On the Risk of Quiet Vehicles to Pedestrians and Drivers

Michael S. Wogalter, Rachelle N. Ornan, Raymond W. Lim, and
M. Ryan Chipley

Department of Psychology
North Carolina State University
Raleigh, NC 27695-7801 USA

ABSTRACT

Technology has enabled the mass production of hybrid and electric vehicles. Interest in these alternative-energy vehicles has been heightened due to air quality concerns in urban areas. However, these vehicles are capable of very quiet operation, which could have negative side effects on pedestrian and driver safety because of the lack of sound cues. A survey of 380 people was conducted to explore interest and concerns about electrically powered vehicles. The data show that there is substantial positive interest in driving quiet hybrid and electric cars. However, in the role of pedestrian, participants expressed concern over the reduced auditory cues to the presence of a moving vehicle. Implications of quiet vehicles are discussed including the additional consideration of reduced driver awareness of their speed. Precautionary measures and suggestions for effective engine noise substitutes are presented.

INTRODUCTION

The 1990 U.S. Environmental Protection Agency's Clean Air Act required automotive manufacturers to build more part-gas, part-electric (hybrid) and fully electric cars. The main purpose of the act was to improve air quality in urban areas such as Southern California, where smog has been a major problem. In fact, the state of California has enacted its own low emission laws that are being met, in part, by vehicles that are partially and fully electric. Clean-fuel vehicles have been shown to be beneficial in reducing the amount of air pollution in certain areas of the U.S. (Meotti, 1995).

The trend towards the use of electrically powered vehicles could have some drawbacks. One potential drawback is pedestrian safety. While electric vehicles will produce some noise during acceleration and at higher speeds because of tires and wind (Robbins, 1995), there may remain a threat to safety because of the lack of engine noise normally attributed to gas-powered vehicles. Relatively quiet vehicles will make position, speed and direction cues less available to pedestrians. Consequently, a greater frequency of pedestrian accidents can be anticipated involving quiet electric vehicles.

Another potential problem with electric vehicles concerns the driver's awareness of speed. Auditory cues indicative of greater speed are reduced even further with sound insulation of the passenger compartment. Research suggests that drivers with diminished hearing also have a diminished sensation of speed. More specifically, under such reduced auditory conditions, drivers tend to underestimate vehicle speed across a wide range of speeds (Evans, 1970).

The purpose of the present research study was to gain insight into people's attitudes toward electric cars and in particular, focus on opinions related to the relative quietness of these vehicles. Among the issues examined are people's interest in partially and fully electrically powered vehicles, their opinions regarding reduced auditory cues for pedestrian and drivers, and their suggestions for substitute auditory cues.

METHOD

Participants

A survey was distributed to 380 individuals in various locales in North Carolina. Mean age was 26 (SD=11) with 232 males and 148 females responding. The survey data was collected by undergraduate students in a human factors class in partial fulfillment of a required project.

Materials

The survey contained items that asked participants for their opinions about current technology. The survey included a section concerning demographic information such as which kind of vehicle they currently drive most often (make, model and year), mileage driven over the last year, and items associated with electric vehicles and their sounds. The specific items in the electric-car and sound section of the survey follow in the order that they appeared:

(1) Electric vehicles are quieter than traditional gasoline engine-powered vehicles. Would this lack of noise pose any threat to pedestrians?

(2) Would you consider purchasing an electric vehicle?

(3) Would you consider purchasing a car powered by a hybrid motor?

(4) When crossing the street, have you used the sound of a vehicle as a cue that the vehicle is approaching?

(5) Does the sound emitted from a moving vehicle, make you more aware of the vehicle's location and direction?

(6) As a pedestrian, if a moving vehicle were totally silent would that bother you?

(7) As a driver, if a moving vehicle were totally silent would that bother you?

(8) Do you think that including an artificial sound like that of an engine or something else would make these vehicles safer to pedestrians?

(9) What type of sound do you recommend be implemented? (e.g., whistle, hum, engine noise, chimes, etc.).

The first eight items requested yes or no answers. The ninth item was open-ended and asked participants for suggestions/recommendations for the type of sound that could be added to a quiet electric vehicle.

RESULTS

Tabulation of the data showed that most people (84%) responded that they would consider purchasing a hybrid (part electric/part gasoline) vehicle. A smaller percentage of respondents (72%) expressed interest in purchasing a vehicle powered only by electricity. A similar percentage of participants (70%) believed that the lack of noise of an electric car would be a potential danger for pedestrians. A substantial number (86%) responded that sound emitted from a moving vehicle made them more aware of its location and direction. In addition, most participants (73%) said that when crossing a street they have used the sound of a vehicle as a cue to judge if a vehicle is approaching. Approximately half (48%) responded that as a pedestrian, a silent vehicle would bother them. Conversely only 30% thought that as a driver, a silent vehicle would bother them. Finally, 68% thought that including some type of engine sound would make electric vehicles safer for pedestrians.

The last question asked participants for suggestions/recommendations for the type of sound that could be added to an electric vehicle, the results of which are listed in Table 1. Approximately 20% did not respond but among the nearly 80% that did, participants preferred a traditional engine sound and a hum sound most often (38.25% each). 11% preferred no sound and the others mentioned

responses varying from music to horn sounds to beeps and whistles.

Table 1. Frequency of responses to question 9 (N=285).

Sound	Frequency (f)
Engine	109
Hum	109
None	31
Music	14
Whistle	8
Beeps	5
Horn	5
Clicking	2
Exhaust	2

DISCUSSION

Instigated by technology and air quality regulations, electric vehicles may become commonplace on the roadways. However, the introduction of electric vehicles raises a safety concern about the motor's inherently quiet operation that might be dangerous for pedestrians, drivers and others (e.g., bicyclists). The results of this initial survey indicate that while people would consider purchasing a hybrid or electric vehicle, about half are concerned about the safety of pedestrians who may use sound cues when crossing a street. There was less concern about drivers operating with reduced sound cues. However, some may not be aware that sound is a correlate of speed and that without it, speed may be judged inaccurately. Nelson and Nilsson (1990) showed that performance on complex driving tasks such as shifting gears deteriorates when auditory cues are blocked out.

Therefore some auditory feedback may be important for pedestrians and drivers. A sound closely related to the vehicle's acceleration and deceleration is probably a useful cue to aid drivers and pedestrians in predicting the functional state of a vehicle. Research on what kinds of sounds could be incorporated into a quiet vehicle has heretofore been limited. Egawa (1988) concluded that a continuous sound is preferred for an automated traveling guided vehicle rather than a tone that sounds in intervals. Participants in the present study suggested types of sounds to add to quiet vehicles to maximize safety. In addition to consideration of sound, it will probably be important to limit the levels of sounds from reaching distracting or intolerable levels as they may be turned off or disabled. Selective active noise suppression could be used to dampen and prevent unwanted sound from entering the vehicle, while still being able to transmit useful auditory cues to maximize driver awareness. For example, this technology should not filter out sounds like ambulance sirens or car horns that could be crucial to driver performance (Heatwole and Bernhard, 1995). Defining those sounds crucial to a driver's performance and behavior will require additional research. As there are many sounds that may affect a driver's evaluation of vehicle state, testing involving presenting sounds individually or in combination with others is recommended. Similar methodology has worked well in the past (Ruspa, 1995).

REFERENCES

Egawa, Y. (1988). A study of auditory warning alarms evaluation for automated guided vehicles. *Ergonomics of Hybrid Automated Systems I*, 529-536.

Evans, L. (1970). Speed estimation from a moving automobile. *Ergonomics*, *13*, 219-230.

Heatwole, C.M., & Bernhard, R.J. (1995). Reference transducer selection for active control of structure-borne road noise in automobile interiors. *Noise Control Engineering Journal, 44*, 35-43.

Meotti, M.P. (1995). Clean fuel vehicles: The air pollution solution. *Journal of Environmental Health*, *58*, 27.

Nelson, T.M., & Nilsson, T.H. (1990). Comparing headphone and speaker effects on simulated driving. *Accident Analysis and Prevention*, *22*, 523-529.

Robbins, M.C. (1995). The effectiveness of emergency vehicle audio warning systems. *Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting*, 1004-1005.

Ruspa, G., Fiorito, A., & Irato, G. (1995). New perspective in the study of noise quality in vehicles. *3rd International Conference, Vehicle Comfort and Ergonomics*, 23-32.