

What color are emergency exit signs? Egress behavior differs from verbal report



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ABSTRACT

Illuminated emergency exit signs inform building occupants about safe egress routes in emergencies. These exit signs are often found in the presence of other colored signs, which may distract occupants when searching for safe exits. Such distractions can lead to confusing and even harmful outcomes, especially if occupants misinterpret the sign colors, mistaking non-exit signs for exit signs. We studied which colored signs people were most likely to infer were exit signs in a simulated emergency evacuation using virtual reality (VR). Participants were immersed in a virtual room with two doors (left and right), and an illuminated sign with different colored vertical bars above each door. They saw all pairwise combinations of six sign colors across trials. On each trial, a fire alarm sounded, and participants walked to the door that they thought was the exit. We tested two hypotheses: a *local exposure hypothesis* that color inferences are determined by exit sign colors in the local environment (i.e., red) and a *semantic association hypothesis* that color inferences are determined by color-concept associations (i.e. green associated with “go” and “safety”). The results challenged the local exposure hypothesis and supported the semantic association hypothesis. Participants predominantly walked toward green signs, even though the exit signs in the local environment—including the building where the experiment took place—were red. However, in a post-experiment survey, most participants reported that exit signs should be red. The results demonstrated a dissociation between the way observers thought they would behave in emergency situations (red = exit) and the way they did behave in simulated emergencies (green = exit). These findings have implications for the design of evacuation systems. Observers, and perhaps designers, do not always anticipate how occupants will behave in emergency situations, which emphasizes the importance of behavioral evaluations for egress safety.

1. Introduction

Emergency exit signs signal building occupants about safe egress routes in case of emergency. Exit signs should be informative when needed, but unobtrusive when not needed. Depending on safety codes, exit signs tend to have either a white illuminated pictogram/text (“EXIT”) on a colored background, or a colored pictogram/text on a white or clear background (e.g., [National Fire Protection Association, 2015](#)). Most international building codes prescribe green as the color for exit signs. However, certain codes, such as the National Fire Protection Association (NFPA) 101 let users choose between red and green exit signs.

Exit sign colors are an important feature of exit sign design because they can convey information under low visibility conditions (e.g., smokiness), when pictograms or text may be illegible ([Fig. 1](#)). These

conditions of low visibility also tend to be ones under which building occupants require guidance about evacuation routes. However, the presence of other colored signs near exit signs can confuse building occupants about which routes lead to safe egress. It would be especially dangerous if occupants inferred that the colors of non-exit signs were more likely to signal “exit” than the colors of exit signs do.

In this study, we investigated people’s inferences about which colors are more likely to signal “exit” in a simulated emergency, their *color inferences*. Understanding color inferences is important for producing effective sign designs because are designs easier to interpret when the encoded mapping between perceptual features and concepts (e.g., the color of exit signs) matches people’s inferred mapping (e.g., their prediction about the color of exit signs) ([Norman, 2013](#); [Schloss et al., 2019](#); [Schloss et al., 2018](#); [Tversky et al., 2002](#)).

Previous studies on exit sign colors suggested people infer that green

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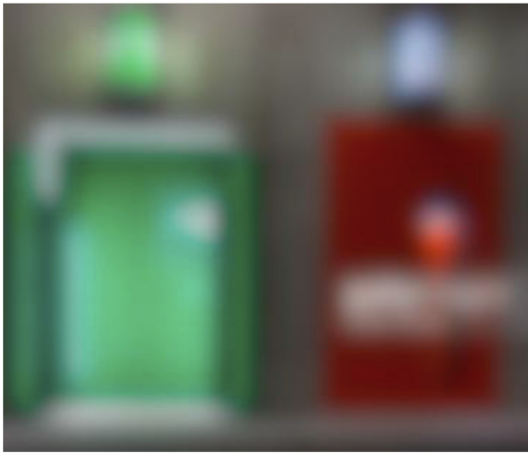


Fig. 1. Photograph illustrating exit choice under low visibility conditions. The picture was taken from a road tunnel. Color appears to differentiate the two kinds of doors, but which color means “exit”? In this case, the green (left) door is an emergency exit, whereas the red (right) door leads into an emergency phone booth. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

signs are exit signs (e.g., Hestestad, 1999; Ronchi et al., 2016; Troncoso et al., 2014). For example, Troncoso et al. (2014) asked Chinese and European participants to navigate a virtual maze using a game pad while seated. When participants encountered bifurcations in the maze, they could follow red or green signs. Participants were more likely to follow green signs.

However, these studies were conducted in parts of the world that require exit signs to be green. As a result, it is unclear whether participants were more likely to choose green because it mimicked the color of exit signs in their immediate environment, which we call the *local exposure hypothesis*, or because green was associated with concepts that signaled “safe exit,” which we call the *semantic association hypothesis*. Although people infer different meanings of colors depending on context (Elliot and Maier, 2012; Humphrey, 1976; Schloss et al., 2018; 2019), the green-associated concepts of “go” (Or and Wang, 2014) and “safety” (Nilsson et al., 2005) are particularly relevant for signaling “safe exit” in emergency contexts. In contrast, the red-associated concepts of “stop” (Or and Wang, 2014) and “danger” (Leonard, 1999; Lesch et al., 2009; Pravossoudovitch et al., 2014) could have the opposite effect.

In the present study, we dissociated the local exposure and semantic association hypotheses by evaluating egress behavior in a region where exit signs are mandated by law to be red. Regulations in the state of Rhode Island, where the experiment took place, specify that exit signs must be red, and participants passed multiple red exit signs on their way to the testing laboratory. If participants still infer that green signs are exit signs, that would indicate that color inferences for exit signs are not based on local exposure, and may, instead, be due to semantic associations.

We briefly note that there are additional factors to consider when evaluating the effectiveness of exit sign colors, which are not the focus of the present research.

1.1. Visibility

It is critical that exit signs are visible under emergency conditions. Visibility is heavily influenced by smoke density, and the degree to which smoke impedes visibility depends on the wavelength of light. The relative spectral extinction coefficient for light passing through smoke peaks between 500 and 580 nm (Yamada and Akizuki, 2016), which is light in the range that appears greenish to yellowish. As a result, longer wavelength orange exit signs are visible from a slightly greater distance

in smoke than green exit signs (Ronchi et al., 2012). However, the effects of hue on visibility in smoke are significantly weaker than effects of other parameters, such as brightness (Wong and Lo, 2007; Yamada and Akizuki, 2016).

1.2. Attention

Dynamic exit signs sometimes have flashing lights, with the goal of capturing the attention of evacuees in an emergency. McClintock, Shields, Reinhardt-Rutland, and Leslie (2001) reported that adding blue flashing strobe lights to a green exit sign increased attention capture, compared to static green exit signs or exit signs with green flashing lights. However, another study found somewhat contradictory results—participants rated sensory affordances of green exit signs with green and white flashing lights to be higher than those with blue flashing lights (Ronchi et al., 2016).

1.3. Aesthetics

In a study on design preferences, Nilsson et al. (2005) found that participants preferred combinations of green exit signs with green flashing lights to green exit signs with orange flashing lights. The results are consistent with evidence that people aesthetically prefer color combinations that have more similar hues (Gramazio et al., 2017; Ou and Luo, 2006; Schloss and Palmer, 2011). If these exit sign choices were indeed due to aesthetic preferences, then participants would probably also prefer orange exit signs with orange flashing lights to green exit signs with orange flashing lights. It is also possible that Nilsson et al.’s participants may have disliked the orange and green signs because of a conflict in semantic association, if they associated green with “safety” but orange with “danger.”

In the present study, we investigated evacuation behavior using an evacuee walking paradigm in a controlled setting. Controlled experiments on evacuation behavior are still rare due to questions of ethical considerations and ecological validity. Immersive virtual reality (VR) techniques provide solutions for ethical considerations by presenting participants with simulated evacuation scenarios in controlled and safe settings (Kinateder et al., 2014). Evidence also supports the ecological validity of VR techniques, with comparable evacuation behavior in a virtual evacuation scenario and a matched real world scenario (Kinateder and Warren, 2016). VR studies have provided insights into what kind of signage is helpful in evacuation situations. Evacuation performance in a virtual environment improved when participants were guided by exit signs compared to no signs (Tang et al., 2009), and attention capture was better when there were dynamic exit signs compared with standard exit signs (Duarte et al., 2014).

We studied inferences about which colors mean “exit” in a simulated evacuation scenario using immersive VR. Participants completed a series of trials in which they chose one of two evacuation routes while walking in a virtual environment. There were two doors with a different colored sign above each door (all pairs of red, yellow, green, blue, magenta, white). After the walking task, participants reported the color of exit signs in their environment and the color they thought exit signs should be. We found that responses to these questions contradicted egress behavior: participants stated that red would be the best color for exit signs, yet they were most likely to walk toward green signs.

2. Methods and apparatus

2.1. Participants

Twenty-four participants (twelve female, mean age 19.79 years, SD 1.28) were recruited for the study. All had normal or corrected to normal vision, gave informed consent, and were compensated for their participation. The study was approved by the Brown University Institutional Review Board.

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