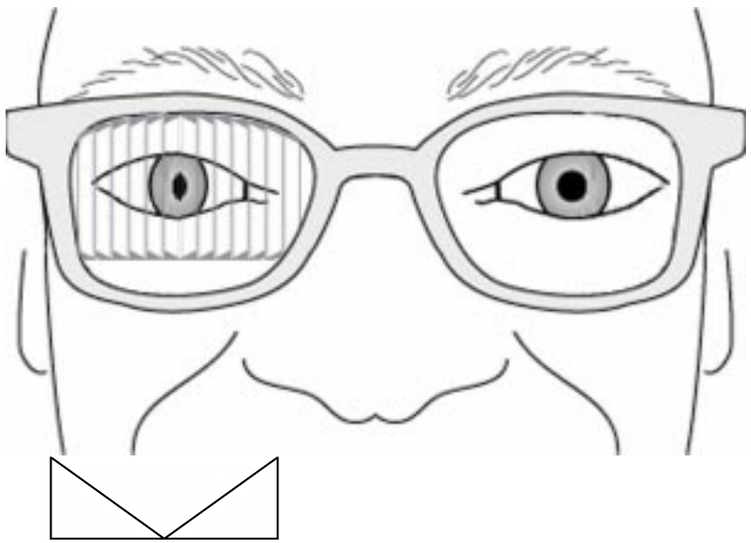


Figure 3. Trifield glasses fitted apex to apex with Fresnel prisms. Base to base prisms is an alternative fitting that we have tried.

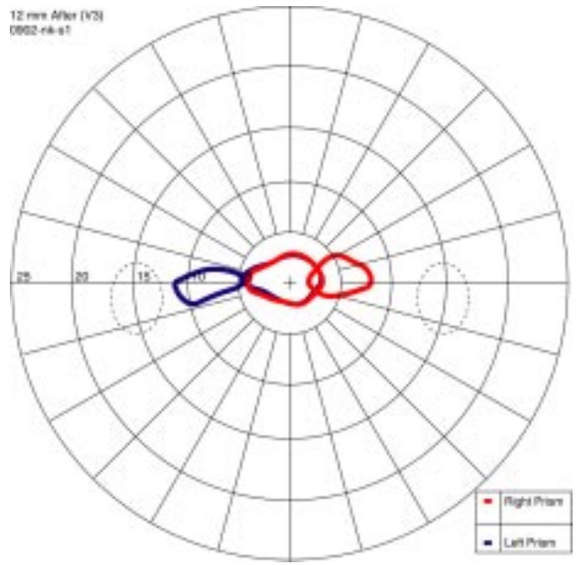


Figure 4. Binocular visual field with Trifield lens worn on the right eye of subject 0902-nk-s3. Prisms 15Δ and 17Δ.

PATIENT'S VIEW

- A simulation of the appearance on primary gaze is shown in figure 5. Note that only on primary gaze do three views combine. Usually only two views are seen with the same visual direction.
- Two objects seen in the same visual direction causes 'visual confusion' (not diplopia).
- Prism power is greater than visual field width so that there is no overlap of the normal and the prism views. Prism power must be sufficient to avoid diplopia.

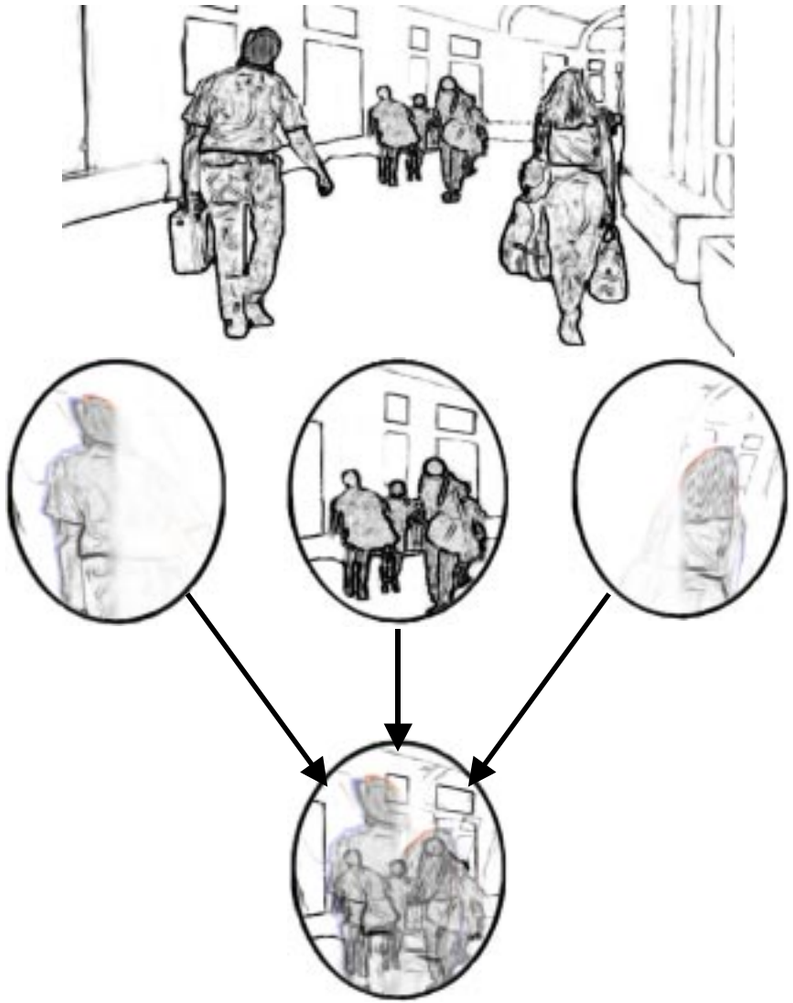


Figure 5. Simulation of the Trifield view on primary gaze (lower panel). Upper panel shows original view. Middle panel shows the three views.

MAKING TRIFIELD GLASSES - manufacture

Fresnel Prisms (figure 3)

- inexpensive, immediately dispensed, easy to modify, flexible power.
- Glare, reduced contrast, reduced visual acuity.

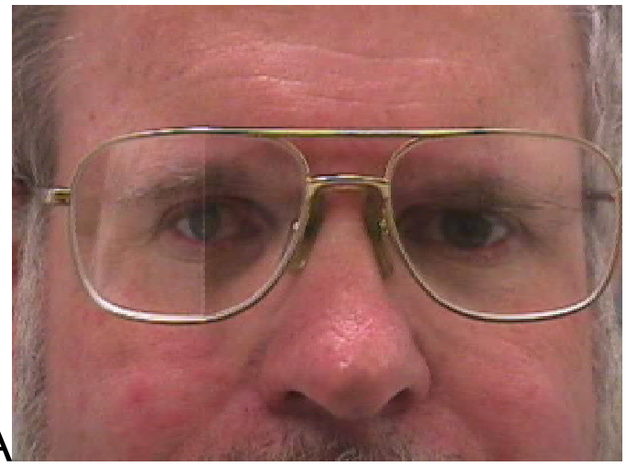
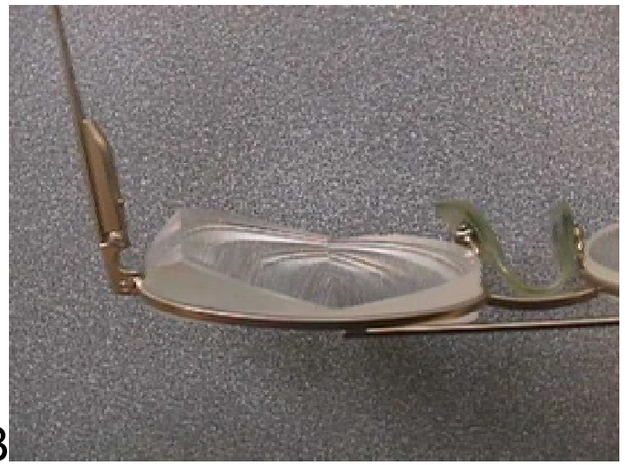
A  B 

Figure 6. Early Trifield lenses in CR39 plastic (A) worn by subject 0694-ym-s1; and (B) top view of these glasses.

CR39 Plastic Lenses (figure 6)

- expensive, complex, weight, better appearance, good visual acuity and contrast.

Prism powers

- Prism powers are determined from the visual field extents (each eye, left and right) and phorias.

MAKING TRIFIELD GLASSES – wearer variables

VISUAL FIELDS

- What is an appropriate target size?
- Patients report double vision of extended objects, even when there is no true diplopia.
- See the notes below about phoria.

WHICH EYE?

- Which eye should have the prisms?
- We started by placing the prisms over the “worse” eye (e.g. smaller VF).
- Subject feedback seems to be that the prisms should be placed over the non-dominant eye.[1]

[1] Sensory dominance as determined using crossed-polaroid glasses and a mirror, or a monocular defocus during binocular view.

EFFECT OF PHORIA

- Trifield lens wearers go into phoria position (relative alignment of the eyes), and hence the prism power required on each side is different (figure 7).
- Prism powers are often asymmetric. Failure to prescribe correct prism powers (visual field measurement or phoria) resulted in diplopia.

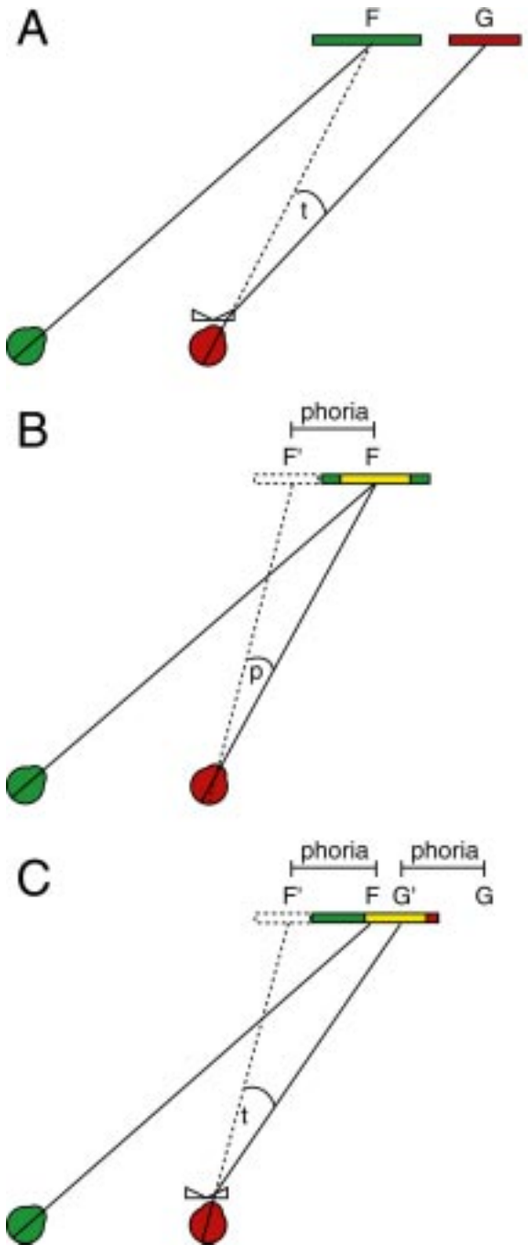


Figure 7. Patient looking to the right at the point F. (**A**) When looking through Trifield glasses (with no phoria), the prism deviates the light (angle t) so that the right eye looks in the direction of G. Visual fields are shown as the red and green bars. Note that the visual fields do not overlap. (**B**) With esophoria the right eye would turn in to look in the direction of F'. Overlap of the visual fields is shown as yellow. (**C**) Trifield lenses as in (A), except that the patient has the esophoria shown in (B). Due to the phoria, the right eye looks in the direction G'. Note that this causes overlap of the visual fields, and hence diplopia. Modification of the Trifield prism power will avoid diplopia.

SPECTRAL MULTIPLEXING

TINT

- Tinted prisms (figure 9) may provide spectral information that may be associated with direction (Kohler, 1964).
- A relatively dark tint was required to make the color difference apparent.

SUNGLASSES

- Fitted clip-on sunglasses improved cosmesis and provided glare reduction required by people with RP (figure 9b).

A

B

Figure 9. (A) The most recent Trifield lenses have prisms tinted green on the left and red on the right. These small frames allow for relatively thin lenses and (B) an additional clip-on sunglass, an important addition for people with retinitis pigmentosa.

EXTENDED WEARING TRIAL

We have begun studies to evaluate:

- Perceived visual direction (using a pointing task).
- Real world mobility (walking in a shopping mall).
- Street crossings (without entering the roadway!).
- Virtual walking (a simulation of the shopping mall, with obstacles that we can control).
- Quality of life (vision and mobility factors).

Study design: 12 subjects, 12 weeks of wear, 9 visits.

PERCEIVED VISUAL DIRECTION

- While objects were detected in the expanded field, no subject could determine the direction of field expansion. Thus, adaptation of visual direction, a perceptual integration of the Trifield lens, was not found (figure 8).

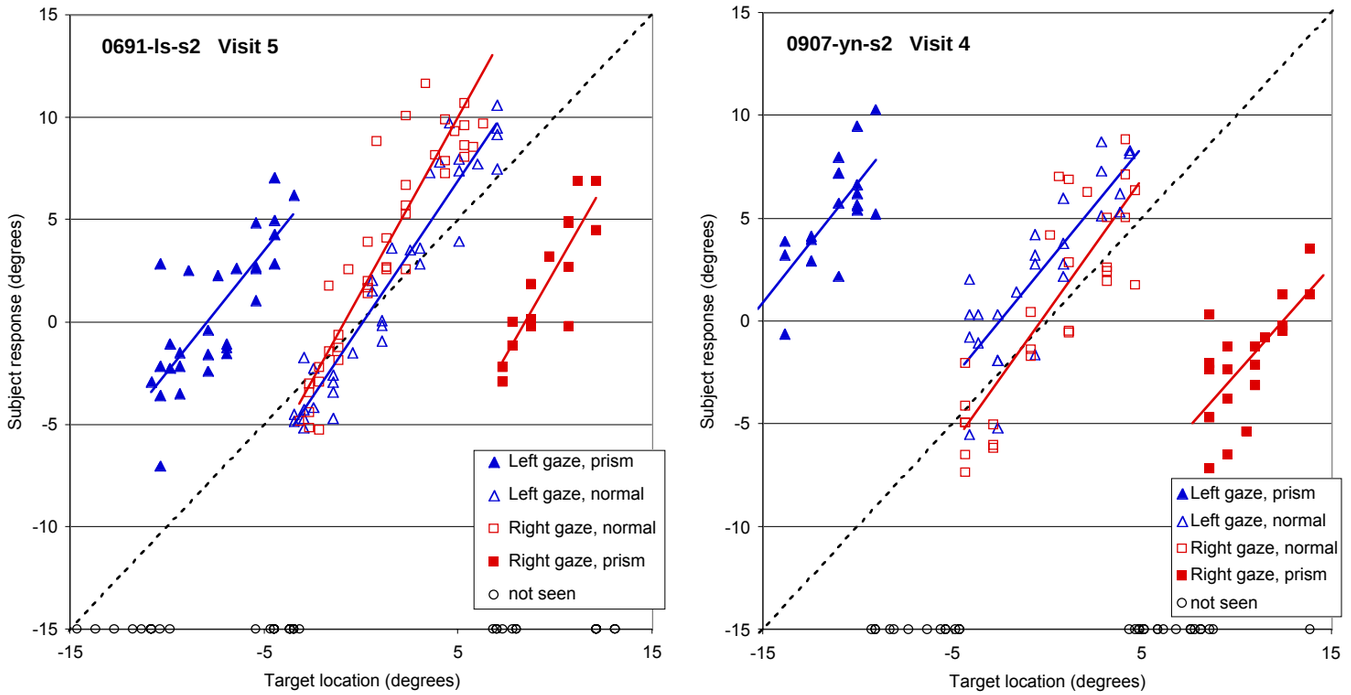


Figure 8. No subject modified their perceived visual direction of objects seen with the Trifield lens to match the real visual direction. If that had occurred, the objects seen with the Trifield lens (i.e. the clusters of points to the right and left) would have been along the dashed 1:1 line shown for the central ("normal") field. Not seen arbitrarily plotted at –15 degrees

SUMMARY

- Many device design issues have been addressed.
- Success has been partial. Subjects had an extension of the visual field, providing early warning, but have not learned the real direction of objects seen with the Trifield lens.
- We are objectively evaluating the impact on walking (safety and navigation), street crossing, visual direction and quality of life on twelve subjects.

ACKNOWLEDGMENTS

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