Electrical Hazards in the Home: What Do People Know?

S. David Leonard
Department of Psychology
University of Georgia
Athens, GA 30602-3013

Rebecca S. Griffin
Department of Psychology
North Carolina State University
Raleigh, NC 27695-7801

Michael S. Wogalter
Department of Psychology
North Carolina State University
Raleigh, NC 27695-7801

ABSTRACT

Consumers' knowledge about electrical facts and hazards in the home was examined to determine whether their understanding of certain aspects of electricity are complete and accurate. Eighty-two college students (who are better educated that most of the population) were surveyed. Results indicated the presence of erroneous assumptions and gaps of knowledge about electricity. These gaps and false beliefs could lead to unsafe behavior. Results have implications for the design of electrical products, education and training, consumer awareness programs, and warnings.

INTRODUCTION

In modern societies electricity is omnipresent. People use it directly and indirectly for a variety of purposes. While electricity has many benefits, there are also hazards, and every year thousands of people in the United States are injured or killed by mishaps involving electricity. Although some of the accidents might be impossible to prevent because they involve truly random and unforeseeable events (e.g., a tree falling across a power line), others could be prevented if the individuals involved knew more about the nature of electricity and some of the specific hazards associated with it. That is, if their mental models or schemas about the properties and characteristics of electricity were relatively complete and accurate, some accidents might not happen. Indeed two of the authors have observed as expert witnesses in various litigation cases the injured plaintiffs saying they did not know about the hazard. The hazardous properties of electricity are not readily apparent, and clearly, first-hand experience is not desirable. The properties and hazards of electricity must be learned from schooling and other means.

Unfortunately, most people have not taken courses in electricity or physics that would prepare them to understand the operation of electrical products. However, most people have some general, often rudimentary, information about electricity. From various sources, they know they could get shocked; they have learned not to handle live wires; and they have some idea that water and electricity together are dangerous. However, people may not know other basic and important information about the properties and hazards associated with electricity, and this lack of knowledge or incorrect assumptions could lead to unsafe behavior.

Vaubel, Donner, Parker, Laux, and Laughery (1989) reported that most people are not knowledgeable about some of the electrical aspects outside the home. For example, they do not know that overhead power lines are not insulated (they appear black because of oxidation); nor do they understand the concept of "ground." They do not know that high voltage can jump a substantial gap to complete a circuit (that is, the conductors do not need to be touching). Moreover, an extensive media campaign by an electric company in Houston, Texas had little effect on people's knowledge about the characteristics of power lines (Vaubel et al., 1989). A possible basis for the failure to attend to such campaigns is the fact that previous benign experiences have immunized individuals to concerns about the risks involved (cf. Leonard & Hill, 1989). The multitude of everyday experiences with electricity that occur without harm make individuals accept its use without scrutinizing the hazards.

The purpose of this study was to examine consumers' knowledge about electrical products and hazards. It focuses on household electrical hazards whose existence may not be recognized. Some of the topics examined were based on known electrocution accidents, some on foreseeable errors that people might make, and some were of a general nature. It was hypothesized that people would know some of the highly publicized hazards associated with electricity, but they might not know others.

METHOD

Participants

A total of 82 undergraduates from North Carolina State University and Metropolitan State College of Denver participated in the study. Thirty six were male and 46 were female. Their ages ranged from 18 to 55 (M = 21.3, SD = 6.28). Ninety three percent were full-time students with an average of 13.6 years (SD = 1.5) of education.

Table 1. ***Survey Questions and Participants' Selection Percentages and Standard Deviations for the Answer Alternatives.***

%	SD		
(3) Plugging several appliances into a single extension cord may produce what ill effect(s)?			
91.5	(3.1)	a.	More current carried may blow a fuse.
89.0	(3.5)	b.	Heat generated by the current could cause a fire.
30.5	(5.1)	c.	Appliances will be destroyed by excess current.
11.0	(3.5)	d.	Insulation could give off toxic fumes.
(2) Electrical wire, such as that used in extension cords is made in different thicknesses. This is done because:			
25.6	(4.8)	a.	Some wires need to be more flexible than others.
43.9	(5.5)	b.	The larger the wire the greater the stress it can take.
57.3	(5.5)	c.	A thicker wire provides less resistance to the flow of current.
39.0	(5.4)	d.	Less insulation is needed for thinner wires.
(3) Aside from cost factors, the primary advantage of a shorter extension cord is that it:			
37.8	(5.4)	a.	Provides less resistance, therefore produces less heat.
32.9	(5.2)	b.	Can carry current faster starting the appliance quicker.
43.9	(5.5)	c.	Is less likely to develop a short circuit.
53.7	(5.5)	d.	Does not cause a tripping hazard.
(4) A ground fault circuit interrupter (GFCI) is used to:			
65.9	(5.2)	a.	Keep fuses from blowing if a power surge occurs
68.3	(5.1)	b.	Cut off the electricity if a dangerous power level occurs
26.8	(4.9)	c.	Maintain the current flow when a circuit breaker has tripped
45.1	(5.5)	d.	Interrupt the circuit if lightning strikes nearby
(5) How often is a test of a GFCI recommended?*			
3.7	(2.1)	a.	Once a week
32.9	(5.2)	b.	Once a month
25.6	(4.8)	c.	Twice a year
37.8	(5.4)	d.	Once a year
(6) Under what circumstances is it dangerous for an electrical appliance to fall into water?			
98.8	(1.2)	a.	When the power switch on the product is on.
64.6	(5.3)	b.	When the power switch on the product is off.
90.2	(3.3)	c.	When the power cord is frayed.
56.1	(5.5)	d.	It may be turned on again before it is fully dried.
(7) Which of the following substances conduct electricity?			
89.0	(3.5)	a.	Copper kettle
62.2	(5.4)	b.	Gold bracelet
79.3	(4.5)	c.	Aluminum wheel
18.3	(4.3)	d.	Wood tree limb

Note. Selection percentages(%) and standard deviations (SD) are shown to the left of each alternative answer.
*Only one alternative could be selected for item 5.

Materials and Procedure

Table 1 shows the seven questions and alternative answers. These items were embedded in a 23-item questionnaire assessing knowledge of various hazards around the home (e.g., ignition sources, poisonous gases). This article focuses only on the topics concerning electricity in the questionnaire. Space does not permit adequate discussion of the other categories of items.

The items were given in a multiple choice alternative format. However, for all but one question (number 5 concerning the test interval for a ground fault circuit interrupter), respondents were allowed to choose more than one alternative answer. This unconventional method of multiple choice selection was employed (a) because creating plausible alternatives is difficult, (b) because the percentages can be reported directly without the need for a correction for guessing, and (c) because it is less influenced by its immediate family of answer alternatives. All questions had four alternative answers with some items having 2, 3 or 4 applicable (acceptable) answers. Participants had as much time as they needed to complete the questionnaire.

RESULTS

The percentages of selection (and standard deviations) for each of the items are given in Table 1. The topics are divided into the categories of knowledge about (a) extension cords, (b) ground fault circuit interrupters (GFCI), and (c) water and other conductors. For the 6 questions that allowed selection of more than one alternative, the average number of alternatives selected ranged from 1.6 to 3.1 responses. Because almost all respondents selected more than one alternative on one or more of the questions, it would be inappropriate to use a standard correction for guessing. Given the sample size of 82, a 95% confidence interval for each item would be closely approximated by adding and subtracting twice the standard deviation to and from the percentage.

Extension cords

The first question concerned the effect of plugging several appliances into a single extension cord. Most respondents (89.0%) chose the primary correct response that doing so produces heat and could cause a fire (alternative b). Respondents also frequently (91.5%) chose that it might blow a fuse (alternative a). Nearly a third (30.5%) incorrectly indicated that it would destroy appliances from excess current (alternative c). Finally, 11% selected the alternative (d) that said insulation could give off toxic fumes, which might be true, but the amount of toxic fumes from the cord's insulation is probably minimal compared to fire burning other things.

The second question asked why extension cords are made in different thicknesses. Only 57.5% selected the primary correct response that thicker wire has less resistance to the flow of current (alternative c). Selection of the other three alternatives ranged from about 26.6 % to 43.9%. All of them are also true (or can be under certain circumstances), but are less important in terms of safety.

The third question asked about the primary advantage of a shorter extension cord. Approximately half of the respondents (53.7%) said that it serves to reduce a tripping hazard (alternative d). Two other alternatives, one that it produces less resistance and less heat (alternative a), and the other that it is less likely to develop a short circuit (alternative c), were chosen by 37.8% and 43.9% of the respondents, respectively. Almost a third of the respondents (32.9%) incorrectly stated that a shorter extension cord can carry current faster starting the appliance quicker (alternative b). Although, there is probably a difference in terms of nanoseconds, it is not a practical reason for purchasing a shorter over a longer extension cord.

Ground Fault Circuit Interrupter (GFCI)

The purpose of a ground fault circuit interrupter (GFCI) is to cut off electricity if a dangerous power level occurs. This item (alternative b) was correctly recognized by about two-thirds of the respondents (68.3%). However, the large number of selections to the other alternatives suggests that participants might be guessing. Roughly a quarter of the participants (26.6%) incorrectly responded that it maintains the current flow when a circuit breaker has tripped. The second GFCI question asked about the recommended interval for testing the device. Only about one in three persons (32.9%) correctly identified once per month (alternative b).

Water and Other Conductors

Electrical appliances falling into water is a very serious hazard. Fortunately, most people seem to be aware of this, as 98.8% of the respondents identified the danger when the product was turned on (alternative a). Unfortunately, only 64.6% realized that the hazard also existed when the power switch is off (alternative b), and an even smaller percentage (56.1%) recognized the danger of using an appliance that had water in it (alternative d). The vast majority of the respondents (90.2%) also selected the alternative (c) that it is dangerous when the power cord is frayed, which while true, it is also a problem when there is no water.

The last question concerned substances that conduct electricity. Failure to realize that different metals conduct electricity was a most surprising finding. Only 89.0% recognized copper as a conductor, yet it is the most commonly-used material in household wiring. A smaller percentage (62.2%) recognized the conductance of gold—one of the most highly conductive materials. Four out of 5 respondents (79.3%) recognized aluminum as a conductor. Very few individuals chose the wood tree limb. Wood is a poor conductor, but in certain circumstances it can be a good conductor, such as when wet or when green and full of sap.

For a few items, males displayed greater knowledge than females (alternatives 3a, 3b, and 5d). More women (39.1%)

than men (11.1%) incorrectly stated that a GFCI maintains the current flow when a circuit breaker has tripped, $\chi 2$ (1, N = 82) = 8.08, $p < .01$. More men (50.0%) than women (28.3%) said that a shorter extension cord is that it provides less resistance, producing less heat, $\chi 2$ (1, N = 82) = 4.06, $p < .05$. More women (39.1%) than men (39.1%) said that a shorter extension cord is that it can carry current faster starting the appliance quicker, $\chi 2$ (1, N = 82) = 17.58, $p < .0001$.

DISCUSSION

The present study examined several points of consumer knowledge concerning a few of the properties and hazards of electricity. Most participants had some knowledge about electrical hazards, recognizing that water and electrically-active appliances do not mix. However there were other details that they missed, for example, that it is equally as hazardous to immerse a plugged-in appliance in water whether its switch is turned on *or* off. Thus, most participants had some knowledge about electrical hazards, but they were not able to recognize them in all of their forms.

Even for some of the better known hazards, the percentage of incorrect responses is unacceptably high. Although some percentages appear low, it still translates to a large number of people. When one considers that 11% of the sample did not know that plugging several appliances into a single extension cord could cause a fire, and that there is a population of about 250 million inhabitants of the US. This small percentage represents over 27 million people who are not aware of this fact and who may be at risk (and risk the safety of even more people). Some of the other results also suggest concern regarding the number of people who might be at risk due to their lack of knowledge or erroneous assumptions about electricity.

The results indicated that participants have limited knowledge about GFCIs. Clearly, this is not acceptable for a device that has such importance in protecting against accidents. A major problem is the conjunction of the lack of knowledge about GFCI's (question 4) and of switched-off but plugged in electrical appliances falling in water (alternative 6b). A nonworking GFCI substantially increases the likelihood of injury from an appliance falling into the water. In fact, although one might test the GFCI on a monthly basis as is recommended on the device (which would require an incredibly compulsive person with a fantastic memory), there could be many days during which its failure would go undetected. A human factors analysis suggests all GFCI's designs should provide a positive means of identifying the failed state, such as a blinking light

Several additional comments are worth mentioning. The participants were not a random sample of the population. The undergraduate respondents in this study are better educated and probably more intelligent than the population at large. Given that these individuals are more likely to have been exposed to science courses in which the topic of electricity was broached, the percentages of the correct responses are probably overestimates. Thus, the hypothesis that a substantial number of the public at large lack basic knowledge about electricity and its associated hazards is supported.

In product liability litigation, it is frequently admitted by the plaintiff that he or she did not know about the hazard. The manufacturer, on the other hand, frequently knows about the hazard. When asked why there was an adequate warning, the industry representatives sometimes claim that they thought the information was obvious. As domain experts, electrical-appliance manufacturers and power companies may erroneously assume that the general public has a good, reasonably extensive working knowledge of electrical concepts. Our results indicate otherwise. Experts frequently do not appreciate that the public does not know what they know. This is the main reason why data should be collected about lay people's knowledge and assumptions. This will benefit the company in terms of decreased liability and benefit their consumers who would be less likely to be injured. By having information on what users know, products including the documentation, could be designed with the user in mind, making them more satisfied, productive, and safe.

There were a few answers which suggested that males were more knowledgeable about electricity than females. However, given that this occurred with a small number of items relative to the total number of assessed alternatives (3 out of 25 or 12%), it is not appropriate to suggest that males might have less need for instructions or warnings. The difference in knowledge might be due to more males taking science courses and being more interested in technology than females, a gap that has been narrowing in recent years.

A key aspect of human factors systems is that it is necessary to know how humans behave in order to develop appropriate designs, procedures, and training techniques. Because electricity is something most of us encounter in our daily lives, this study suggests the need for procedures to educate the public about electrical hazards and the ways to abate them. It is not acceptable simply to assume that the public understands potential dangers or will actively seek out answers to questions or doubts they might have. The findings of this survey suggest that consumers could benefit from implementation of safety programs, such as public service announcements and safety training in schools, to inform the public about safe practices with electricity.

REFERENCES

Leonard, S. D., & Hill, G. W., IV (1989). Risk perception is affected by experience. In *Proceedings of the Human Factors Society 33rd Annual Meeting*. Santa Monica, CA: Human Factors Society, 1029-1033.

Vaubel, K. P., Donner, K. A., Parker, S. L., Laux, L. F., & Laughery, K. R. (1989). Public knowledge and understanding of overhead electrical power lines: A second look. In *Proceedings of the Human Factors Society 33rd Annual Meeting*. Santa Monica, CA: Human Factors Society, 560-564.