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Improving Pedestrian Conspicuity at Night: Testing the Efficacy of a Video-Based Educational Intervention

Morgan McCree

Clemson University, mmccree@g.clemson.edu

IMPROVING PEDESTRIAN CONSPICUITY AT NIGHT: TESTING THE EFFICACY OF A VIDEO-BASED EDUCATIONAL INTERVENTION

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Morgan McCree
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Dr. Richard Tyrrell, Committee Chair
Dr. Joanne Wood
Dr. Patrick Rosopa

ABSTRACT

The majority of fatal crashes involving pedestrians occur at night. Insufficient conspicuity has been implicated as a causal factor in these crashes, and there is a critical need for innovative strategies to increase the nighttime conspicuity of pedestrians. This experiment investigated the efficacy of an 11-minute educational video aimed to teach road users about critical and relevant visual perception concepts (e.g., contrast, retroreflectivity, biological motion) that impact nighttime conspicuity. Fifty-four college students were randomly assigned to either watch the video (intervention; n=27) or not (control; n=27). Each participant provided quantitative judgments regarding the nighttime visibility of a pedestrian on an unilluminated roadway. The pedestrian's clothing was manipulated using five strategically chosen configurations. The results confirmed that those who watched the video correctly estimated shorter recognition distances for clothing configurations that did not include retroreflective markings, and correctly estimated longer recognition distances for configurations that included retroreflective markings configured to present biological motion information. Similar patterns were also present in the participants' ratings of safety and visibility. Further, the participants who watched the video exhibited greater comprehension of critical concepts and they more accurately ranked the visibility of the five clothing configurations. Overall, these results provide strong support for the effectiveness of an online, video-based intervention that is designed to increase awareness of key concepts that are critical in helping vulnerable road users to better understand the dangers of interacting with traffic at night and to maximize their own conspicuity to approaching drivers at night.

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INTRODUCTION

Too many pedestrians and other vulnerable road users (VRUs) are injured in traffic collisions. In 2021, 7388 pedestrians were killed nationwide, which is a 12.5% increase from 2020 and the highest since 1981 (NHTSA, 2023). Of these fatalities, 77% occurred during nighttime hours when it is estimated that pedestrians are three to seven times more at risk of being involved in a fatal crash (Sullivan & Flannagan, 2002). A FARS crash analysis by Owens and Sivak (1996) revealed that even when the presence of alcohol and fatigue are held constant, poor visibility was the main factor for fatal crashes involving pedestrians.

Research suggests that better road lighting and vehicle headlights could improve visibility at night (Tiwari, 2020). However, in the absence of streetlighting, drivers and pedestrians overestimate the visibility of pedestrians at night (Tyrrell et al., 2016; Hu & Cicchino, 2018). While insufficient street lighting is relevant in crashes involving pedestrians, degraded visual abilities at night and misconceptions regarding the ability to see at night impact decision-making even more. Much of the previous literature has identified reasons why vision is impaired at night and ways to enhance the conspicuity of pedestrians (Tyrrell et al., 2016). Several researchers (e.g., Balk et al., 2012; Leibowitz et al., 1998; Tyrrell, Patton, and Brooks, 2004; Tyrrell et al., 2016) have suggested and found evidence supporting a solution that involves correcting vulnerable road users' misconceptions regarding nighttime visibility issues that may make them more conspicuous to drivers at night. Thus, this study aims to educate road users on important visual concepts that could increase pedestrian safety in nighttime conditions.

Relative to daylight conditions, our vision is significantly less effective at night (Tyrrell, et al., 2016). However, it appears that road users underestimate the extent to which their visual abilities are degraded at night (e.g., Leibowitz & Owens, 1977; Tyrrell et al., 2016). Leibowitz and Owens (1977) offered the selective degradation hypothesis, a theory based on visual neurophysiology, to explain this discrepancy, by distinguishing between two modes of visual processing: focal and ambient vision. Focal vision, which uses the central visual field to discriminate and identify objects, is particularly sensitive to decreases in illumination. Ambient vision, on the other hand, uses the entire visual field to facilitate steering and guidance and is more robust to reduced illumination (Leibowitz & Owens, 1977). When night falls, our ambient vision remains strong, and our focal vision is degraded. Because drivers get continuous feedback that their ability to steer remains robust at night, and because many objects in the roadway environment are engineered to be highly visible, drivers can fail to notice the impairment in their focal abilities. The net result can be that drivers fail to adjust to the fact that they cannot easily recognize the presence of vulnerable road users at night. Thus, there is a critical need for pedestrians to make themselves conspicuous to drivers at night.

Insufficient contrast is a fundamental problem that makes it difficult for drivers to recognize the presence of pedestrians at a safe distance at night. Retroreflective materials are an effective way to increase pedestrians' contrast on night-time roads. These engineered materials help increase the contrast of objects and people against the night sky by reflecting incident light back toward the source of the illumination. Because these materials add contrast without requiring their own power source, they can be a user-friendly tool for VRUs. Babic et al. (2021) utilized eye-tracking technology to investigate the effectiveness of retroreflective materials compared to other clothing configurations on drivers' ability to recognize pedestrians at night. This study was conducted at night on a closed-circuit, rural road without street lighting that could help make a pedestrian more visible. Five different clothing outfits (orange fluorescent vest, all black outfit, all white outfit, yellow fluorescent vest, and an all grey outfit) were assessed. The findings demonstrated that the black, gray, and white configurations did not provide enough conspicuity to pedestrians, and participants often did not notice them until it was too late, while pedestrians wearing orange or yellow colored vests were significantly more visible than the other conditions. Eye-tracking data revealed that participants produced more fixations and saccades when approaching pedestrians wearing retroreflective vests, which shows the effectiveness of retroreflective materials compared to other clothing options.

While retroreflective materials can enhance pedestrian visibility, it is the orientation and layout of these markings on the body that are critical for increasing conspicuity. Johansson (1973) was the first to use point-light displays of biological motion to demonstrate that observers can perceive a person quickly and effortlessly based on the spatial arrangement of lights on the body's moving extremities. Researchers and designers can capitalize on this perceptual ability to enhance pedestrian visibility at night. By combining the ingenious construction of retroreflective materials and the distribution of this material on their extremities, pedestrians are more easily recognized by approaching drivers. To highlight the effect of strategic placement of retroreflective material/tape, Cassidy et al. (2005) compared the conspicuity differences between area reflective and trim garments. Area reflective uniforms involve strips of reflective material distributed throughout the entire garment. Trim garments are the traditional arrangement characterized by material placed in specific locations like ankles, arms, torso, etc. When these garments reflect the same amount of light, area reflective uniforms are not as conspicuous as the traditional trim garments (Cassidy et al., 2005). While this study did not explicitly mention the biological motion mechanism as a possible explanation for this result, it appears to be the case that the arrangement of retroreflective materials does matter, even if they are just as bright as other configurations. Wood et al. (2014) examined a similar sample of road workers who typically only wear the typical ANSI Class II reflective vests. Results revealed that workers wearing biomotion were recognized at distances three times further than a reflective vest alone.

Given the perceptual advantages of biological motion configurations of retroreflective material, other studies have examined how effective it can be. Balk et al. (2008) explored conspicuity differences between stationary pedestrians and pedestrians walking in place. They found that biomotion resulted in the longest response distances compared to five other clothing configurations. When pedestrians were walking, response distances were 2.9x greater than for the stationary pedestrian. The motion effect was most prominent in the retroreflective configurations (ankles, ankles and wrists, and full biomotion). This is important because it shows that convenient subsets of the full biomotion configuration can significantly enhance a pedestrian's nighttime conspicuity. Pedestrians who wore a retroreflective vest did not produce significantly different estimates than the all black condition, which supports the findings of Cassidy et al.

(2005). Because the biomotion configuration resulted in the greatest recognition distances in both the standing and walking conditions, these results highlight the importance of form perception and human motion when understanding why biological motion is so powerful for the perception of VRUs (Balk et al., 2008).

Further support for biomotion comes from a Wood et al. (2017) study that used eye-tracking to determine driver response to different retroreflection arrangements. This study was conducted at night on a closed-circuit, rural road without street lighting that could help make a pedestrian more visible. Two different clothing outfits (retroreflective vest and biomotion configuration) were tested. The findings suggested that biomotion grabbed drivers' attention faster, and they fixated on those pedestrians for less time before fully recognizing a human form. Drivers perceived pedestrians nearly twice as fast in the biomotion condition compared to the vest condition (6.4 vs. 13.9 seconds). This finding provides further evidence that biomotion configurations consistently yield earlier pedestrian recognition. Tyrrell et al. (2016) provide a review of the literature on pedestrian conspicuity and the evidence that supports the utility of biomotion configurations of retroreflective markings.

The overarching problem affecting all road users is the misconception about how well we can see at night. Road users do not adequately understand the critical concepts– discussed above– that limit one's ability to see at night accurately. While the reasons for this are undoubtedly complex (e.g., selective degradation of focal vision, lack of coverage in driver education curricula, lack of differential day/night speed limits), the implications are that the degradations in our visual abilities at night are particularly dangerous to our most vulnerable road users (Leibowitz et al., 1998).

Fylan et al. (2020) explored VRUs' understanding of their nighttime conspicuity and their approaches to making themselves safe at night. A series of focus groups revealed that many participants believed simply wearing bright colors in low light conditions was enough; they discussed color contrast but failed to realize that without a light source, contrast remains dangerously low. Previously, Allen et al. (1970) discovered that over 95% of participants overestimated their perceived visibility against their actual visibility as a pedestrian–with an average of 343 feet *over* the actual visibility distance. These overestimations can have deadly consequences for pedestrians who choose to act on the belief that a driver can see them and will stop in time to avoid hitting them (Shinar, 1984). Based on Mikoski et al. (2019) survey data, the findings indicate that people are unfamiliar with their decreased visual capabilities at night because they reported similar maximum comfortable speeds in both day and nighttime conditions. If they knew they could not see, results would reflect lower comfortable speeds in the dark. Because of this compounded effect, education has been frequently suggested as a probable solution to combat the harm rates associated with driver and pedestrian misconceptions (Allen et al., 1970; King et al. (in press); Leibowitz & Owens, 1977; Leibowitz et al., 1998; Shinar, 1984; Tyrrell et al., 2016).

The research into pedestrian conspicuity and ways to enhance it are plentiful and informative. Tiwari (2020) highlighted three comprehensive options. She first suggested that speed control could help reduce the impact of harm, but this does not necessarily increase the perceptual ability or likelihood of recognizing a pedestrian while driving. Secondly, she recommended improving environmental factors such as traffic characteristics, road and sidewalk infrastructure, making it easier for pedestrians to cross when necessary. However, while providing a safer environment for VRUs to travel, it still does not address the critical issue of road users being unaware of the added risks associated with interacting with traffic at night. Finally, Tiwari (2020) advocated training and education as a valuable strategy, representing the sole recommendation aimed at fostering an understanding of individuals' visual and perceptual limitations at night. Education has the potential to effectively convince all road users of their misjudgments of visibility. All road users may be served by better understanding the visual limitations that all road users experience at night (Tyrrell et al., 2016).

Historically, the literature extensively delves into pedestrian education, particularly with children, revealing mixed but support-leaning evidence for the efficacy of educational interventions in promoting safety (Livingston et al., 2011; McLaughlin et al., 2019). While recognizing these contributions, this study emphasizes adults and beyond. An early examination of the effectiveness of educational interventions in this broader context was conducted by Tyrrell, Patton, & Brooks (2004). In two experiments, researchers gave a 75-minute lecture to a sample of undergraduate psychology students (Experiment 1) and high school driver's ed students (Experiment 2). This lecture discussed relevant visual concepts covertly related to pedestrian safety at night, including contrast, retroreflectivity, biomotion, and data concerning pedestrian conspicuity. Roughly two months after hearing the lecture, a different experimenter asked participants to estimate their nighttime visibility in different clothing and headlight conditions. In both experiments, lecture participants reported shorter visibility distances than those who did not hear the lecture. These results support the idea that educating road users about nighttime visibility issues can be worthwhile.

In 2012, Balk and colleagues attempted to replicate these findings using a computer-based technique. Typical on-road experimentation is expensive and time-consuming, so a computerized distance estimation assessment is attractive to determine education efficacy. Subjects were shown daytime photos of a vehicle at 15 different distances and were asked to select "the farthest distance that you think the driver of the vehicle could recognize you as a pedestrian" (Balk et al., 2012). In addition, they adapted their lecture from the Tyrrell, Patton, and Brooks (2004) manipulation and found similar results. The control group did not understand the benefits of retroreflection as much as the lecture group did, reflecting the mindset of the general public. Further, a second experiment with construction workers provided more support for the finding, indicating that they do not appreciate the advantages of different configurations of retroreflective material. These experiments provide evidence that education works and can influence how road users think about human visual capabilities and general road safety.

Based on the reviewed literature, there is good evidence that educating road users about drivers' perceptual challenges at night has considerable potential. However, up to this point, interventions have only been tested in lecture/classroom settings for an extended period of time. It is worth exploring whether an alternative educational approach–in which a shorter, prerecorded video that provides consistent delivery of critical information–could be valuable to participants. Unlike in-person lectures, videos have the potential to quickly reach large numbers of road users with relatively little expense.

The main objective of this study was to determine if a video-based educational intervention could influence participants' understanding of the reduced conspicuity of pedestrians at night and appreciation of the conspicuity benefits retroreflective materials provide. Participants were split between two video exposure groups and assessed on several measures to determine the program's effectiveness. Based on previous work, the expectation is that as a result of the intervention, relative to participants who have not seen the video, participants who have seen the videos would exhibit a deeper understanding of the key concepts emphasized in the intervention, estimate shorter recognition distances across all clothing configurations, and exhibit a greater appreciation for the utility of biological motion clothing configurations and the minimal conspicuity in the absence of retroreflective markings. Lastly, I explored the extent to which participants appreciate the role of clothing in influencing their safety and conspicuity at night.

METHOD

Participants

Fifty-seven students from undergraduate psychology courses were recruited to participate in this experiment in exchange for course credit. An a priori power analysis performed using G*Power (Faul et al., 2009) indicated that a minimum sample size of 9 participants per group (N=18) would be required to detect an effect size of .25 and achieve a power of .80 or greater. Thus, the obtained sample size is sufficient to analyze these data. Of the fifty-seven participants who signed up, data from only fifty-four participants (n=27 per group) are reported here for reasons detailed in the results section.

Design

This study featured a mixed-subjects design consisting of a single between-subjects independent variable—group (control (n=27) and intervention (n=27))—and three within-subjects independent variables. The within-subjects variables include: 1) *Point of view (POV; 2 levels)*, 2) *clothing configuration (5 levels)*, and 3) *sequence (2 levels)*. Five dependent variables were included each measured as a function of different combinations of the independent variables; Table 1 summarizes the full design.

Table 1

Methodological Design Summary

Dependent Variable	Within-Subjects IV	Between-Subjects IV
Estimated Recognition Distance	POV, Sequence, & Clothing Configuration	Group
Expected Safety	POV & Clothing Configuration	Group
Expected Visibility	POV & Clothing Configuration	Group
Visibility Ranking	Clothing Configuration	Group
Comprehension Questions	None	Group

Independent Variables

Group

Participants were randomly assigned to watch the educational intervention video (intervention group) or not (control group). Details of the intervention video are described in materials section.

Point of View (POV)

This within-subjects variable describes the way questions were worded using pedestrian or driver perspective language. Participants were asked to imagine either as a driver approaching a pedestrian (driver POV), or a pedestrian being approached by a vehicle (pedestrian POV). This manipulation was meant to determine if judgments of clothing differed based on the imagined role. Unlike previous studies that measured visibility judgments from a single perspective, this approach examined whether different roles influence participants' assessments of visibility and safety. This insight is important for understanding how an observer's role may affect their thinking and can guide the way this content is taught in the future.

Sequence

To measure estimated distances, participants selected from an array of 14 photos of a pedestrian (driver POV) or vehicle (pedestrian POV) on a two-lane roadway. These photos were presented either in ascending order (increasing distance separating pedestrian and vehicle) or descending order. The manipulation of the sequence was not a key variable of interest. Instead, it was designed to force the participants to make conscious judgments of recognition distance rather than repeatedly selecting the photograph in the same relative position in the array.

Clothing Configuration

Participants viewed photos of a pedestrian wearing five different clothing configurations. Clothing conditions include: (1) *regular clothing* (dark long-sleeve cotton shirt and medium wash cotton jeans) with reflectance values of 10.4% and 13.8%, respectively (2) *fluorescent vest* (fluorescent lime-yellow fabric with no retroreflective surfaces, worn over a black jacket and pants) with a reflectance value of 5.5%, (3) *combo vest* (ANSI Class II high visibility vest that included fluorescent fabric with retroreflective trim worn over the same black jacket and pants), (4) *wrists & ankles* (Scotchlite beaded retroreflective strips on wrists and ankles over a black cotton sweatsuit) with reflectance value of 4.2%, (5) *biomotion* (beaded retroreflective strips on the wrists, elbows, shoulders, waist, knees, and ankles all worn over the black cotton sweatsuit) with a reflectance value of 4.2%. The surface area of retroreflective material visible to the camera in both the biomotion and wrist & ankles conditions totaled 525 cm^2. The clothing configurations are seen in Figure 1. It is important to note that every time photos of the pedestrian were shown in the survey, questions were written using the phrase “these clothes” instead of a description of the clothing. This phrasing was used so that participants (especially those in the control condition) could make assessments of the clothing based solely on what they *saw* and not how the clothing was described.

Figure 1

Partial Images of the Five Clothing Configurations

Note. From left to right: regular clothing, fluorescent vest, combo vest, wrist & ankles, biomotion

Dependent Variables

Among the following dependent variables, three different measures of visibility (Estimated Recognition Distance, Expected Visibility, and Visibility Rankings) were implemented to determine the reliability and validity of participants' responses. The use of multiple measurements to assess a single construct served two main purposes: (1) to investigate whether participants' visibility judgments were consistent across different measures, thereby enhancing the credibility of the findings, and (2) to establish a comprehensive evaluation of their judgments, ensuring that observed patterns are not an effect of a particular question wording *or* dependent on a single measurement approach.

Estimated Recognition Distance

To measure the participants' estimates of the distance at which they would just be able to recognize that a pedestrian is present (i.e., recognition distance), experimenters crafted photos of the front of a sedan and a pedestrian wearing each of the five clothing configurations at 14 different distances (3.0 m, 4.3 m, 6.1 m, 8.6 m, 12.2 m, 17.3 m, 24.4 m, 34.5 m, 48.8 m, 69.0 m, 97.6 m, 138.0 m, 195.1 m, 276.0 m). The distances were spaced logarithmically, in 0.15 log unit steps, in order to have smaller increments at shorter distances and larger increments at farther distances. All photos were taken – with the camera positioned in the position of a driver's eyes– in the right lane of a two-lane, flat, rural road with the vehicle on the oncoming (left) lane and the pedestrian in the right lane. Figures 2 and 3 feature some of these photos. All photos were intentionally captured during daylight hours on a partly cloudy day. This decision was driven by the goal of measuring participants' perceived visibility of each clothing configuration based on their previous knowledge about how they would expect these garments to appear in nighttime conditions. The use of nighttime photos would elicit participants' judgment of observed visibility as it appeared in a photograph, which does not provide any insight into assessing one's belief or expectation about how a particular clothing configuration will perform at night. Participants repeatedly viewed this array of 14 photographs and selected the photograph that they judged to best represent the distance at which a driver would recognize the presence of a pedestrian. The participants made these estimates as a function of POV, sequence, and clothing configuration.

For the pedestrian's perspective, the photographs displayed a car positioned in the oncoming lane (Figure 2). The photographs for the driver's perspective featured a pedestrian positioned in the right (camera’s) lane of a road; these photos were taken with the camera from the driver’s position inside the vehicle (Figure 3). Participants responded to a total of 20 trials (5 clothing configurations x 2 presentation sequences x 2 perspectives).

Figure 2

Selection of Vehicle Photographs

Note. Four of the fifteen vehicle photos shown to participants to make recognition distance estimates. From top left to bottom right: 34.5 m, 24.4 m, 17.3 m, and 12.2 m.

Figure 3

Selection of Pedestrian Photographs

Note. Four of the fifteen pedestrian photos shown to participants to make recognition distance estimates. From top left to bottom right: 34.5 m, 24.4 m, 17.3 m, and 12.2 m from the vehicle's front bumper.

Expected Safety

This measurement aimed to explore participants' subjective assessments of safety based on a given scenario. For each clothing configuration, participants were asked questions like, "If you had to walk across a busy unlit street **at night**, wearing **these clothes** would make you feel safe." Participants responded using a 5-point Likert scale, ranging from strongly disagree to strongly agree. These questions were asked twice, using both "pedestrian" and "driver" perspective language. Each participant responded to a total of ten expected safety questions.

Expected Visibility

Here, the participant responded to the question "If you had to walk across a busy unlit street **at night**, wearing **these clothes** would make you visible enough to drivers." Participants used the same 5-point Likert scale to respond to ten expected visibility questions.

Visibility Rankings

All participants responded to a question asking them to rank the five clothing configurations from most (1) to least visible (5). Clothing configuration was the only within-subjects factor applied to this variable. Each participant ranked the five clothing configurations in terms of their nighttime visibility to approaching drivers. This question allowed for a direct assessment of participants' relative judgements of different clothing configurations in nighttime conditions.

Comprehension Questions

Participants responded to twelve multiple-choice questions that assessed their comprehension of the topics that were presented in the video. These questions were implemented to assess their knowledge and application of important key concepts related to pedestrian nighttime conspicuity explained (details in next section).

Intervention Video

An 11-minute video – partly adapted from Whetsel Borzendowski et al. (2014) – presented both verbal explanations and visual demonstrations. Across three segments, a subject matter expert (SME) discussed key topics in visual perception and showcased how different clothing affects visibility during the day and at night.

In the first segment, the SME introduced the problem of nighttime pedestrian fatalities, pointing out that poor visibility and the unawareness of our limitations are major contributing factors. He referenced the selective degradation theory (Leibowitz & Owens, 1977; Leibowitz et al., 1982) as the source of typical road users' misconceptions.

The second segment covered the critical concepts relevant to nighttime visibility: visual contrast, retroreflectivity, and biological motion. The SME stressed the importance of contrast, explaining that retroreflectivity is superior to fluorescence for nighttime visibility. One clip demonstrated this by showing mannequins dressed in a gray t-shirt, a fluorescent vest, and a combo vest in a well-lit room. As the lights dimmed, the gray t-shirt and fluorescent vest became hidden, while the combo vest remained visible because of the retroreflective materials. Participants also saw daytime and nighttime demonstrations of pedestrians wearing different outfits (all black clothing, fluorescent vest, combo vest, and a biological motion configuration), illustrating the real-world performance of these clothing configurations.

In the third segment, data from Wood et al. (2005) and Tyrrell, Wood, and Carberry (2004) were presented to exhibit the discrepancy between pedestrians' perceived and actual conspicuity at night. Finally, the video concluded with a content summary and general safety recommendations for nighttime travel.

Overall, the video was structured to provide a brief yet thorough exploration of the problem and its underlying context while offering practical solutions to enhance one's conspicuity and safety at night.

Procedure

Before beginning any part of the experiment, participants read and agreed to the informed consent documentation and verbally confirmed that they met the inclusion criteria (over the age of 18, possessed a valid driver's license, and self-reporting an absence of uncorrected visual problems). Participants were randomly assigned to one of two groups. Those in the control condition skipped the video and immediately responded to the dependent measures described previously. Participants assigned to the intervention group viewed the intervention video on an Apple iMac desktop computer with a 27" Retina 5K display (5120 x 2880 resolution). The participants sat in an office chair and watched the video from the display on the desk in front of them. Viewing distance was not controlled, but participants were instructed to maintain a consistent and comfortable viewing distance during the duration of the video. All measurements were collected using Qualtrics survey software.

The first measurements collected in this experiment were the estimated recognition distances of a pedestrian wearing different outfits. This protocol was adapted from procedures developed by Balk et al. (2012). Initially, participants read the following instructions (which varied slightly depending on POV):

> Instructions for the driver POV: "In the following section, you will see a series of daylight photos taken from inside a car. In each photograph, a person is

present on the road. **Although these photos were taken in daylight, we want you to imagine that you are driving a car at night and you are using your low beam headlights.**

You will be asked to select the photo that represents the farthest distance at which you could recognize that a pedestrian is present.

As you are deciding which photograph to select, feel free to scroll up and down as needed."

Instructions for the pedestrian POV: "Imagine you're walking in the roadway at **NIGHT** wearing these clothes and a car is present. Please select the photograph that represents the **farthest distance** at which the driver could recognize you as a person. Remember, scrolling up and down is okay." To explain what "these clothes" referred to, the researcher provided each participant with five separate laminated 8x11 photos, each depicting a different clothing configuration, allowing them to choose the most appropriate estimated distance. They selected the "distance" by clicking on the image that they judge best represents the requested condition.

Next, participants responded to questions measuring the visibility, safety, and ranking of different clothing configurations which were all designed to assess the degree to which they were able to apply the intervention knowledge to these subjective assessments of different clothing configurations relevant to pedestrian nighttime conspicuity.

Third, participants answered twelve multiple-choice comprehension questions (see Appendix A).

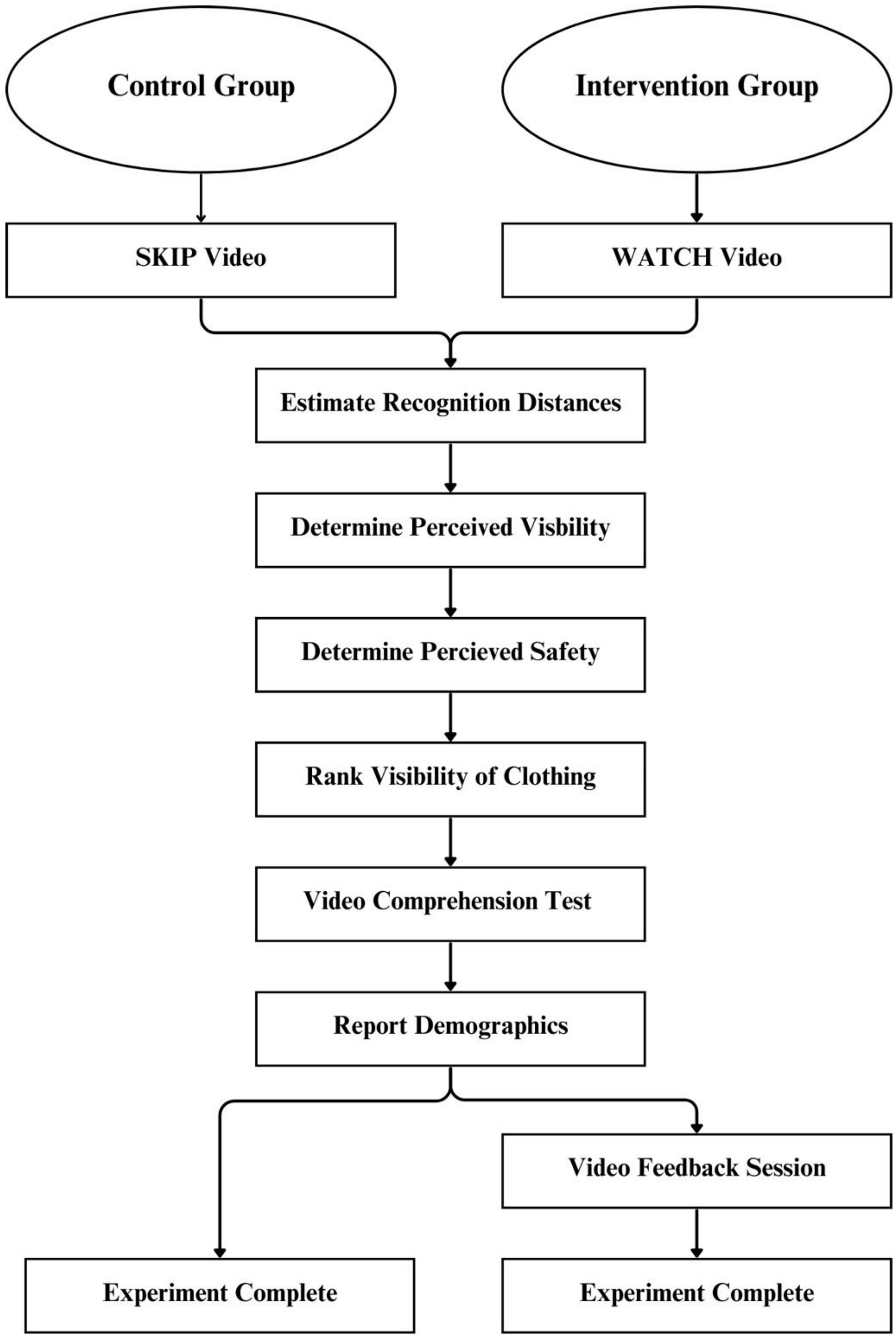
Fourth, all participants reported relevant demographic information. This section asked participants about their gender, age, length of driving experience, prior driver training, average duration of day and nighttime travel as a pedestrian and driver, their nighttime safety and visibility concerns as a pedestrian, and what methods they may take to enhance their visibility to drivers at night.

Finally, participants in the intervention group participated in a video feedback session in which the researcher used a semi-structured method to elicit their opinions on the video (e.g., what was most impactful, what was confusing, how would they improve the video, what would they keep or get rid of).

All measurements were randomized in Qualtrics, so the order of questions *within* each section was different for each participant, but the procedural order remained consistent across the sample. This procedure is summarized in Figure 4 below.

Figure 4

Procedure Flowchart



RESULTS

Prior to data analysis, three participants were excluded for important reasons. Two participants were removed because they did not have the corrective lenses they normally wear when driving. One participant was removed from analyses because he was currently enrolled in a course that covered concepts similar to those presented in the intervention video. Participants included 43 women and 11 men with an average age of 19.9 years. Each student reported possessing a valid driver's license and a lack of uncorrected visual problems. The majority (90.7%) of participants had driving experience of 3 years or more, and 98.1% reported taking driver's ed or formal driver training. Of those who participated in a driver's education course, 31.5% indicated being taught about how to make themselves visible as a pedestrian. When asked about how much time they spend traveling as a pedestrian near traffic, 11.1% never travel as a pedestrian, 16.7% spent 1-9 minutes, 37% spent 10-29 minutes, 29.6% spent 30-60 minutes, and 5.6% spent more than 60 minutes as a pedestrian. Of their time spent walking, jogging, or running near traffic, majority (68.5%) of participants said they spent less than 10% of that time at night. On the other hand, 53.7% of participants said they spend 10-29 minutes driving at night. Participants were also asked about how concerned they were about their safety and whether drivers can see them when traveling as a pedestrian at night. 59.2% said they were somewhat concerned (29.6%) or moderately concerned (29.6%) about their safety. 57.4% indicated that they were slightly (27.8%) or moderately concerned (29.6%) about their visibility to oncoming drivers. The final demographic question asked about whether they do anything to enhance their visibility at night. 79.6% reported they do not alter their appearance to increase their visibility. Of the participants who said yes, many described wearing brighter clothes (54.5%) or using a flashlight (54.5%). An analysis of group differences revealed that there were no significant differences between how groups responded to these demographic questions.

Estimated Recognition Distances

Initial exploration revealed that these data violated the normality assumption necessary to run a factorial ANOVA, so log-transformed data were used for data analysis of this variable (Maxwell et al., 2018). The transformed data was used for statistical analysis, but the figures present the untransformed data. All post-hoc and simple effects are reported using Bonferroni-adjusted analyses.

A four-way mixed ANOVA was conducted to explore the separate and combined effects of group, POV, sequence, and clothing on the estimated recognition distance selected by participants. Results from Mauchly's test of sphericity indicated a violation of the sphericity assumption for the clothing variable [$\chi^2(9) = 62.48$, $p < .001$], and POV*Sequence*Clothing interaction [$\chi^2(9) = 17.37$, $p = .044$], therefore degrees of freedom were corrected using Greenhouse-Geisser and Huynh-Feldt estimates of sphericity ($\varepsilon = 0.698$ and $\varepsilon = 0.977$ respectively). These corrections were selected because it is standard practice to use the Greenhouse-Geisser correction when $\varepsilon < 0.75$ and Huynh-Feldt when $\varepsilon > 0.75$ (Verma, 2016).

There was a significant main effect of Sequence, $F(1, 52) = 15.19$, $p < .001$, $\eta^2_p = 0.23$, suggesting that participants estimated different distances depending on the presentation order of photos (photos seen in descending vs. ascending distances).

Specifically, participants selected farther distances for the descending (*M* = 49.43, *SE* = 0.33) sequence and closer distances for the ascending (*M* = 43.05, *SE* = 0.33) sequence ($p < .001$). These results simply indicate that participants were more likely to click photos earlier in the presentation sequence. This effect was not considered to be important because there were no interaction effects that include sequence; further, this was not highly relevant to this investigation, as sequence was manipulated for psychometric reasons only.

There was a significant main effect of POV, $F(1, 52) = 4.02$, $p = .05$, $\eta^2_p = 0.07$, indicating that participants selected recognition distances differently for each perspective. Specifically, when questions were written from a pedestrian's perspective (*M* = 48.31, *SE* = 0.33), participants selected farther recognition distances than for the driver's perspective (*M* = 43.05, *SE* = 0.33). Further, there was a significant interaction between POV and Clothing, $F(4, 208) = 5.556$, $p < .001$, $\eta^2_p = 0.097$. Analysis of simple effects demonstrated that participants estimated significantly farther distances for the combo vest ($p < .05$), wrists & ankles ($p < .05$), and biomotion ($p < .01$) configurations when responding to questions written from the pedestrian perspective. There were no differences in distance between perspectives for regular clothing ($p = .313$) or the fluorescent vest ($p = .244$).

There was a significant main effect of Clothing, $F(2.79, 145.27) = 127.86$, $p < .001$, $\eta^2_p = 0.71$, indicating that participants gave non-equal distance estimates to the clothing configurations. Descriptive statistics are displayed in Table 2, see "Mean" column. Importantly, there was also a significant interaction between Clothing and

Group, $F(4, 208) = 83.78$, $p < .001$, $\eta^2_p = 0.62$. This interaction is shown in Figure 5. Examining simple effects of this interaction revealed that participants in each group estimated significantly different recognition distances for all clothing configurations. The intervention group estimated significantly farther distances than the control group for the wrists & ankles ($p < .001$) and biomotion ($p < .001$) configurations while estimating significantly shorter distances for regular clothes ($p < .001$), fluorescent vest ($p < .001$), and combo vest ($p < .001$) configurations.

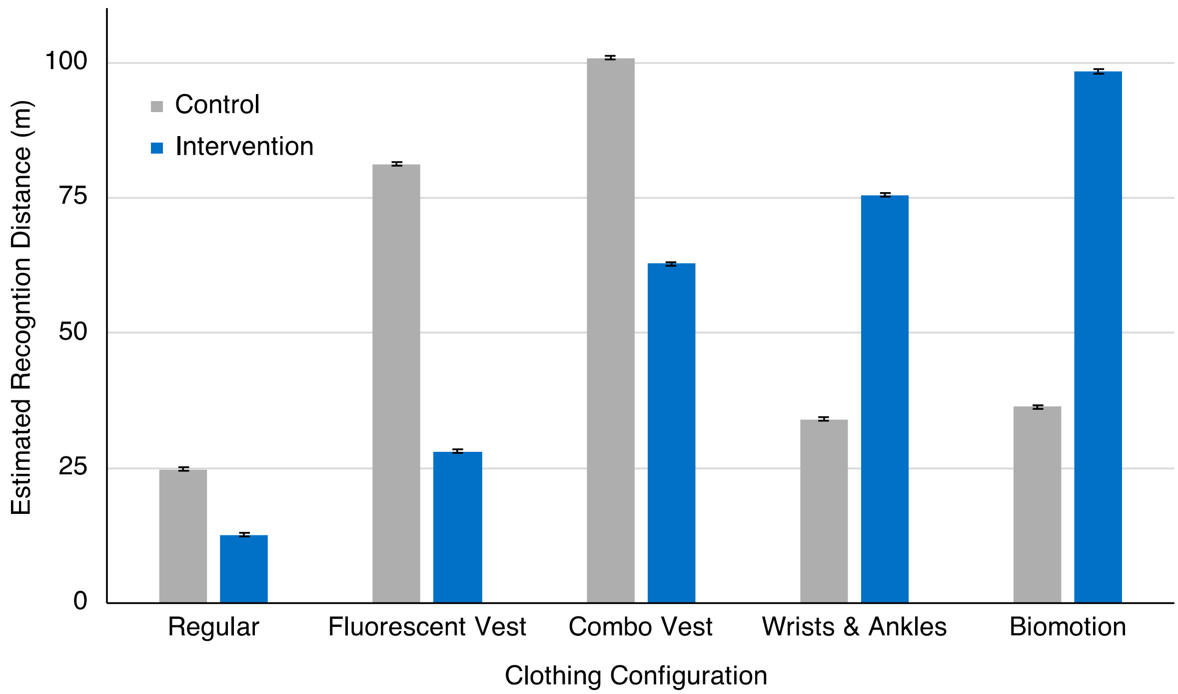
Table 2

Descriptive Statistics for Estimated Recognition Distances

Clothing Configuration	Control		Intervention		Mean	
	M	*SE*	*M*	*SE*	*M*	*SE*
Regular	24.78	0.34	12.62	0.34	17.10	0.33
Fluorescent Vest	81.29	0.34	28.06	0.34	47.75	0.33
Combo Vest	100.93	0.34	62.81	0.34	79.62	0.33
Wrists & Ankles	34.04	0.34	75.51	0.34	50.70	0.33
Biomotion	36.39	0.34	94.40	0.34	59.84	0.33
Mean	47.86	0.33	44.06	0.33	—	—

Figure 5

Effect of Group and Clothing Configuration on Estimated Recognition Distances



Note. These means are averaged across the POV and sequence variables. Error bars represent ± 1 standard error of the mean.

There was no interaction between POV and group, $F(1, 52) = 0.60$, $p = .81$, indicating that the two groups responded similarly for the two POVs.

Expected Safety

A 3-way mixed ANOVA was conducted to examine how safe participants evaluated the safety of the clothing configurations. All post-hoc analyses were adjusted using a Bonferroni correction.

Levene's test indicated that some of the variables had violated the homogeneity assumption of the factorial ANOVA. For some of the variables, it was noted that the experimental group had a variance of 0, meaning that every participant answered identically for a specific question. However, given that each between-subjects group has equal sample sizes, this violation is negligible when interpreting the results (Rosopa et al., 2013).

Results from Mauchly's test of sphericity indicated a violation of the sphericity assumption for the clothing variable [$\chi^2(9) = 41.55$, $p < .001$] and POV*Clothing interaction [$\chi^2(9) = 37.16$, $p < .001$], therefore degrees of freedom were corrected using Greenhouse-Geisser and Huynh-Feldt estimates of sphericity ($\varepsilon = 0.733$ and $\varepsilon = 0.826$ respectively) based on the reasoning mentioned previously.

There was a significant main effect of Clothing, $F(2.93, 152.41) = 165.67$, $p < .001$, $\eta^2_p = 0.76$, which suggests that when averaged across the two groups, participants anticipated safety of the five clothing configurations differently. Descriptive statistics appear in Table 3. Pairwise comparisons indicated expected safety ratings were significantly different between every clothing configuration except (1) fluorescent vest and wrists & ankles ($M = 2.82$, $SE = 0.10$) and (2) fluorescent vest and biomotion ($M = 3.19$, $SE = 0.12$).

Table 3

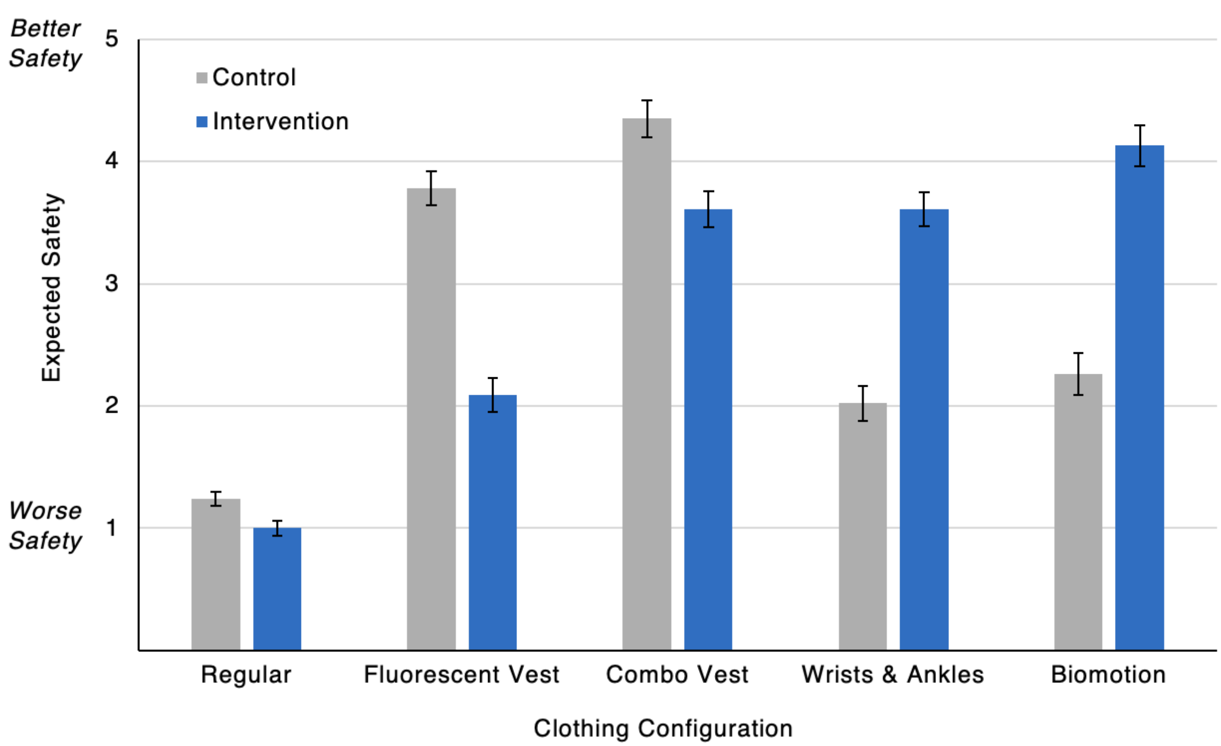
Descriptive Statistics for Expected Safety & Expected Visibility

Variable	Control		Intervention		Mean	
	M	*SE*	*M*	*SE*	*M*	*SE*
Expected Safety						
Regular	1.24	0.06	1.00	0.06	1.12	0.05
Fluorescent Vest	3.78	0.14	2.09	0.14	2.94	0.10
Combo Vest	4.35	0.15	3.61	0.15	3.98	0.11
Wrists & Ankles	2.02	0.14	3.61	0.14	2.82	0.10
Biomotion	2.26	0.17	4.13	0.17	3.19	0.12
Expected Visibility						
Regular	1.22	0.08	1.11	0.08	1.17	0.06
Fluorescent Vest	4.11	0.12	2.02	0.12	3.07	0.09
Combo Vest	4.65	0.10	3.85	0.10	4.25	0.07
Wrists & Ankles	2.07	0.16	3.65	0.16	2.86	0.11
Biomotion	2.43	0.16	4.43	0.16	3.43	0.12

While there was no main effect of group, $F(1, 52) = 1.47$, $p = .230$, there was a significant interaction between clothing and group, $F(3.19, 165.61) = 88.24$, $p < .001$, $\eta^2_p = 0.63$ (see Figure 6). Investigation of simple effects revealed that, relative to the control group, the intervention group expected significantly higher safety ratings for the wrists and ankles ($p < .001$) and biomotion ($p < .001$) configurations but significantly lower safety judgements for regular clothing (p = .01), fluorescent vest ($p < .001$), and combo vest (p = .001). Pairwise comparisons were also carried out within each group. For the control group, findings demonstrated significant differences between all clothing except between wrist & ankles and biomotion configurations. Within the intervention group, there was a significant difference between all clothing configurations except the following pairs: (1) combo vest and wrists & ankles; (2) combo vest and biomotion. See Table 3 for descriptive statistics from expected visibility and safety.

Figure 6

Effect of Group and Clothing Configuration on Expected Safety



Note. These means are averaged across the POV variable. Error bars represent ± 1 standard error of the mean.

There was no significant main effect of POV, $F(1, 52) = 0.50$, $p = .482$, indicating that participants rated the safety of clothing similarly whether they imagined they were a driver or a pedestrian.

Expected Visibility

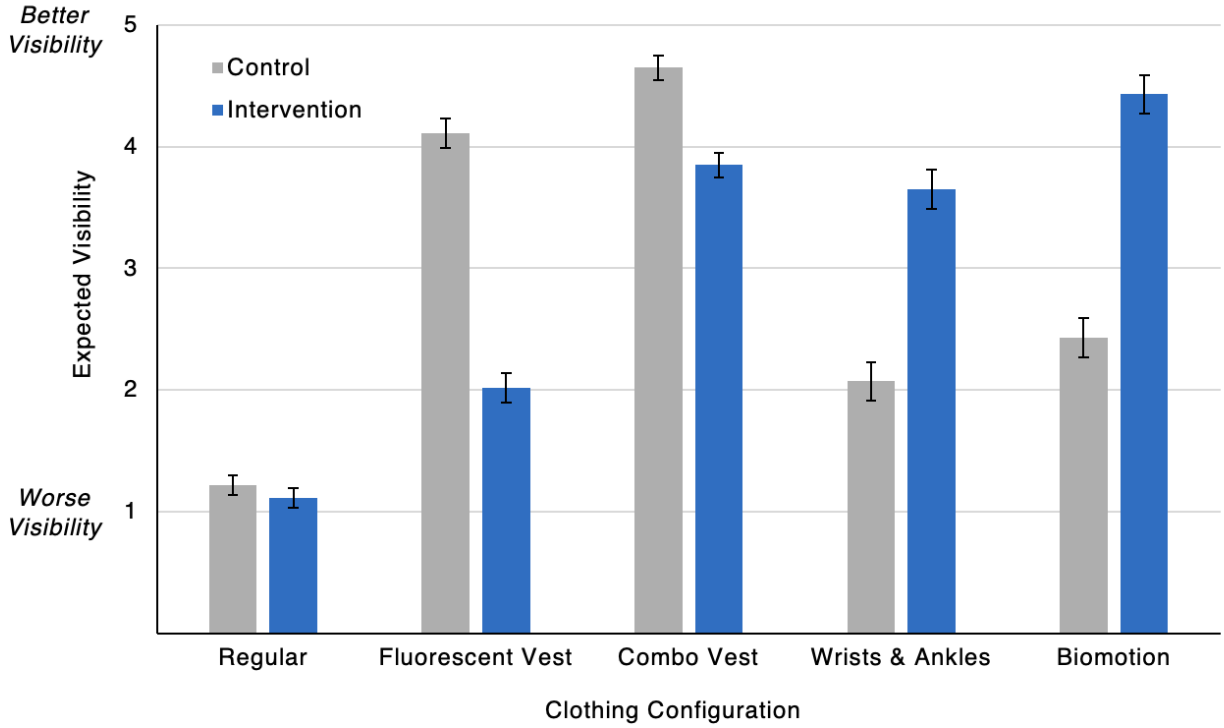
A 3-way mixed ANOVA was conducted to examine how visible participants anticipated different clothing configurations to be. All post-hoc analyses were adjusted using a Bonferroni correction. Results from Mauchly's test of sphericity indicated a violation of the sphericity assumption for the clothing variable [$\chi^2(9) = 52.10$, $p < .001$], thus degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.61$). Analyses of this variable revealed the same pattern of results as the expected safety measurement.

There was a significant main effect of clothing, $F(2.44, 126.90) = 205.78$, $p < .001$, $\eta^2_p = 0.80$. Participants thought the expected visibility of each clothing configuration at night to be different. Additionally, there was a significant interaction between clothing and group, $F(4, 208) = 114.97$, $p < .001$, $\eta^2_p = 0.69$. Figure 7 depicts these effects. Here, the intervention group anticipated more visibility than the control group for the wrists & ankles ($p < .001$) and biomotion ($p < .001$) configurations while estimating less visibility for the fluorescent vest ($p < .001$) and combo vest ($p < .001$) configurations. Both groups ranked regular clothing similarly ($p = .352$).

Pairwise comparisons within the control group revealed significant differences between all clothing. Participants in the intervention group, however, judged the visibility of each clothing configuration as significantly different from each other with one exception: the comparison between combo vest and wrist and ankles outfits ($p = 1$).

Figure 7

Effect of Group and Clothing Configuration on Expected Visibility



Note. These means are averaged across the POV variable. Error bars represent ± 1 standard error of the mean.

Visibility Ranking

A 2 (Group) x 5 (Clothing) mixed ANOVA was conducted to analyze the differences of visibility rankings across the two groups. Results from Mauchly's test of sphericity indicated a violation of the sphericity assumption for the clothing variable [$\chi^2(9) = 106.01$, $p < .001$], thus degrees of freedom were corrected using Greenhouse-

Geisser estimates of sphericity ($\varepsilon = 0.45$). Levene's test indicated that some of the variables had violated the homogeneity assumption necessary to run the factorial ANOVA, but equal sample sizes permit interpretation of the results without prior transformation.

There was a significant main effect of clothing on the visibility rankings, $F(1.79, 92.97) = 133.64$, $p < .001$, $\eta^2_p = 0.72$. Bonferroni post-hoc comparisons indicated that all comparisons were significant at the .001 level except in these two scenarios: (1) fluorescent vest and wrist & ankles configuration ($p = 1$) and (2) combo vest and biomotion configurations ($p = 1$). Furthermore, there was a significant interaction between clothing and group on the visibility rankings, $F(4, 208) = 57.83$, $p < .001$, $\eta^2_p = 0.53$. Analysis of simple effects revealed that the control group ranked the fluorescent vest ($p < .001$) and combo vest ($p < .001$) higher (more visible) than the intervention group. Conversely, the control group ranked the wrists & ankles ($p < .001$) and biomotion ($p < .001$) configurations as less visible than the intervention group. Both groups ranked regular clothing as the least visible ($p = .155$). Overall, the control group ranked the configurations in the following order from best to worst: combo vest, fluorescent vest, biomotion, wrists & ankles, regular clothing, and there were significant differences of rankings for all clothing configurations. The intervention group rankings were in the following order: biomotion, wrists & ankles, combo vest, fluorescent vet, regular clothing, and each clothing configuration was significantly different ranking except when comparing the combo vest with the wrist and ankles configuration. Figure 8 depicts these rankings, and Table 4 contains descriptive statistics for this interaction.

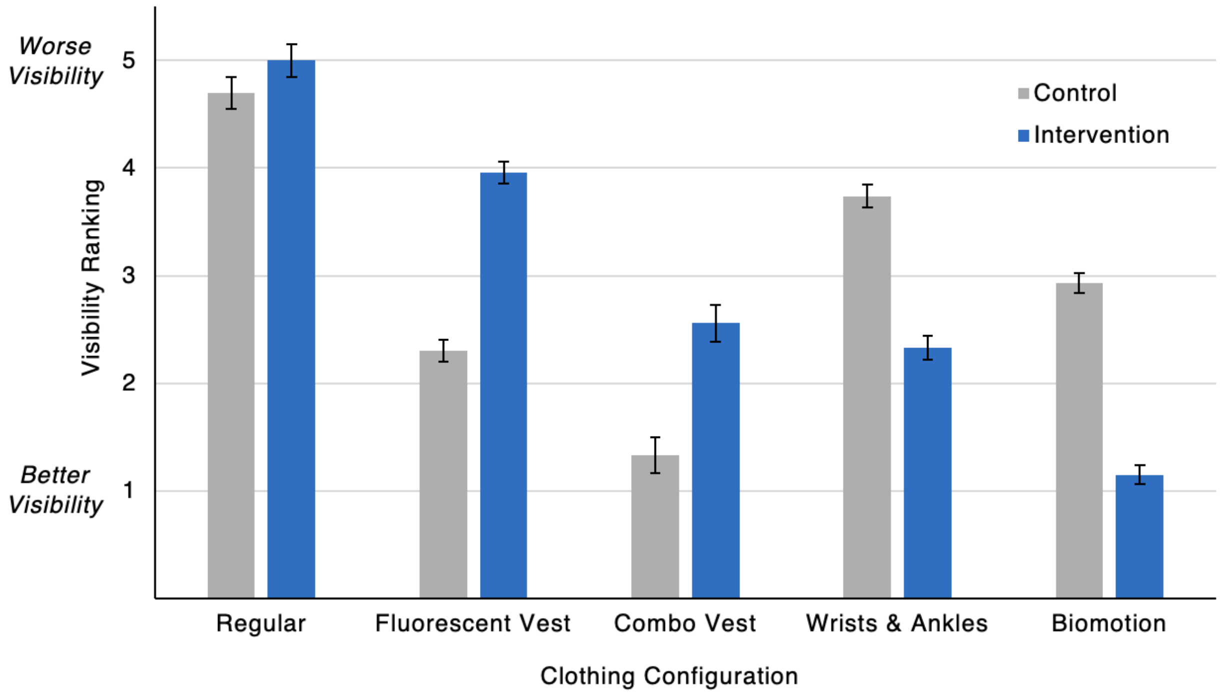
Table 4

Descriptive Statistics for Clothing Visibility Rankings

Clothing Configuration	Control		Intervention		Mean	
	M	*SE*	*M*	*SE*	*M*	*SE*
Regular	4.70	0.15	5.00	0.15	4.85	0.03
Fluorescent Vest	2.30	0.10	3.96	0.10	3.13	0.03
Combo Vest	1.33	0.17	2.56	0.17	1.94	0.03
Wrists & Ankles	3.74	0.11	2.33	0.11	3.04	0.04
Biomotion	2.93	0.90	1.15	0.90	2.04	0.04

Figure 8

Effect of Group and Clothing Configuration on Visibility Rankings



Note. 1 = most visible, 5 = least visible. Error bars represent ± 1 standard error of the mean.

Comprehension Questions

An independent samples t-test was conducted to compare the two groups' performance on the comprehension test. Upon examination of the data, it appeared that the intervention group followed a non-normal distribution. However, based on the larger sample size (n = 27), the Central Limit Theory suggests that the sampling distribution will be normal even if the raw data are not. Levene's test for equality of variances was significant, F = 9.22, p = .004, indicating that the assumption of equal variances was violated. In these cases, Student's t-test is known to be underpowered and may not provide accurate results, so Welch's t-test was used. Results revealed that the intervention group (M = 89.81%, SD = 8.75) performed significantly better than the control group (M = 58.02%, SD = 14.71), $t(42.36) = -9.65$, $p < .001$, Cohen's $d = -2.63$. A Student's t-test produced similar results: $t(52) = -9.65$, $p < .001$, Cohen's $d = -2.63$. Overall, these findings indicate that the intervention group demonstrated remarkable comprehension of the key concepts that were addressed in the video while the control group did not.

Video Feedback Session Responses

Qualitative data from the video feedback sessions is available in Appendix B.

DISCUSSION

Multiple studies have found that, at night, pedestrians tend to dramatically overestimate their own visibility to oncoming drivers (Allen et al., 1970; Shinar, 1984; Tyrrell et al., 2004; Tyrrell et al., 2016). For example, in one study, pedestrians wearing dark clothing estimated that they would be perceived by an approaching driver from a distance that was 7.0 times greater than the actual distance at which drivers responded to indicate that a dark-clad pedestrian was present (Tyrrell, Wood, & Carberry, 2004). More recently, King et al. (in press) revealed that typical road users do not appear to understand retroreflectivity, which is an inexpensive and user-friendly tool for pedestrians to enhance their conspicuity at night. For decades, transportation safety researchers have called for efforts to educate road users about the special visual challenges drivers face at night (e.g., Leibowitz et al., 1998). Specifically, educating vulnerable road users about key fundamental principles related to increasing pedestrian conspicuity at night has the potential to encourage them to take simple steps to enhance their own safety when interacting with traffic at night. Prior studies (Balk et al., 2012; Tyrrell, Patton, and Brooks, 2004; Whetsel Borzendowski et al., 2014) have explored and successfully provided evidence for the positive impact of education – in the form of lectures by a subject matter expert – on pedestrians' understanding and application of relevant concepts. The present study investigated the efficacy of a shorter, *video-based* educational intervention that could eventually afford the possibility of reaching larger viewership. Participants were randomly assigned to watch the 11-minute educational video (intervention group) or not (control group). All participants made several judgments of recognition distances, expected visibility, and expected safety, as well as a comprehension test based on five distinct clothing configurations. Overall, there were significant differences between the intervention and control groups across all measures, supporting the efficacy of the educational video. The following sections will delve into the key findings of each dependent variable.

Participants were asked to estimate the distance at which they could recognize (or be recognized) for each of five clothing configurations. As can be seen in Figure 5, the intervention group judged that the biomotion configuration would maximize recognition distances followed by, in order, wrists & ankles, combo vest, fluorescent vest, and regular clothes. Alternatively, the control group estimated that the combo vest would maximize conspicuity, followed by the fluorescent vest, biomotion, wrists & ankles, and regular clothes. These patterns suggest that a key impact of the video was to help participants appreciate the conspicuity benefits of using retroreflective markings in configurations that present biomotion information. This finding is consistent with previous studies that relied on an in-person lecture from a subject matter expert (King, 2024; Tyrrell, Patton, and Brooks, 2004; Whetsel Borzendowski et al., 2014). The finding that these effects were successfully conveyed by an 11-minute video is encouraging.

The expected safety and visibility of the clothing configurations were also assessed. Considering these measurements alongside recognition distances was important because they provided an alternate – and more qualitative – means of assessing the participants' beliefs. Generally, both groups judged regular clothes to be the least safe and least visible. However, the intervention group accurately judged that safety and visibility would be maximized by the biomotion configuration, followed by wrist & ankles, combo vest, fluorescent vest, and regular clothes. This differed from the control group, who incorrectly reported that the two vests would be safer and more visible than either of the two biomotion configurations (biomotion and wrists & ankles). These findings are consistent with earlier reports that typical road users do not appreciate either retroreflectivity or biomotion (King et al., in press; King, 2024; Tyrrell, Patton, & Brooks, 2004; Tyrrell, Wood, & Carberry, 2004)

The participants' visibility rankings provided additional evidence that the intervention group – but not the control group – correctly appreciated the conspicuity benefits of retroreflectivity and biomotion. This measure differed in that it required participants to make direct comparisons of the visibility of each clothing configuration. As can be seen in Figure 8, the intervention group judged that the two biomotion configurations would be maximally visible. Meanwhile, the control group judged that the two vest configurations would maximize visibility.

All participants answered questions designed to assess their level of understanding of the key concepts in the video (e.g., contrast, retroreflectivity, and biomotion). The responses from the control group functioned as a measure of typical road users' knowledge of those topics. The data demonstrated that the control group correctly answered only 58% of the comprehension questions, while the intervention group averaged 90%. This difference is both significant and substantial: the intervention group comprehended the key concepts from the video better than the control group. Given the extensive literature on pedestrians' tendency to overestimate their visibility (Allen et al., 1970; Balk et al., 2012; Shinar et al., 1984; Tyrrell, Wood, & Carberry, 2004), these results provide additional evidence that typical road users lack awareness of the factors contributing to their overestimations and that an 11-minute educational video can provide important and useful insight.

Two unexpected findings emerged from the data that are worth mentioning. First, participants in the intervention group judged the expected safety and visibility of the combo vest to be similar to the wrist & ankles and biomotion configurations. Based on the distance estimation task, the intervention group portrayed a pattern of responses indicating they understood the differences between these three configurations because they selected significantly different recognition distances. However, when assessing the relative safety and visibility of these garments, it is possible that the presence of retroreflective materials on the combo vest was enough to equalize against the other configurations. Then again, using a Likert scale response option may have restricted the ability to adequately distinguish the differences between these configurations, unlike the distance task allowed. Secondly, the data showed that the control group consistently predicted the combo vest, which has both fluorescent and retroreflective material, to be the “best.” This suggests that they understood that there was a difference between the two vests but for the wrong reasons (i.e., believing that brighter color in daylight equates to high visibility at night). As evidenced in the present study, education offers road users the chance to overcome these misconceptions.

Overall, the data from the control group was consistent with a lack of awareness of the degradations in visual performance that all drivers experience on unilluminated roads at night. Further, the results provide encouraging evidence for the potential value of an educational intervention that does not require the in-person presence of a subject matter expert. Unlike the control group, the intervention group consistently exhibited a solid understanding of key concepts regarding nighttime visual performance and the applications of these concepts to pedestrian nighttime safety. Consistent with this result is a recent finding by Zhou et al. (2024), who employed the use of a knowledge-attitude-practice (KAP) intervention to improve drivers’ hazard perception ability at night. Based on a series of family planning studies in the early 1950s, the KAP concept posits that behavioral change involves acquiring relevant knowledge, forming attitudes, and adopting new behaviors or practices (Hermalin et al., 1985; Zhou et al., 2024). As a result of their intervention, Zhou et al.’s participants demonstrated enhanced visual search and attention allocation patterns, indicating an overall improvement of hazard perception abilities. Taken together, the existing evidence supports the effectiveness of educating road users about visual issues relevant to night driving.

Limitations

An important limitation of this study is that data was collected from participants who had just completed the educational video. The fact that this experiment did not employ a substantial delay was intentional; the goal of this initial study was to confirm the video's efficacy under optimal conditions (i.e., data collected in a laboratory setting and without a delay). Whether these effects will persist "in the wild" is an open question that awaits further testing. Future research should implement follow-up assessments at various intervals to determine the longevity of the intervention effects. Further, more data are necessary to more thoroughly evaluate the intervention's impact and better inform the development of effective educational strategies. Further, testing outdoors at night would provide a useful test of the validity of the present results.

Another limitation of this study pertains to the sample of participants recruited for this study. Data in this study came from healthy young college students in a university setting. While the general public is more diverse than this sample, it is reasonable to assume that most road users are unaware of critical visual concepts affecting pedestrian safety at night. These concepts are not typically taught in the average K-12 curriculum. Although 31.5% of participants indicated that they had been taught about the importance of visibility as a pedestrian in driver's ed, the control group showed limited understanding of relevant concepts. Alternatively, one might argue that more educated individuals would possess greater knowledge or critical thinking skills to make better judgments of recognition or visibility. Yet, the findings suggest that would be an incorrect assumption. Additionally, most (94.4%) of the sample reported spending less than 60 minutes a day traveling near traffic as a pedestrian, with most indicating that less than 10% of that time was at night. While the lack of pedestrian experience could have influenced the pattern of data provided, this effect is likely minimal.

Another limitation of this study is that it was conducted in a lab setting. Participants might have felt pressured to pay attention to the video because of the researcher's presence. Future studies should investigate the efficacy of an educational intervention in different settings to further validate the results found here. It will be important to know if the participants will achieve the same understanding and application of the visual concepts when they are not directly observed or after watching a video in different contexts.

Lastly, the use of online distance estimation and self-reported expectations of safety and visibility may not fully reflect actual behaviors in real-world situations. Although Balk et al. (2012) developed and validated a computerized version of the recognition distance task, even on-road studies may not precisely match what participants perceive in reality. Therefore, results from this and previous studies should be supplemented with data from real-world roadway conditions at night.

Conclusions

The current study provided strong and valuable evidence for the utility of a video-based educational intervention to influence pedestrians' knowledge of visual perception related concepts and encourage them to enhance their own conspicuity to approaching drivers at night. Relative to the control group, participants who saw the educational video made judgments that more accurately reflect the reality of drivers' decreased visual abilities and pedestrians' decreased conspicuity at night. Future studies should revise the current video based on the quantitative and qualitative (Appendix B) findings from the present work. Plans are under development to test the effectiveness of this intervention in different settings with various populations to better generalize the efficacy of educating vulnerable road users to be safe at night. These efforts will help to inform a larger goal of implementing this education in driver's education courses, school curriculum, public access to be viewed on demand, and other settings in which drivers and VRUs could benefit from this knowledge.

APPENDIX A

Video Comprehension Questions

Correct Answers are in bold

1. Which of these is correct?
    a. We see as well at night as we do during daylight
    b. Objects that are visible during daylight are also visible at night
    c. We often think we see well at night, but we actually do not
    d. In general, a driver who has their headlights turned on can see pedestrians from a safe distance as long as they are paying attention
2. What does the selective degradation hypothesis explain about night vision?
    a. At night, our ability to see objects is degraded but our ability to steer our vehicle is not
    b. At night, our ability to use vision to steer our vehicle is degraded
    c. At night, certain colors are less visible than they are during daylight
    d. Overall, we see better in daylight than at night
3. A consequence of the selective degradation of human vision at night is that:
    a. Drivers are not aware of how difficult it is to see things at night
    b. Fluorescent clothing is not useful in making pedestrians visible at night
    c. We tend to drive more slowly at night
    d. Because focal vision is not impaired, at night it is easy for drivers to steer

Contrast

4. Which of these is an example of contrast?
    a. How much the brightness of the text in a road sign differs from the brightness of the visual background
    b. The font size of the text in a road sign
    c. Whether some of the text in a road sign is printed in italics
    d. Whether a road sign is illuminated by a light source

5. Bill and Jo are jogging along the shoulder of a dark road at night. Bill has on dark clothes, and Jo has on white clothes. Relative to Bill, Jo has more
    a. Contrast
    b. Retroreflectivity
    c. Fluorescence
    d. Biological motion

Fluorescence & Retroreflectivity

6. Which is true about fluorescent materials?
    a. They are activated by ultraviolet rays from the sun
    b. They reflect light back to the source
    c. They reflect light poorly
    d. They are highly visible at night

7. Which of the following best describes retroreflective materials?
    a. They are activated by ultraviolet rays from the sun
    b. They reflect light randomly in many directions
    c. They reflect light poorly
    d. They are highly visible at night
8. At night, why do stop signs appear brighter than the surface of the road?
    a. Because stop signs are using electricity to appear bright
    b. Because stop signs are retroreflective
    c. Because stop signs are engineered to scatter light in many directions at the same time
    d. Because stop signs are fluorescent
9. In terms of nighttime visibility, which of these is correct?
    a. Retroreflective materials create light, while fluorescent materials do not
    b. Retroreflective materials scatter light in many directions, while fluorescent materials reflect light directly back to the driver
    c. Fluorescent materials create contrast against the environment, while retroreflective materials do not create contrast
    d. Fluorescent materials are ineffective at night, while retroreflective materials increase contrast at night

Biological motion

10. What does biological motion refer to?
    a. Natural traffic patterns along the highway
    b. **Characteristic movements of humans and animals**
    c. The brain's ability to coordinate muscles
    d. The maturation of children
11. For a pedestrian who is trying to be more visible at night, which of these is the best strategy for using retroreflective materials?
    a. Picking materials that have bright colors
    b. Placing the materials on the moveable extremities
    c. There is no effective strategy for using retroreflective materials at night
    d. Picking materials that absorb ultraviolet radiation
12. Why is the strategic placement of retroreflective materials important?
    a. It improves color perception
    b. It creates a light source
    c. It helps to highlight biological motion
    d. It prevents selective degradation of the driver's vision

APPENDIX B

Video Feedback Session Responses

This section presents general findings from the qualitative responses collected during the video feedback session administered to participants in the intervention group. These responses will aid in the improvement of a future educational video. The results are organized by the question asked.

How engaging did you find the video overall?

Most participants (85%) felt that the video was “pretty” engaging or interesting. Three participants did not find the video engaging specifically because they were uninterested in the topic, the speaker was somewhat monotonous, and the slow pace of the video.

How did you feel about the length of the video?

Almost all participants (92%) felt the length was adequate. Some participants described it as “short enough,” “wasn’t bad,” and “good length for the amount of information provided.” Two participants, in particular, reported checking the time during the video, which indicated there may be pace or engagement issues at some point during the video.

Were the concepts presented in a logical sequence?

Overwhelmingly, the consensus (100%) was that the concepts were presented in a logical sequence. Many participants expressed an appreciation for the organization of the video, which introduced the problem, discussed the three main concepts in a logical sequence, and provided a solution to the problem posed in the beginning.

MIXED QUESTION: What aspects did you find most helpful in understanding the video content? Which sections did you find most important or impactful?

Responses to this question varied much more across participants. The two most frequently reported answers to this question involved the explanation of biological motion (44%) and the experimental data from Wood et al. (2005) and Tyrrell, Wood, and Carberry (2004), which described perceived vs. actual response distances measuring pedestrian nighttime conspicuity (41%). Other responses included appreciation for the video demonstrations showing four pedestrians walking across the road wearing different outfits during the day and nighttime (30%), the overarching comparison between fluorescence and retroreflection (15%), and fatality statistics, which appeared when introducing the problem (11%). At least one participant mentioned each major section of the video.

Were there any parts of the video that you found confusing or unclear?

Overall, 65% of participants did not think anything in the video needed to be clarified. Five participants believed that the retroreflection graphic that illustrated the difference between diffuse and retroreflection could have been clearer and preferred it be left out. Two participants felt like the discussion of experimental data was too fast to be fully understood. One participant needed clarification about where exactly to place retroreflective straps, and another wondered about the magnitude of the difference between wrists & ankles and the full biological motion configurations.

Was there anything in the video that you found distracting or ineffective?

81% of students did not find anything distracting while watching the video. For the five participants that reported, the sources of ineffective included where to put retroreflective straps, the retroreflection graphic, outdated fatality statistics, having two videos going at once (four pedestrians walking across the road), and the slow pace of the video overall.

Were there any sections of the video that you wish were explained in more detail or any sections that seemed repetitive?

Following the trend, about half the participants (52%) did not believe they needed more detail than what was provided. For those who expressed dissatisfaction, they mentioned slides that were previously cited to be ineffective or confusing. They included the retroreflection graphic, the experimental data graphs, further clarification of retroreflective placement and thickness, and selective degradation theory. One participant wanted to know what they could do as a driver in this situation.

What did you learn from the video that you didn't already know previously?

Participants were most surprised to realize that fluorescence (vests) are not helpful when used at night (50%) and the phenomenon of biological motion (42%). Other topics mentioned include learning about retroreflection (19%), the difference between retroreflection and fluorescence (19%), and the experimental data that shows pedestrians are not as conspicuous as they think they are (19%). Others were surprised to know they cannot be seen just because a driver's headlights are on.

After watching the video, do you feel motivated to take any specific actions or learn more about how to stay safe at night?

Ten participants were not motivated to change their behavior or learn more to stay safe because they do not travel at night as pedestrians. Four participants explained they would not get any retro straps, while five said they would want retroreflective gear specifically. Two participants expressed concerns about being too visible because they did not want to become victims of violence due to their gender identity. Others expressed learning more about how to implement the retro straps, what they can do as a driver, and spreading the message to others around them.

Are there people in your life who you think would benefit from this video?

Most participants discussed wanting to share this video with their friends (42%) and family members (54%). They discussed how their parents and siblings often walk their pets outside early in the morning or late at night while their friends were avid runners. A small group mentioned the utility of such a video to college students who may not take their safety seriously when going to bars or parties across town. Two students were unable to come up with someone they thought would benefit from viewing this video since (1) it should be common knowledge to make sure drivers can see you before crossing the road, and (2) he doesn't know anyone who travels as a pedestrian at night.

If you were to make the video shorter, which content would you consider removing?

The most frequently mentioned suggestion (26%) involved shortening or removing the contrast slide, as it was considered common knowledge and thus unnecessary to include in the video. However, three people felt that the animation should remain because it effectively illustrated contrast. The second most popular recommendation (22%) was to eliminate the diagram on the retroreflection slide. Many people found it difficult to understand in the brief time it was shown or believed they could grasp the video's main points without it. Several people suggested removing slides that seemed redundant or combining related slides. For instance, some recommended merging the discussions of fluorescence and retroreflection, presenting only one of the videos demonstrating different clothing configurations at night (abbey road), using only one of the mannequin videos, and showing data from slides 20 and 21 simultaneously. Other suggestions included removing the contents slide and the summary of the problem slide, which were intended to help orient viewers.

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