3M Science. Applied to Life.™

Illuminating the way we see

Workers, runners, kids, cyclists — everyone — needs to be seen. Help increase your visibility to nearby motorists with 3M™ Scotchlite™ Reflective Material

Factors that can affect visibility

1. Needing more light to see as we age

Seeing becomes more challenging as we age. After the age of 20, a person's need for illumination **doubles every 13 years**. For example, by age 59, a person will need up to eight times as much light to see the same level of detail as they did at age 20. This has critical implications for the safety of pedestrians, construction workers, law enforcement personnel and others as they share the road with drivers.

After the age of 20,
every 13 years

2x

a person's need for illumination doubles

2. Visual systems that affect how we see

It's easy to believe that we see everything clearly and in full colour. However, **Figure 1** compares **the way we think we see versus the way we really see**. We have two distinct visual systems: foveal vision and peripheral vision. In the picture below on the right, you will see the sharpness in the centre of the figure. This represents our foveal vision, while the remainder of the photo, which appears blurry, represents our peripheral vision.

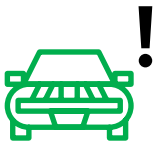
How we think we see

How we actually see

Figure 1

Our foveal vision is in full colour and high resolution, and is useful for examining highly detailed objects. **It covers only the middle 2 degrees of our visual field.** Our peripheral vision is in low resolution and is used to observe our environment. We have surprisingly low visual resolution in the parts of the visual field that are not in the centre of our gaze. However, we don't notice this because we instinctively direct our centre of gaze at a specific object or in the direction we want to look.

Because our peripheral vision is more sensitive to motion and contrast, pedestrians and workers need to wear reflective material on movement locations to stand out and help get a driver's attention.



Help get a driver's attention by wearing reflective material on movement locations:

- **wrist**
- **torso**
- **ankles**

3. Change blindness

We all suffer from a condition called "change blindness[2]." **This occurs when we try to take in a whole scene and our brain receives too much information to process at once.** Since we can only focus on a narrow area, we may not notice some changes right away, such as a pedestrian unexpectedly darting out into a roadway. While visually scanning our environment, we are purposely turning our gaze from the direction we are looking in towards items that appeared first in our peripheral vision. High-visibility products can be effective because they are more noticeable in our peripheral vision, meaning we are more likely to turn our gaze to see them.

You may not notice a pedestrian unexpectedly darting on to the road if they are not wearing high-visibility materials

4. Seeing white clothing at night

A study[4] evaluated drivers' responses to obstacles and found that drivers moving only 48 kilometers per hour (30 miles per hour) may travel more than 152 metres (500 feet) in the time it takes to recognize and properly manoeuvre their cars in response to an obstacle. **A common misconception is that pedestrians wearing white clothing at night can make it easier for drivers to notice them, and therefore avoid hitting them – see Figure 2.**

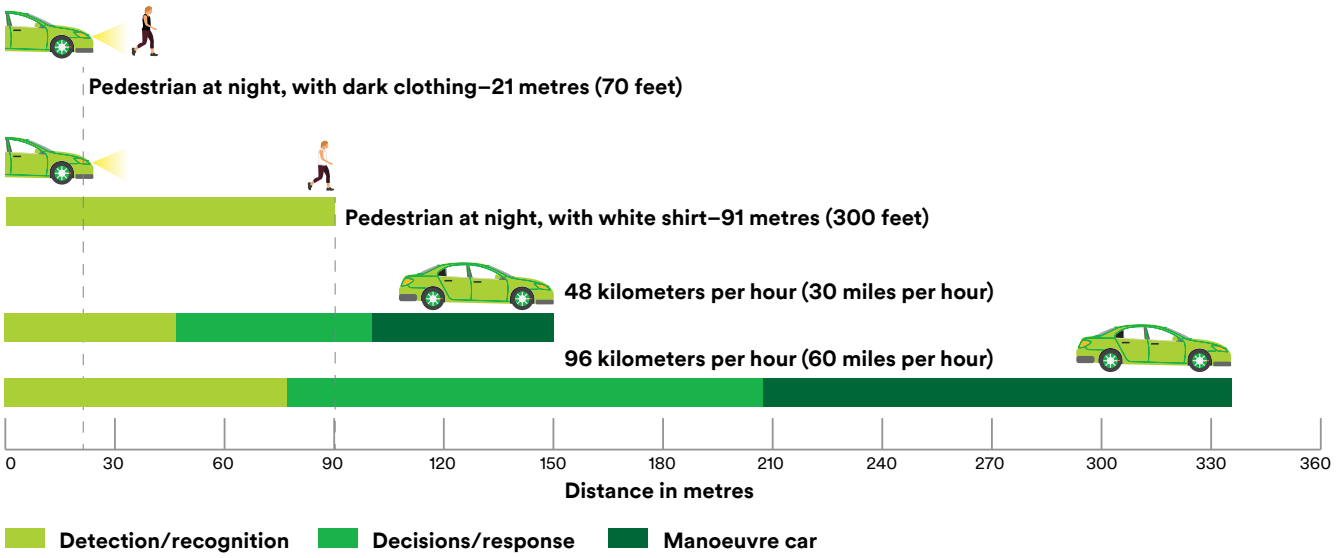


Figure 2

1. R.D. Blomberg, A. Hale, and D.F. Preusser, "Experimental valuation of Alternative Conspicuity-Enhancement Techniques for Pedestrians and Bicyclists," Journal of Safety Research, Volume 17, pp. 1-12, 1986.
2 "Decision Sight Distance for Highway Design and Traffic Control Requirements," Report number FHWA-RD-78-78.

The United States National Safety Council has shown that a pedestrian wearing a white shirt may not be visible to drivers until they are within 91 metres (300 feet) of a moving car (Figure 2). When pedestrians were wearing dark clothing, their visibility decreased to only 21 metres (70 feet). While wearing white clothing is an improvement over dark clothing, white clothing alone cannot give pedestrians the level of visibility they may need against drivers at night.

The ins and outs of reflective and fluorescent materials

When fluorescent colours aren't enough

Fluorescent colours like neon yellow capture our attention. But why are they so easy to see? **Figure 3** compares how conventional and fluorescent-coloured materials act.

Conventional colours vs. fluorescent colours

Conventional colours

Absorb
- visible light

Emit
- visible light in the primary wavelength of the colour we see

Fluorescent colours

Absorb
- visible light
- ultraviolet light, which we can't see

Emit
- ultraviolet light energy at a longer wavelength, which we can see

Figure 3

As a result, more light energy comes off the surface of fluorescent colours than we can see going into it. The extra light captures our attention in our peripheral vision and causes us to turn and look at the fluorescent object. The fluorescent phenomenon is noticeable in the daytime but is most noticeable in limited-light conditions like at dawn and dusk. However, **because fluorescent material needs light to function, it is not always effective in ensuring pedestrians will be seen at night**.

How reflective materials help us see people more easily in low light conditions

Our brains are wired to recognize human motion. When we see moving objects, we can tell it is a person if certain points of the body are outlined. These points on the body are called "biomotion points." The pattern created by biomotion points helps us distinguish humans from inanimate objects. The most effective high-visibility garments take advantage of our ability to recognize human motion by placing reflective material on the biomotion points. In darkness, reflective materials properly placed on garments help identify objects as people.

Types of high-visibility material

Phosphorescent

- Needs to be exposed to light (i.e., glow in the dark)
- Short lived/no daytime benefit

Fluorescent

- Good daytime, dawn, and dusk benefits
- Poor at night-time

Chemiluminescence

- Chemical reaction (i.e., light sticks)
- Short lived/no daytime benefit

Retroreflective

- Requires light source
- Dawn and dusk benefits
- Great night-time benefits, poor daytime

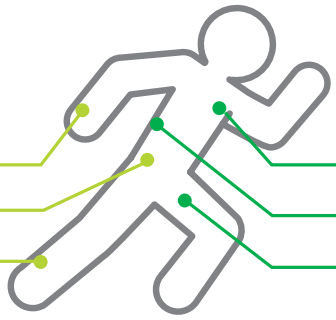
A study[3] was conducted to compare the placement of an identical amount of reflective material in various patterns on clothing worn by workers at night:

The most effective material placement followed the human form and marked the limbs or parts of the body that have the most movement, like

wrists

torso

ankles



In addition to marking the motion points, to give the wearer 360˚ of visibility, reflective materials should be placed on the

front

back

sides

For optimal visibility, and greater brightness, reflective materials meeting high-visibility standards should be used. **Designs incorporating both fluorescent materials and reflective materials can, therefore, help provide visibility during both day and night.**

fluorescent materials + **reflective materials** =  **24-hour visibility**

How bright is bright enough?

Our ability to notice reflective garments is based on a combination of the total amount of light returned by the garment and the position where the reflective material is placed on the body. The total amount of light is a combination of the brightness of the material and the amount of material used. Assuming the reflective material is in the right places, such as on biomotion points, how bright does it need to be to be effective?

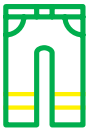
We naturally assume that the brighter the material, the easier it will be to see. However, the scientific principle of Stephen's Power Law proves that this is not always true. Luminance perception does not increase in a linear manner. Instead, the perception of bright objects increases sharply at first, but then levels off.
In practical terms, this means that materials need to be three times as bright to be noticeably different.

Ability to notice reflective garments

=

Total amount of light returned by the garment

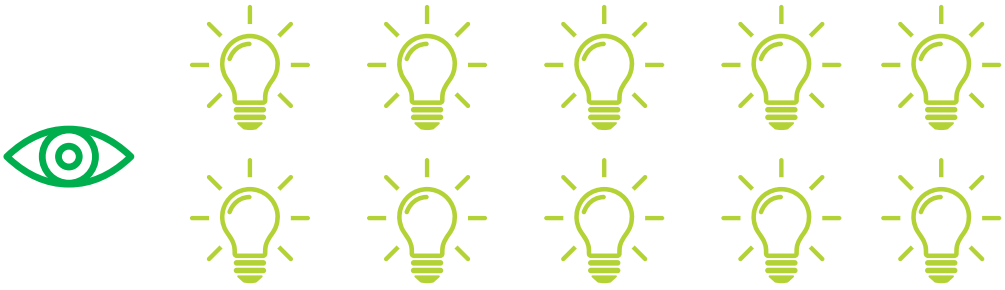
+



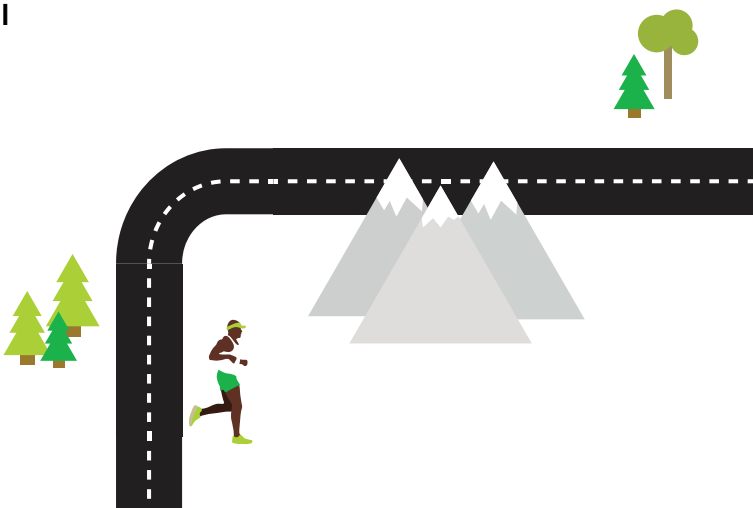
Where the reflective material is placed on the body

Comparing 300R$_A$ (reflective brightness) materials

When comparing a 30R$_A$ material typically found in activewear with one that is 300R$_A$, the 300R$_A$ is 10 times brighter so it is much more noticeable. At higher brightnesses — often found in high-visibility workwear — the perception curve levels off, yielding diminishing returns. The same difference at higher levels — between a material that is 500R$_A$ and 770R$_A$, for instance — will not be significantly easier to see.



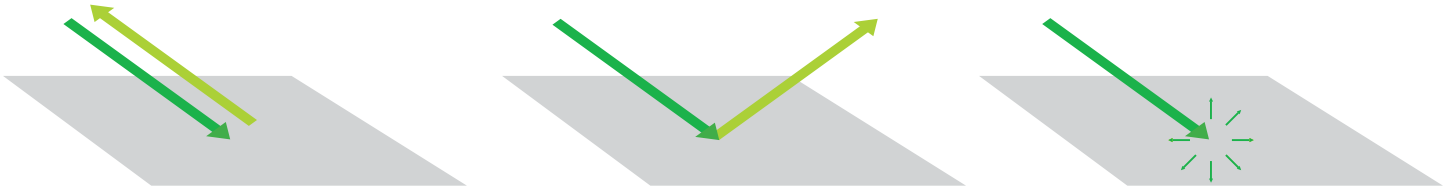
300R$_A$ materials are 10x brighter and are more noticeable than 30R$_A$ material



The science behind 3M™ Scotchlite™ Reflective Material

3M™ Scotchlite™ Reflective Material uses retroreflection technology to incorporate thousands of microscopic beads or prisms into the reflective material. In low light, when this material is illuminated by a light source such as vehicle headlights, it returns light rays back to the vehicle driver. **Figure 4** compares the types of reflection.

Types of reflection



Retroreflection

- A large amount of reflected light is returned directly to the original light source.

Mirror reflection

- Light is reflected at the same angle as it comes in from the source. Light is not returned to the source.

Diffuse reflection

- Very little light is returned to the source. Light is scattered as it hits the surface.

Figure 4

3M works with manufacturers of converted products to meet their reflective material needs. 3M™ Scotchlite™ Reflective Material comes in a variety of forms for maximum design and application flexibility, including transfer films, fabrics, high-gloss materials, pressure-sensitive adhesive (PSA) films and graphic transfers. They have the visibility and durability needed for excellent reflective performance.

Curious if one of our 3M™ Scotchlite™ Reflective Materials will work for you?
Visit 3M.com/Scotchlite for more information.

References

1. National Safety Council, Walk Alert National Safety Program, 1989, FHWA RD 022-89.
2. http://psychology.about.com/od/cognitivepsychology/f/change-blindness.htm.
3. Balk, Stacy, and others. “Highlighting human form and motion information enhances the conspicuity of pedestrians at night.” Perception. volume 27. 2008. 1276-1284. page 88.
4. Franklin-Smith, Shari. “Surprising facts about the way we see.” Head 2 Toe Protection, volume 1. 2014.