The colours, visibility, conspicuity and recognisability factors of emergency vehicles and workplace signage.

TOUR3108

Emma Chidlow

Bachelor of International Tourism
This research project was undertaken as part of course requirements for topic TOUR3108 Tourism Project B and the project result provided should be read in that context. I certify that this project does not, to the best of my knowledge and belief, incorporate without acknowledgment any material previously published or written by another person except where due reference is made.

Signed ______________________ Date 10/6/12
Executive Summary

This report was commissioned to examine the roles of colours in emergency services and workplaces signage. Colours play an important part in our society. They evoke feelings, emotions and memories. However, colours are also important factors in warning society of potential hazards and dangers. Issues such as visibility, conspicuity, recognisability are of high focus of emergency personnel to ensure people stay safe on the roads. Workplace signage, also, needs to take these issues into consideration to ensure all employees remain safe. Retroreflective material is often used to support visibility issues on both emergency vehicles and some signage.

The research draws attention to “The Moth Effect”, a new term, coined for the high number of incidents in which motorists crash into parked emergency vehicles on the side of the road illuminated by their bright flashing lights. Theories for this effect focus on the human instinct to look towards light, and the tendency to steer in the direction of which the light is fixated.

The report also takes into consideration factors of Environmental Psychology to understand the meanings of colour such as the colour red: imbued in the human psyche as a call to action. The histories of both the police and ambulance forces were taken into consideration as to why those colours were chosen. It was found that the Battenburg Markings on the sides of the vehicles dramatically increased the visibility of emergency vehicles.

Further investigations reveal that the colours for workplace signage were traditionally endorsements of British Standards, including BS 381C:1964, Colours for Specific Purposes, and BS 4800:1972, Paint Colours for Building Purposes.

Note: The following report is based on colour understandings in Western cultures. Different colour meanings can be associated with differing cultures.
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1. Introduction

People will react first to that which is most visible and colour plays a central role in allowing us to detect objects quickly, thus allowing more time to react to and avoid a hazard. (Solomon, 1999, p71)

Colours play an important role for society and can evoke various emotional feelings such as excitement, energy and calmness (Ou et al, 2003). Internationally, there are different traditions and cultural impacts that determine the colourings used on emergency vehicles and warning workplace signage. Whatever the traditions are surrounding these colourings, however, there is strong evidence for the choice on the particular colours.

2. Conspicuity

In terms of emergency vehicles, conspicuity refers to the ability of a vehicle to draw attention to other road users to its presence, even when other road users are not actively looking for it (Cook et al, 1999). Conspicuity is one of the aspects of ensuring emergency vehicle safety while vehicles are moving in traffic or parked along roadways. Recognition and driver action(s) are also important facets of what can be seen as an extremely complicated, interdependent and largely ill-defined system that includes multiple vehicles, drivers, their cultures and the environment. Historically, emergency vehicle operators relied primarily on active signalling, using various mechanical devices to enhance their vehicles’ visibility and conspicuity while responding to, and on the scene of, emergency incidents. These included emergency warning lights and sirens designed to attract surrounding other drivers’ attention. While these systems will always be needed to promote visibility, passive treatments such as using retroreflective sheeting material, which reflects light back along the incident path, are becoming used increasingly.
3. Visibility

Visibility refers to “quality or fact or degree of being visible; perceptible by the eye or obvious to the eye” (The Free Dictionary, 2012). A number of interrelated factors affect the visibility of an emergency vehicle to other drivers. These factors include the size of the vehicles, livery, the use and colour of marker lamps, the use and positioning of retroreflective striping (material which reflects light back to the origin) and the presence/operation of warning devices including lighting systems or audible sirens and horns. Environmental conditions also influence visibility, including time of day, lighting, weather conditions, and the presence of other driver distractions such as drowsiness, mobile phones, CD players and poorly considered signage or advertising that can generate visual clutter.

In terms of workplace signage, signs should be clearly visible, positioned from the line of sight and from any obstructions or clutter. Signs should be kept in a well-lighted position, an appropriate distance from the hazard it is pointing out (IAPA, 2007). No more than three symbols should be used in the same location. Signs should also be visible from all directions, utilizing arrows wherever the direction is not obvious (IAPA, 2007).

4. Recognizability

Recognition of emergency vehicles is of utmost importance. While catching the eye of another driver is the ‘first thing’, the larger goal is to help provide other drivers with information about a vehicle’s presence, size, position, speed and direction of travel. As a driver, the critical objectives of conspicuity are to clearly broadcast your aims and easily recognize surrounding drivers’ intentions, enabling the appropriate action to avoid a collision. For emergency vehicles, recognition and identification are likely very important aspects of promoted this ‘cognitive conspicuity’ (Tijerina et al., 2003).
There have been many advances in the livery of the police cars to meet certain visibility and recognisability standards. As seen in figure 1, the sensitivity of the human vision peaks in the yellow-green portion of the spectrum. It has been established that white is the most visible colour for warning lights, followed by green, amber and red (Allen, Strickland, Adams, 2009). White is effective in gaining attention, but fails to identify the vehicle, therefore it is rarely used alone (Lamm WH: Vehicle Warning systems. Emergency 1983;15:32-35). Green is visually effective but has similarly failed to gain widespread use as green is a ‘go’ or ‘safe’ colour in our society (Scarano, 1981). Yellow is a colour that signifies danger or warning in Western cultures, however the colour is often mistaken for a white flash (Vo,s 1971). Red is another colour that signifies danger (Sebok, Danesi, 1999).

Police vehicles in South Australia are white in colour, with a red and blue emergency warning lighting. In terms of photometry, the differences between these colours are very large. The scotopic system, the vision of the eye under low light conditions, is shifted substantially toward shorter wavelengths, which appear as blue, and away from longer wavelengths, which appear as red. This difference in spectral sensitivity gives rise to a visual experience known as the Purkingke Shift. During this, blue and red surfaces appear equally bright when seen under normal daytime levels of illumination. During the night time, the blue surface becomes more visible. (Flannagan, Devonshire,2007).
5. Retroreflectivity

Generally speaking, every surface reflects light to a certain degree. This allows people to see objects when they do not emit their own light source. There are two principal types of reflection; diffuse reflection, when light strikes a rough surface and is reflected or ‘diffused’ in all directions, and specular or ‘mirror-like’ reflection which occurs when light strikes a smooth surface and the reflected light is returned along the same angle as the incoming path, returning an image along with the reflected light. A third type of reflection, retroreflection, occurs when a surface is specially engineered to reflect light back to its origin (Federal Highway Administration, 2005). Contemporary retroreflective sheeting products are made by applying microscopic glass spheres or cubes, to a flexible substrate in an arrangement which promotes internal reflection and efficient return of incoming light back to its source. The surfaces are subsequently polished and/or coated with metallic materials to give a mirror effect. The amount of light returned by a retroreflective material, at a specific viewing geometary, is known as the products’ retroreflective efficiency (FEMA, 2009). Retroreflective efficiency typically ranges from 7 to 14 percent for materials made with the glass beads, and up to 32 percent for truncated cube sheeting, and 58 percent for full-cube microprismatic sheeting. However, higher retroreflective efficiency does not necessarily imply a “better” material. There are other factors at play such as cost, flexibility of the material and colour (FEMA, 2009). Also, although the glass beading is relatively less efficient, it has the added bonus of maintaining its performance over a wider range of viewing. Retroreflective sheeting materials are generally used on traffic control devices such as signs, barriers and cones, as well as on clothing and on vehicles.
6. The “Moth-Effect”

Studies of warning lights within the last few years have looked at light output, flash rate, colour and reaction to light emitted. When emergency vehicles at a crash site, warning lights can actually, make the area more dangerous. If the target is a light viewed at night, the lights distract the responders and other motorists. “The Moth Effect”, is a new term, coined for the high number of incidents in which motorists crash into parked emergency vehicles on the side of the road illuminated by their bright flashing lights. Theories for this effect focus on the human instinct to look towards light, and the tendency to steer in the direction of which the light is fixated (Younger, 1997). Advocates of the moth effect have supported these beliefs with anecdotal accident reports, supplemented by evidence (Taylor & Sucov, 1973, Murdoch & Caughey, 2004) showing that humans innately orient toward light. However, Vanderbilt (2008), notes that perhaps the reason for this that most drivers, upon seeing a car on the highway, assume that it is moving at the same speed as everything else, and a vehicle with flashing lights are usually moving even faster than that. By the time a driver understands what is actually happening, it may be too late to avoid the crash.

The moth effect studies (Hill, 1972; Morgan, 1978) show that people are unable to maintain their sense of egocentric direction when fixating eccentrically. Instead the sense of straight-ahead moves in the direction of fixation. Thus, the driver looking right, while attempting to travel down the road, will inadvertently steer to the right in an attempt to steer straight. Also, the intense attention focus is a way that the moth effect can take hold. The core attention focused on one task, the less is available to others. Even automatic behaviour, such as maintaining lane position, requires some degree of attention. The perceptual narrowing may prevent the driver from monitoring road delineations in peripheral vision. Therefore, the driver would not be aware that he had lost lane positioning. Lastly, drivers who start with less attention resources (fatigue, bored, affected by drugs or alcohol), should suffer a greater chance of suffering the moth-effect. These drivers should be
more prone to steer off the road. However, it is not these conditions that directly cause the result, it is the way they affect distribution of attention (Summala, 1998).

The ‘moth-effect’ is a myth in one sense, and a reality in another. The idea that drivers may steer off the road when they fixate flashing lights is likely correct, but they are not drawn to the lights like moths to a flame. Rather, they inadvertently steer left, which may or may not take them into collision with the roadside vehicle.

7. Environmental Psychology

In terms of meanings, red is associated with fire, violence and warfare, but it also associated with love and passion. Red can be associated with anger, but is also associated with importance (consider red carpets at award shows). Red also indicates danger (stop lights, warning labels). Red is a great colour to use when power or passion want to be portrayed (Chapman, 2010). Red also is imbued in the human psyche as a call to action – an instinctively primal reaction as it’s the colour of blood and fire, two important elements for human existence. They are, at the same time, life threatening, yet life sustaining. Conversely, blue is often associated with sadness in the English language. It is a colour used extensively to represent calmness and responsibility (Eiseman, 2003).

8. Police Cars

The reason behind the choice of the colours for police vehicles are one based on both history and science. The world’s first police car was sent on the streets of Akron, Ohio in 1899. Electrically powered, the vehicles’ first assignment was to pick up an intoxicated man. Early police cars were painted black with white doors and roofs, so that the police car would stand out from other vehicles on the road (Chrises
Cars, n.d.) In general, police forces have taken their lead from the Metropolitan Police Service, recognized as the first police force in England, formed in 1829. The base colour for the force was a very dark blue, opposed to the military red of the time. This was to appear neutral, due to public fears concerning the deployment of the military in domestic matters (Taylor, 2003). Interestingly, in 1931, in America, new uniforms were adopted for the police force, to honour the brave men who fought in the Civil War 70 years before blue was selected for the uniforms (Virginia State Police, 2009).

9. Ambulances

Ambulances have a specific colouring system in place, to ensure that they remain conspicuous in road traffic situations. The South Australian Ambulance Service changed livery in 2007 from a white and red colouring. The side markings were replaced with green and lime Reflexite. The visibility factor during daylight from the side is dependent on the fluorescent lime outline stripes which are used to increase visibility, from the side on, during daylight hours.

A number of studies have confirmed the effectiveness of yellow-green as the most conspicuous colour for emergency vehicles (Ambulance Visibility, 2010). The liveries of the South Australian Ambulances have a green and yellow pattern on their vehicles.

Figure 2: SA Ambulance pre 2007

Figure 3 SA Ambulance post 2007
10. Battenberg Markings

Battenberg markings are a pattern of high visibility markings used primarily on the sides of emergency services vehicles. The pattern was originally developed in the mid 1990s in the UK by the Police Scientific Development Branch (now the home Office Scientific Development Branch). The brief was to create a livery for motorway police vehicles which would maximise the visibility of the vehicles when stopped on scene. Both in daylight and under headlights from a minimum distance of 500m, and which would distinctively mark it as a police car (Harrisson, 2004). The research showed the human eye is most sensitive to blue/green shades at night and yellow/green in daylight. The Battenberg design typically comprises of 2 or more rows of alternating retroreflective squares or blocks, usually starting with yellow at the top, along the sides of a vehicle (Harrisson, 2004).

During the development of the Battenberg markings, one of the key functions was to clearly identify a vehicle as being linked to the police. In addition to the Battenberg markings effectiveness, the pattern was reminiscent of the Sillitoe Tartan pattern of either black and white or blue and white chequered markings, first introduces by the City of Glasgow Police in the 1930s, and was subsequently adopted as a symbol of police services in Australia (Harrisson, 2004).

However, there is some research which expresses concern that the Battenberg pattern may actually hinder visibility by creating a camouflage effect, particularly against a visually-cluttered background (De Lorenzo & Eilers, 1991; Langham & Rillie, 2002; Tijerina et al., 2003). Additional research is needed to determine if, on balance, the Battenberg pattern aides or impedes emergency vehicle visibility.
11. Workplace Signage

Workplace signage is used to ensure the safety of all people involved in or around a work site. There are three basic sign categories used in the workplace; regulatory, warning and information.

Regulatory signage indicates that an order in force. The signs are circular and include Prohibition signs, which forbid action and Mandatory signs, which require action. The signs in the regulatory category are red and black on white, or with white text on black background (IAPA, 2007).

Warning signs indicate caution or danger and are triangular sign. These include caution signs, indicating a potential hazard and danger and those indicating a definite hazard. These signs are black on a yellow background or white on a red background (IAPA, 2007).

Information signs indicate information regarding the worksite or area and are on a square sign. This sub-category includes emergency, indicating the location of first aid, health, fire protection, fire fighting and emergency equipment as well as general information, indicating permission or public information. The signs in this category are written in white on a green background, or white on a blue background. (IAPA, 2007).

Prior to 1985, Australian colour standards were traditionally endorsements of British Standards, including BS 381C:1964, Colours for Specific Purposes, and BS 4800:1972, Paint Colours for Building Purposes. In 1980 BS 381C was reissued under revision, with many colours removed which were in low demand in Britain at that time (Standards Australia, 2011). This proved to be a matter of concern of Australians, as the increased interest in restoration of period buildings demanded that these colours remain available. Thus, AS2700-1985 was created to cater to all Australian needs (Standards Australia, 2011). The theory behind the use of clearly defined specific standardized safety colours, is that through their long term use, people will come to intuitively understand the different degrees of hazard seriousness associated with each colour use on safety signs and labels. This only works if the colours are visually different. In the past, the warning sign was a sign which consisted of
a triangle with an exclamation mark. This was known as the ‘General Warning Sign’. The sign was, and still is, used to indicate the risk of personal injury when no other specific safety sign exists to communicate the intended message. The sign was accompanied by other text or other symbols to convey a safety message (Clarion, 2008). When it came to illustrate the use of signal words of product safety labels, the International Organisation for Standards (ISO) nations involved, insisted that the triangle became the standard for warning signs. This was based on several reasons; at the international standardization level, there should not have more than one symbol for the same meaning, the combination of a specific colour with a surround shape is key to the ISO vocabulary of safety symbols (Clarion, 2008).

Another form of signage is the exit sign. The traditional version was a sign with bold red letters spelling out the word. The contrast between the letters and the background renders it highly legible, the illumination stresses the importance of the message and the colour is evocative of both fire and fire-safety devices (fire extinguishers, fire engines, and fire alarms). More recently these signs have been changed in colour to green and white. Green is the colour of safety, a colour that means go in western cultures. Red, on the other hand, often means danger, alert, halt, please do not touch.

Green is used to remove caution for people who are attempting to evacuate. People who are potentially under extreme stress may instinctively stop when they see red (Turner, 2010). Green exit signs also have an important advantage when there is smoke in the air. Red exit signs look like a fire. There have even been cases of firemen rushing into burning building and tried to put out the signs. With a green sign, people know it is not the fire itself, but the way to safety (Morton, 2011). Red exit signs still remain prominent in the United States and Canada; however, they are starting to implement the running man sign in subways and new buildings (Turner, 2010).
12. References


Eiseman (2003), The Colour Answer Book, Capital Books Inc, Virginia


Flannagan, M.J., & Devonshire, J.M. (2007) Effects of Warning Lamps on Pedestrian visibility and driver behaviour, The University of Michigan: Transportation Research Institute, Michigan, USA


Accessed 26/5/12


Vanderbilt, T., (2008) Traffic: Why We Drive the Way We Do (and What It Says About Us), Knopf Publishing, NY, USA


13. Appendices
13.1 Appendix 1: Glossary of Terms

*Battenberg Marking*: a pattern of high-visibility markings used to maximise conspicuity, primarily used on vehicles of the emergency services, but also in other applications such as uniforms. The name comes from the similarity in appearance to the cross-section of a battenberg cake.

*Cognitive conspicuity*: with the perceived relevance of the information

*Conspicuity*: to look attentively

*Livery*: A special design and colour scheme used on the vehicles, aircraft, or products of a particular company

*Purkinje Shift*: The changes in perception of the relative lightness and darkness of different colours as illumination changes from daylight to twilight.

*Recognizability*: Able to be recognized or identified from previous encounters or knowledge

*Retroreflective*: A device which reflects light back along the incident path, irrespective of the angle of incidence

*Scotopic system*: Of or relating to low illumination to which the eye is dark-adapted.

*Visibility*: The state of being able to see or be seen, the distance one can see as determined by light and weather conditions, the degree to which something has attracted general attention.
### 13.2 Appendix 2: Workplace Signs Classifications

<table>
<thead>
<tr>
<th>Category</th>
<th>Sub-category</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Regulatory</td>
<td>1.1 Prohibition forbids an action</td>
<td>Red and black on white</td>
</tr>
<tr>
<td></td>
<td>1.2 Mandatory requires an action</td>
<td>White on black</td>
</tr>
<tr>
<td></td>
<td>A circle indicates that an order is in force</td>
<td></td>
</tr>
<tr>
<td>2. Warning</td>
<td>2.1 Caution indicates a potential hazard</td>
<td>Black on yellow</td>
</tr>
<tr>
<td></td>
<td>2.2 Danger indicates a definite hazard</td>
<td>White on red</td>
</tr>
<tr>
<td></td>
<td>A triangle indicates caution or danger</td>
<td></td>
</tr>
<tr>
<td>3. Information</td>
<td>3.1 Emergency indicates first aid, health, fire protection, fire fighting and emergency equipment</td>
<td>White on green</td>
</tr>
<tr>
<td></td>
<td>3.2 General Information indicates permission or public information</td>
<td>White on blue</td>
</tr>
<tr>
<td></td>
<td>A square indicates information</td>
<td></td>
</tr>
</tbody>
</table>