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The Design and Management of Recreational Trails on Forested Lands Using Eye Tracking Technology

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Introduction

Recreational trails on forested lands need to both satisfy the needs of recreationists and safeguard important habitats for animals and plants while maintaining the natural environment. Reconciling recreational and environmental goals is challenging (Littlefair, 2004), and appropriate management and protection of natural areas are critical because of the increasing numbers of visitors and the impacts associated with their visitation.

One of the negative impacts of visitors on recreational trails is fire hazards. An analysis of the high-resolution satellite data from hundreds of California wildfires has shown human ignition is to blame for 84% of all wildfires in the United States (Balch et al., 2017). Human-started wildfires resulted in over 5.1 million square kilometers burned, while lightning-started fires were dominant in only 0.7 million square kilometers (Balch et al., 2017). Campfires and smokers are two of the biggest causes for human-started wildfires (Cornwall, 2017), and they tended to be in remote areas but near access points such as hiking trails and roads (Stringer, 2021). Hikers and campers bring potential fire hazards, but with insufficient knowledge of how dangerous it can be and how to prevent campfires from spreading to other places (Stringer, 2021). Therefore, forestland management needs to take action to raise visitors' awareness and have effective management to reduce human-started wildfires.

Another impact of trail users is the waste they bring to forested areas, which can negatively affect forested lands and wildlife. Litter left behind on recreational trails is a persistent problem. Over 300 million people visit the national parks each year, bringing in and generating millions of tons of trash (Hanna & Moralez, 2020). Littering attracts wildlife, which can interrupt the lives of the animals and negatively impact the ecosystem. Additionally, litter on trails make leisure and recreational experiences less enjoyable by impacting the visual natural environment. Therefore, there is a need to raise public awareness regarding waste left on recreational trails and encourage litter pick up.

Despite these negative impacts of trail users, their visits are an important economic driver for communities and forested lands. Outdoor recreation is a major part of the economy across the West. Every year, the outdoor recreation economy provides $887 billion in economic output nationwide, generates $125 billion in tax revenue, and creates 7.6 million direct jobs (Center for Western Priorities, n.d.). National Park visitor spending contributed $28.6 billion to U.S. economy in 2020 (USGS, 2021). Providing visitors with enjoyable hiking experiences is important for economic development.

The management of recreational trails on forested lands needs to reduce the negative impacts of trail users but also meet people's leisure and recreation needs. Sensory cues (e.g., interpretive signs and trash bins) are one of the management tools that park managers often use to influence visitor behaviors (Forest Stewards Guild, 2018; Huffman & Grosnickle, 1995; Johannes et al., 2021). It is perceived to be a cost-effective method to reduce the negative impacts of visitors and enhance visitor experiences (Brown et al., 2010). However, how the sensory cues can influence visitor experiences and behaviors has not been investigated adequately.

From the methodology perspective, previous studies only used self-reported data to understand visitor experiences (Sever & Verbič, 2018), but self-reported data pose inaccurate recall, response bias, misinterpretation and validity issues (Dolnicar, 2018). Also, the previous research lacks an understanding of the effectiveness of sensory cues (Brown et al., 2010). Therefore, this research will use a triangulated approach including eye tracking technology, surveys, and interviews to investigate how visitors view sensory cues and the scenery of the trails. Experimental design will be conducted to examine if the messages on interpretive signs can encourage visitors to pick up litter, dispose of litter properly, and pay attention to potential fire hazards. Also, the relationships between seeing remnants of a campfire and people's awareness of fire hazards will be tested.

Overall, reconciling recreational and environmental goals is challenging for park planners. This research will provide implications on how to design effective sensory cues to guide and encourage people's behaviors regarding litter and fire. The findings will provide an understanding of how sensory cues could impact visitors' attention and influence their behavior accordingly.

Literature Review and Hypotheses

The ELM (Elaboration Likelihood Model) of persuasion demonstrates that people can be persuaded by communication through either a central or a peripheral route (Brown et al., 2010; Chaiken, 1980; Petty & Cacioppo, 1986). The central route requires the greatest people's mental effort to process the information, while the peripheral route is a kind of shortcut that people use when they are not motivated to think carefully about the message. The ELM of persuasion has been widely used to understand website design (Cyr et al., 2018) and visitor guide design (Shen et al., 2020). However, previous studies have not used this theory to investigate the design of interpretive signs. When people are hiking, they enjoy trails and experience nature, so they may not pay close attention to the interpretive signs containing a lot of information. Information or messages on interpretive signs are more likely to be processed through the peripheral route. Pictures and highlights will be useful to the peripheral route as they are easier to understand and can cover the key information. Therefore, this research hypothesizes that pictures and highlights on interpretive signs will be more eye-catching compared to full sentences. The findings will provide implications on how to design attractive and effective interpretive signs.

Researchers found that the approaches of messages conveyed on interpretive signs could significantly influence people's behavioral compliance based on framing theory (Fairhurst & Sarr, 1996; Newcomb & Newcomb, 2020; Reich & Robertson, 1979). Some signs are direct in warning or demanding, such as "Don't Litter" and "Don't Smoke." This puts external pressure on the person to comply with not littering or smoking, and it does not mention or take into account internal personal factors in the decision-making process. However, such information run the risk of generating psychological reactance, so people may not follow the instruction (Newcomb & Newcomb, 2020). Another type of statement attempts to appeal to the person's desire and willingness to support societal standards. These statements attempt to elicit the reader's involvement and desire to comply with the verbal request of the statement. One example is that "Keeping the Trail Clean Depends on You." This statement is a type of action framing, which sets beliefs and meanings that motivate people to act (Smith, 1996). According to the framing theory and psychological reactance theory, this research puts forward the following hypothesis: Interpretive signs with the message that elicits people's involvement will be more effective in persuading people to comply with the requested behavior than the interpretive signs with a warning message.

According to priming theory, the stimulus to which people are exposed could influence people's response to a subsequent stimulus (Iyengar et al., 1982). People make decisions based on preconceptions that have already been stored in their memory. The memories are stored as a form of nodes, which are interconnected effectively and mostly act as a frame of reference to the decisions that people make. Priming enables people to evaluate the situation and avoid dangers (Mogambi & Nyakeri, 2015). Therefore, this research hypothesizes that if people see the spots with remnants of a campfire and how the forest could be destroyed, they will be more cautious about fire hazards.

Methodology

The purpose of this study is to understand how visitors pay attention to sensory cues (e.g., interpretive signs and fire hazards), view the scenery of the trails, and behave when hiking on trails with an eye tracker. Forty students will be invited to participate in this research. They will be asked to visit and explore the trails for 30 minutes with the eye tracker. Right after their hiking, they will be asked to complete a short survey regarding their evaluation of their hiking experience and their perceptions of littering and fire hazards. A 30-min interview will be conducted to further probe their survey answers and the reasons for looking or not looking at the sensory cues. This research will use Swanton Pacific Ranch in California as a case to investigate the design and protection of recreational trails on forested land.

To test the first hypothesis, an interpretive board will be set up at the entrance of the trail, which includes both the information about the trail and the message about encouraging people to pick up litter and a prohibition against bringing fire hazards. The information will be presented in pictures, highlights, and full sentences. The eye tracking data will be analyzed to compare which type of information attracts more attention.

To test the second hypothesis, the 40 participants will be randomly assigned to two conditions, and each condition will have 20 participants. When participants are hiking, one group will see the interpretive signs with the statement "Don't Litter," and the other will see the interpretive signs with the statement of "Keeping the Trail Clean Depends on *You*." The eye tracker will record how participants view the interpretive signs and behave during their hiking. Also, the surveys and follow-up interviews will give insights into how participants perceive the statements on the signs.

The third hypothesis will be tested based on eye tracking data and interview transcripts. The eye tracker will be used to test whether people pay attention to the remnants of a campfire and the related fire hazards. The in-depth interviews will probe how participants perceive the remnants of a campfire and their intention to avoid fire hazards.

This research will also include interview questions to understand how to motivate visitors to have pro-environmental behavior when hiking. The sensory cues (e.g., interpretive signs and two spots with remnants of a campfire) examined in this research are expected to lead visitors to reduce their negative impacts on trails. Other factors will be identified through the in-depth interviews.

After data collection, the eye tracking data will be analyzed with the Tobii Pro Lab software. The fixation duration measures the length for all fixations within an area of interests (AOIs), an indication of how long an AOI holds people's attention. The time to first fixation shows the sequence of participants' eye movements. Heat maps visually demonstrate how long a certain area holds people's attention using different colors. Descriptive analysis of the survey will be used and

results will be linked to participants' answers in interviews. Interview transcripts will be analyzed in NVivo Pro using thematic coding.

Expected Findings and Contributions

This research will have both theoretical and practical contributions. From the theoretical perspective, the expected findings will extend the theory of selective attention to the context of trail management and forest protection. This research will bridge the literature gap by investigating how to use sensory cues to attract attention and raise people's awareness of protecting trails and forested lands.

Second, the findings will contribute to the elaboration likelihood model (ELM) of persuasion by using eye tracking technology. The design of interpretive signs and boards has been discussed in previous research (Johannes et al., 2021; Newcomb & Newcomb, 2020), but no known research has examined the relationships between the words or sentences that people see on the interpretive signs and their actions during hiking. Therefore, this research will use a triangulated method, including eye-tracking, surveys, and in-depth interviews to examine those relationships. Also, the effects of different designs of interpretive signs will be compared, giving insights into how to use interpretive signs to effectively lead to people's pro-environmental actions.

Third, this research will identify the factors that motivate visitors to do not litter, pick up litter, and avoid bringing in fire hazards when hiking. The findings will contribute to the literature on the management of trails and the protection of forested lands. Experimental design will be conducted to manipulate different sensory cues and to compare their different effects on people's attitudes and actions. Additionally, the interviews will shed light on the factors that motivate visitors to have pro-environmental behavior when hiking.

From the practical perspective, it will help to reduce litter and lessen the possibility of human-started wildfires. This research will provide implications on how to use sensory cues (e.g., interpretive signs and remnants of a campfire) to encourage people to stop littering and avoid bringing in fire hazards to trails. Less litter and fewer fire hazards will help to save budgets for waste management and wildland fire management.

Additionally, the findings will give insights into enhancing hiking experiences and offering a better hiking environment. The use of trails and outdoor space is finite and a significant increase of visitors on open space continues to increase. Much of this increased use has been created with COVID since individuals are looking for experiences that are social distanced from others. Understanding how we can educate, remind, and influence visitors on natural lands is paramount for the future preservation of the land.

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