Clothing for Improving Mine Worker Visibility

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The Problem



- Low light levels are a constant hazard in underground mines and for night-time operations at surface mines
 - Collisions between vehicles and workers are a major cause of fatal accidents in the mining industry
 - Account for ~28% of the 112 fatalities in the mining, exploration and extraction industries in Australia during 1998 – 2008 (Kizil et al 2011)
- Improving the visibility of workers to drivers of mining vehicles and equipment is one potential approach for reducing the risk of collisions and fatalities
 - This approach has been explored in the context of road safety for improving the visibility of vulnerable road users and could <u>potentially</u> be translated to the mining industry

Night-time Driving



- Driving at night can be dangerous
 - Crash statistics indicate that fatality rates at night are <u>3x</u> higher than those for daytime (National Safety Council 1999-2004)
- The night-time elevation in road safety risk is even greater for collisions involving vehicles and pedestrians
 - Fatal pedestrian collisions are up to <u>7x</u> more likely at night than in the day (Sullivan & Flanagan 2002)
- Highly relevant in general road systems, particularly at road work sites
 - 844 workers were killed at road construction sites in the USA between 1995 and 2002 (Pegula 2004)
 - Night-time construction 5x more hazardous than day-time (Arditi et al 2007)

Night-time Visibility



- Crash database analyses indicate that reduced visibility is a key factor in night-time crashes involving vulnerable road-users (Owens & Sivak 1996; Sullivan & Flannagan 2002)
- Problems of poor visibility compounded by:
 - Drivers' underestimation of their own visual limitations at night
 - Confidence is largely based on lane-keeping ability (which is relatively unimpaired) but drivers are unaware of the reduction in their visual function at night (Owens & Tyrrell 1999; Owens 2003)
 - Pedestrians/cyclists overestimation of their own visibility (Tyrrell et al 2004; Wood et al 2013)
 - Increasing driver age with associated declines in visual function
 - Relevant in the mining industry where ~25% of mineworkers are aged 50 years and above

Age-related Vision Changes

- Pupil gets smaller (less light)
- Clouding of the lens (reduced contrast and more glare)
- Retinal/neural slowing (slowing of visual processing)





Night-time Visibility

- Retroreflective clothing is a <u>low cost option</u> for improving the visibility of pedestrians
 - Most common clothing intervention is a retroreflective vest
 - BUT studies show night-time pedestrian visibility is better enhanced via alternative placement of retroreflective markers
- A promising configuration is 'biological motion'
 - Pattern of motion of living creatures known as 'biological motion' - is very different to that of inanimate objects
 - Helps identification of the moving object and it's action even with limited visual information





Biological Motion



Application of Biological Motion

- Application of the perceptual phenomenon of biological motion to improve night-time pedestrian visibility
 - Retroreflective strips attached to moveable joints illuminated in headlamp beam
 - Our studies have demonstrated the visibility benefits of biomotion clothing in both closed and open road environments





Closed Road Pedestrian Studies

- Participants drive an instrumented vehicle around a closed road course at night
 - Distracter task: Call out all road signs
 - Distracter cones
 - Glare lights to simulate oncoming vehicle headlamps
 - Announce

"pedestrian!" and press touch pad when they first recognise a pedestrian is present





Clothing & Age



- Older drivers recognised pedestrians less often and at significantly shorter distances than the younger drivers
 - Overall, older drivers recognised only 58% of the pedestrians and at half the distance
 - Clothing really matters!
 - Recognition distances for biomotion 50x greater than black...
 - ... and 3x greater than vest!

Clutter & Motion

 5 clothing configurations: all pedestrians wore black and all except black wore the same amount of retroreflective material



Clothing & Clutter



- Limb markings recognised more often
- Clutter effect not significant

Clothing & Motion



Benefit of motion greatest when limbs are marked

Tyrrell, VTyrrell et al 2009

Roadworker Open Road Study

- Conducted at 2 road work sites:
 - Suburban & freeway prepared according to standard work site guidelines
- 20 participants: seated at range of distances
 - Rated conspicuity of 4 road workers walking in place wearing 4 different clothing configurations at 3 distances at each site
 - Standardised rating scale















ankle and knee

joints)



(standard configuration plus retro-reflective strips around elbow, wrist, ankle and knee joints)

Biomotion

Effects of Roadworker Clothing

- Overall rankings
 - Suburban & freeway sites







by 95% of

people



by 95% of

people



Ranked 4th by 100% of people

- Significant main effect of clothing
 - Biomotion > ankle & knee > thigh > standard
- Pattern of effects were apparent at both work sites



Effects of Roadworker Clothing

- Overall rankings
 - Suburban & freeway sites



Ranked 1st by 95% of people



by 95% of

people



Ranked 3rd by 95% of

people



Ranked 4th by 100% of people

Study undertaken on the closed road confirmed these ranking results



Fig. 3. Mean (+1 SE) distance at which the younger and older drivers responded to the presence of the primary road worker.

Wood et al 2013

Interventions

 Key element of the pedestrian and cyclist visibility problem is their tendency to overestimate their own visibility to oncoming drivers (Tyrrell et al 2004; Wood et al 2013)



Tyrrell et al 2004

Interventions

- A lecture on night-time visibility improved subsequent judgments of pedestrians own visibility in an on-road situation (Tyrrell et al 2004)
- This approach has potential for translating the findings from biomotion research into safety benefits for workers
 - In addition to those already gained by biomotion clothing
- Recently developed video-based intervention outlines the problems of conspicuity of pedestrians under low light levels
 - Highlights the need to be aware of difficulties that drivers have in seeing pedestrians at night
 - Demonstrates the value of biomotion markings in relation to other clothing configurations

Impact on Night-time Distances



 Viewing of this intervention had a significant impact on participants' perceptions of their own visibility at night

Potential Translation



- Low illumination is a hazard in underground mines and for night-time operations at surface mines
 - Importance of retroreflective markings on clothing is recognised by the mining industry and is standard on all sites
 - Some sites mandate reflective strips on upper and lower body
- Biomotion clothing has the potential to be a low cost and practical way to provide safety benefits in the mining industry
- Does not involve modifications to vehicles, drivers or infrastructure
 - Capitalises on well-documented human perceptual sensitivities
 - Road safety research demonstrates that biomotion clothing is relatively robust to the effects of age, eye conditions, clutter, glare and other factors encountered in mine sites

Potential Translation

- Potential application for an effective and easily implementable custom-based video intervention in the context of mining organisations
 - Potential to change both knowledge and behaviour of mine workers (both drivers and pedestrians) with ultimate benefits for workplace safety
- BUT important that visibility research is undertaken in representative mining environments
 - To further explore the unique visual challenges presented in underground mines and surface mines at night
 - In order to optimise the visibility and hence safety of mine workers in low light conditions

You Are Now Entering Training Area





Centra

Age-related Visual Function Changes

- Visual acuity
 - Ability to see fine detail



PVEHR VPHDE URZVH EZHPV ZVUDN EHVDF

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- Contrast sensitivity
 - Ability to see faint images

Age-related Visual Function Changes

Glare sensitivity

Ability to see objects in the presence of bright light sources





- Motion sensitivity
 - Ability to detect and identify the direction of movement of objects



