

**Visible or Invisible Runners? Studying the Effect Reflective Vests Have  
on Driver Reactions**

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Visibility is a key factor in Motor Vehicle Crashes (MVCs) involving pedestrians. In order to reduce MVCs, pedestrians are encouraged to wear reflective clothing. The effect of a runner and a vest on driver reactions was examined to determine if cars swerved out more when a vest was present as opposed to no vest. The amount of light present was also looked at in respect to vest status. A 2 mile path was run every other day from May 14th to June 10th. Runs were recorded using a GoPro Hero 8 and then uploaded to the GoPro App where videos were analyzed using JAMOVI Software. It was found that overall, the vest had a statistically significant impact on driver reactions with a p value of < 0.001. Supporting that driver reactions were dependent on whether or not a vest was present. In regards to light level, when running in daylight, a p value of 0.017 was produced displaying significance. In low light, a p value of 0.382 was produced, failing to show significance.

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## **Visible or Invisible Runners? Studying the Effect Reflective Vests Have on Driver Reactions**

By: Nicole Boyea

### **Rationale/Introduction:**

During the COVID-19 pandemic, schools and communities began to emphasize exercising outside for several physical, mental, and social benefits [1]. People were encouraged to leave their homes and get fresh air. Because of increased focus on outdoor activities, there was a distinct and noticeable increase of pedestrians on roads. Additionally, participation in high school sports also increased. At Burnt Hills - Ballston Lake High School alone, participation in the sport of cross country increased by 76.32% from 2021 to 2022, due to the creation of a modified team for middle schoolers. In September of 2023, the High School started a cross country program for elementary to middle school aged students. This meant that there were even more younger runners on the roads in our area. Simultaneously, the number of Motor Vehicle Crashes (MVC) involving pedestrians also increased [2]. This increase in crashes can be attributed to distracted driving, alcohol consumption, speed limit violations, and law enforcement. Many roads are not designed to favor pedestrians, but rather the drivers. However, as a society, we are moving to a more pedestrian friendly mindset. This could be accomplished by widening the shoulders on roads or even creating a separate lane. There are many groups and organizations that are focused on making roads more pedestrian friendly. Groups such as Road to Zero and Papren are working to create a better and safer environment [5,6]. As a runner and captain of the cross country team, I am highly concerned with my teammates' safety when running, prompting the examination of visibility when running on the road.

Many efforts have been made to educate both pedestrians and drivers. A study at Clemson University examined the effects of education on pedestrians' estimates of their own visibility. The study looked at whether a series of lectures helped pedestrians accurately assess their visibility from an oncoming vehicle. The study found that after a lecture, people were able to identify what would be most visible to drivers in terms of color and amount of reflectors. Compared to the people who received the lecture, those who didn't were unable to accurately identify what would make them visible [7]. Because of these findings, the importance of education is supported. This shows that an increased education of both drivers and pedestrians on safety could be beneficial to both. Pedestrians have been told to face traffic, remove headphones to hear oncoming cars, wear bright colors, or even a reflective vest [8] and drivers have been taught to learn the hand signals used by cyclists. Multiple studies have looked at the visibility of different colors worn by pedestrians to increase pedestrian safety. One particular study, Benea et al., 2019, looked at visibility at night. This study examined 6 colors; Black, Blue, Green, Yellow, Red, and a Reflective Vest. When tested for contrast on a 50 meter section of road at 10 meter increments, it was found that wearing the reflective vest produced the greatest contrast, making the pedestrian the most visible. The other colors produced very little contrast and couldn't be seen from distances greater than or equal to 50 meters, thus supporting the use of a reflective vest [9]. In June of 2021, a study was conducted to see how placement of reflectors affected visibility. The results demonstrated that the use of retro-reflective strips on joints (Biomotion), significantly increased a drivers' ability to identify a pedestrian and the direction they were walking at night [10].

Although wearing a reflective vest has been shown to make pedestrians more visible, no studies have examined driver reactions when approaching a pedestrian wearing a reflective vest.

How time of day and the amount of light present impacted driver reactions was also an important question.

### **Research Question and Purpose:**

*RQ:* Does the use of a reflective vest while running have an effect on oncoming drivers' reactions?

*Purpose:* To determine if a reflective vest worn by a runner affects the reaction of an oncoming motor vehicle driver.

*Hypothesis:* It is hypothesized that the use of a reflective vest will modify the behavior of drivers. In relation to the time of day, drivers are predicted to swerve out more in the daylight due to higher levels of awareness. It is expected that drivers will be less alert during dawn and dusk and will therefore swerve less or not move at all.

### **Methods and Materials:**

This 4 week long study started on Sunday, May 14th and ended on Saturday, June 10th. I ran a 2 mile path along Goode Street, Burnt Hills, Ny every other day for the duration of the study (Figure 1). The route was a 1 mile path South and then a mile back North, along the same path. Goode Street has a consistent shoulder width of approximately 1.7ft and a lane size of about 10.3ft. The route was completed at alternating times: dawn, daylight, and dusk.

When considering attire, all black was worn regardless of the vest or no vest status. This allowed me to examine the effect of the vest alone. When running, my hair was up and the same shoes were worn. In addition, a camera was worn on my chest at all

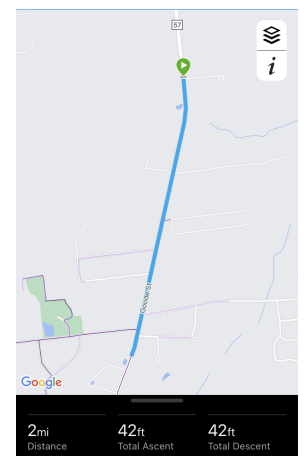


Figure 1. Out and back 1 mile path segment on Goode St. (2 miles total).

times in order to accurately identify and document vehicles. When choosing the reflective vest to use in the study, I bought the most popular model on Amazon (Figure 2) in order to simulate what a common pedestrian might do if they were to purchase a vest. Beginning in Week One, the vest was worn on alternate weeks. This pattern repeated itself for the remainder of the study. To mitigate the chance of an accident when running, a headlamp was worn to increase visibility at all times, including daylight.



Figure 2. GoxRunx reflective vest used in study.

### Participants, Protection and Privacy

This study was unique as I was the only runner. Because I am a minor, my parents signed an informed consent form. All license plates, faces, or any personal identification visible in videos were blurred and all data was treated as confidential. At the end of the project, files will be deleted.

### Data Collection:

To record and document drivers' reactions, a GoPro Hero 8 was used. The camera was strapped to my chest using a harness. Once a run was finished, the video was uploaded to my phone using the GoPro Quik app. After uploading, the videos were then transferred to a PC where they were kept and analyzed in relation to vest or no vest as well as the time of day.

Videos were sorted by two conditions, vest (1) and no vest (0).

The drivers' reactions were analyzed and sorted by responses using a point system of 0, 1, 2, and 3 assigned based on car movement (Figure 3). If a car touched or went over the yellow

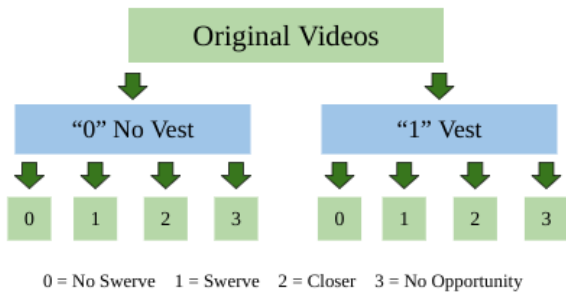


Figure 3. Process used to sort videos and the driver’s respective reaction.

from its path, it received a 0. Any car that swerved closer to me received a 2. Lastly, any car that was unable to fully swerve due to an oncoming car or another pedestrian, received a 3.

line in the middle of the road, the car received a 1, meaning that it swerved out and created space between it and the runner (Figure 4). However, if the car did not touch the yellow line or move

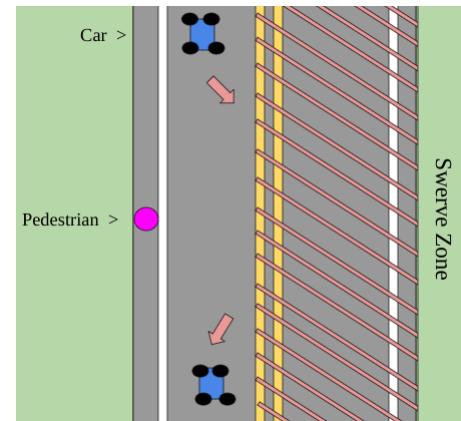


Figure 4. Pink dashed area depicts what counts as a swerve.

**Data Analysis and Statistics:**

The study was conducted with the focus on the vest significance as well as the light present; however, other variables were examined to see if they also had a significant effect on the reactions. These variables consisted of a dotted/dashed vs a solid yellow line, the weather, and even the type of car.

Data collected was uploaded to JAMOVI Statistics Software. A goodness of fit Chi squared test was used to evaluate the impact of the reflective vest on driver reactions in both scenarios (vest vs no vest). Two 2 proportion z tests were performed to determine the effect of light level and the vest on driver reactions.

**Results:**

Altogether, 28 miles were run and approximately 220 minutes of footage has been recorded. This resulted in a total of 161 cars observed among all categories (Table 1).

Table 1. Total number of cars in each light level

	Number of Cars	Dawn	Dusk	Daylight
Vest	82	5	53	24
No Vest	79	8	50	21

**Vest vs No Vest**

In terms of vest versus no vest, the driver reactions were as expected. The most popular reaction was to swerve regardless of vest status (Figure 5). However, wearing the vest resulted in more swerves than when not wearing the vest. In addition, the data points were more compact meaning driver reactions were more consistent when a vest was present. The number of no swerves was much greater without the vest compared to with the vest.

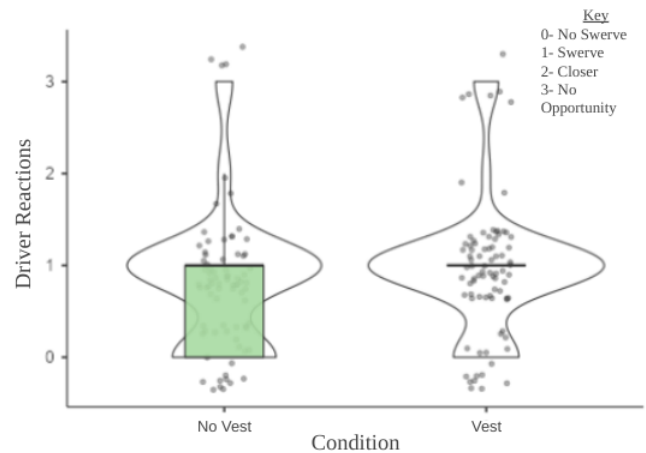


Figure 5. Driver Reactions in relation to Vest or No Vest. Each dot represents one driver.

Table 2. Percentage of Reactions In Relation to Vest and No Vest

Frequencies of Response				
Response	Condition	Counts	% of Total	Cumulative %
0 No Swerve	0 No Vest	25	15.5 %	15.5 %
	1 Vest	16	9.9 %	25.5 %
1 Swerve	0	47	29.2 %	54.7 %
	1	58	36.0 %	90.7 %
2 Closer	0	3	1.9 %	92.5 %
	1	2	1.2 %	93.8 %
3 No Opportunity	0	4	2.5 %	96.3 %
	1	6	3.7 %	100.0 %

When examining the reactions drivers had, when no vest was present, less cars swerved compared to when a vest was present (29.2% as opposed to 36.0%) (Table 2). This result flips when looking at the amount of no swerves. When a vest was present, the percentage of no swerves was less than when

no vest was there (9.9% as opposed to 15.5%). It's notable that in responses no swerve and swerve closer, no vest produced higher percentages. Looking at the other responses, swerve, and

Table 3.  $\chi^2$  Goodness of Fit

$\chi^2$	df	p
96.5	3	< .001

no opportunity, the vest produced the higher percentages. This shows that when wearing the vest, more cars swerved out than when not and also displays that when not wearing a vest, it was more likely for a car to stay in its path rather than swerve. This corresponds to the goodness

of fit test which produced a p value of <

0.001 (Table 3), suggesting a strong

relationship between the driver behavior

and the use of a reflective vest. The

results from wearing the vest and not are

the reverse of each other. It was found

that when wearing the vest, more cars

swerved out and less cars didn't swerve

(Figure 6). The results from not wearing a vest are

the opposite in that less cars swerved out and more

stayed in their path which confirms the validity of the results.

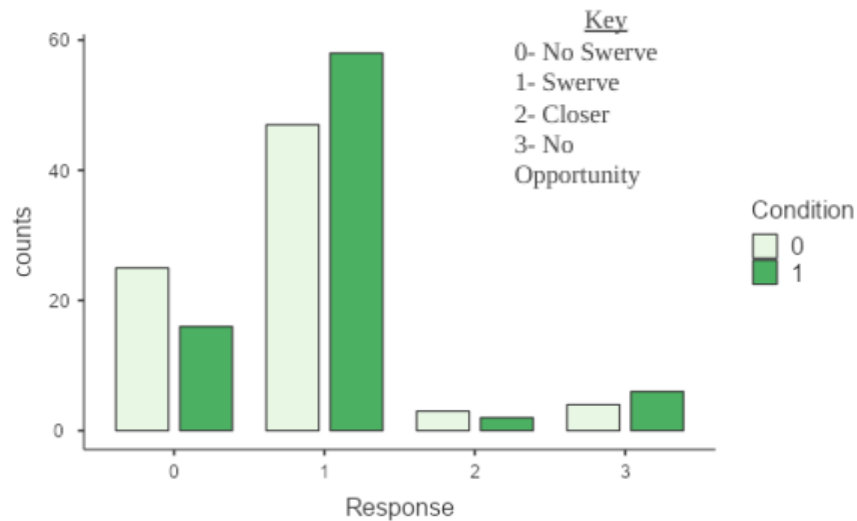


Figure 6. Direct comparison of driver reaction in respect to weather or not a vest was present. Condition 0 = No Vest, Condition 1 = Vest.

In terms of Responses 2 and 3, there was no significant difference when wearing the vest.

**a) Time of Day: Daylight vs Lowlight**

Due to the small number of cars observed in both dawn and dusk, I decided to combine the groups into one category, “lowlight”.

Two 2 - Proportion z-tests were used to examine the relationship between a non swerving reaction and the amount of light present. Proportions were generated using

$$\frac{\text{Number of No Swerves}}{\text{Total Number of Cars (vest or no vest)}}.$$

An alpha value of 0.05 was used to determine significance.

**i) Daylight**

A total of 103 cars were examined during the daylight, 53 with a vest and 50 without. The proportion  $\frac{11}{53}$  (with vest) was compared to  $\frac{20}{50}$  (no vest). It was found that the use of a reflective vest in daylight had a significant impact on the number of no swerves. A p-value of 0.017 suggests that there is a significant difference in reactions when wearing a vest than when not wearing one in the daylight.

**ii) Lowlight**

A total of 58 cars were examined in low levels of light (dawn and dusk), 29 with a vest and 29 without. The proportion  $\frac{7}{29}$  (vest, 0.2414) was compared to  $\frac{8}{29}$  (no vest, 0.2759). These results did not meet the conditions to perform the test however, the test was done regardless to build an understanding of my study. Contrary to what was expected, there was no significant difference in the number of no swerves when wearing a vest compared to not wearing one (P = 0.382).

**Discussion:**

**a) Vest versus No Vest**

When looking at the data spread, it is notable that overall the most popular response was to swerve regardless of vest or no vest which is represented through the mean value approaching 1 in both conditions (Table 4). There was not much variation in Responses 2 and 3. However, although not significant, there were slightly more people that swerved closer to the runner when no vest was worn. This could be due to drivers trying to recognize and locate the person and as a result drifting towards them. Although this is not significant statistics wise, it could still raise concern when looking at true safety of pedestrians. The slight difference in

Table 4. N and Mean Values

Descriptives		
	Condition	Response
N	0	79
	1	82
Mean	0	0.823
	1	0.976

Condition 0 = No Vest, Condition 1 = Vest

response 3 (no opportunity), raises no concern since those cars did not have the option to swerve and the response was not based on vest status.

It is notable that there were not many outliers in the dataset. The violin plot helps show that the main portion of the data was composed of Responses 0 and 1 (Figure 5) as expected (mean value = 0.823 and 0.976).

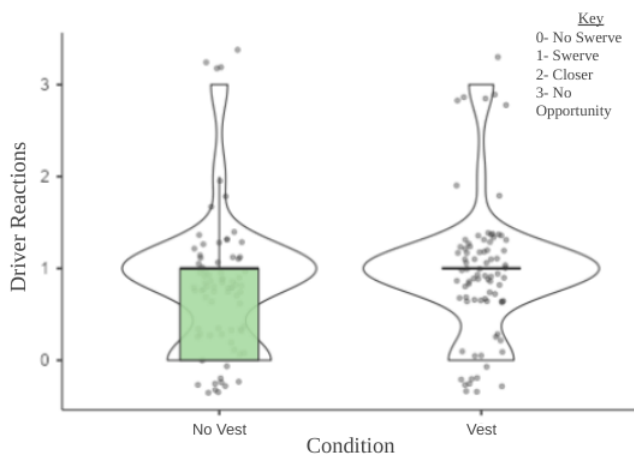


Figure 5. Driver Reactions in relation to Vest or No Vest. Each dot represents one driver.

Wearing the vest had a significant impact on driver reactions ( $p < 0.001$ ). When wearing the vest, reactions were more predictable as indicated by the more compact data points (Figure 5). Cars were more likely to swerve and move out when they came across the runner. When no vest was worn, the cars were not as predictable as shown

by the wider spread of data points. Although the most popular reaction was to swerve, the data points were more spread out compared to the compacted points seen in condition 1. Even though many cars swerved regardless of vest status, the chances of a car swerving when the pedestrian was wearing a vest was higher, supporting the idea that vests impact driver reactions.

### b) Time of Day - Daylight versus Low Light

When taking into account the light levels, the low light level results were very unexpected. I hypothesized that wearing the vest in dawn or dusk, drivers would be more likely to swerve out, but that was not the case. The reactions were near equal when comparing vest to no vest (0.2414, 0.2759). It is notable that the low light proportions did not meet conditions. If this study were to be conducted again, a larger number of cars would need to be examined in the

low light levels. It is also possible that the headlamp worn affected these results. The headlamp could be seen by all drivers, prompting them to swerve regardless of the vest status. Results could be different with the absence of the headlamp, but was worn for safety since I was the lone participant.

One of the most influential setbacks faced was the poor air quality specifically on June 5th and 7th. People were encouraged to stay inside and local community events were canceled. As a result, I saw less cars on those days.

Another limitation was oncoming cars that would prevent the drivers in my study from having the ability to fully move out. This was combated by creating another response category, no opportunity. Although this only happened with 10 cars, those were 10 cars that I couldn't observe in relation to the vest or no vest which limited my data set.

### **Conclusion:**

Although previously published research has shown that wearing a reflective vest does make pedestrians more visible [9,10], this is the first study to look at how drivers actually reacted to seeing a runner.

Results of this study support that the use of a reflective vest significantly impacted and modified drivers' reactions when encountering a runner wearing a vest ( $p < 0.001$ ). In addition, this study showed that drivers are more predictable when a runner wears a vest. However, unexpectedly, wearing a vest during levels of low light did not significantly impact a drivers' reaction but did during daylight. This is an area that needs to be studied in greater detail.

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