Forensics Cases Highlight Human Variability in Product Use

Brian Peacock

Ergonomics in Design: The Quarterly of Human Factors Applications 2012 20: 19
DOI: 10.1177/1064804612445007

Forensics Cases Highlight Human Variability in Product Use

Forensics cases and their conclusions are rarely straightforward and are always clouded by human variability.

By Brian Peacock

FEATURE AT A GLANCE:
In this article, I present six forensics human factors/ergonomics cases that are typical of many situations in which the defendant had no intent to harm the plaintiff and the plaintiff made a (perhaps foreseeable) mistake. Human factors/ergonomics arguments on both sides delved into the latent hazards associated with the product or system design and operation. In some of the cases, the design decision was made for a reasonable purpose, but the safety trade-off was either not considered or simply ignored. In other cases, the "victim" did not behave as intended but did behave in a foreseeable way.

KEYWORDS:
design, operations, design trade-offs, latent failures, forensics, court decisions

The adversarial court system is, by nature, concerned with probable cause so it can assign blame, costs, and penalties. But for many years, human factors/ergonomics (HF/E) professionals have recognized that there is rarely a single cause (Hale & Heijer, 2006; Holnagel, Woods, & Leveson, 2006; Reason, 1990; Weigman & Shappell, 2003). The unsafe act is the culmination of many contributory factors and various human performance "laws." Human, situational, and temporal variability should always be considered in both accident investigation and design.

During litigation, the plaintiff's representative will usually address the technological issues that were the responsibility of the manufacturer, followed by the operational issues that also may have been the province of some third party. The defense argument will emphasize the unusual contextual or environmental factors and attempt to discredit the competence of the unfortunate victim.

The plaintiff's representative will counter with HF/E dogma about design for intended use (users) and foreseeable misuse (misusers) and will add that products should be resilient in their capability to withstand the effects of unusual contexts and foreseeable operational demands.

The defense expert will point out the difficulty of anticipating and designing safeguards for all possible extreme users, usages, and contexts.

The six cases described in this article have elements of technological, human, contextual, and operational variability and their inevitable interactions. The outcomes of these cases were not always as expected.

THE SIX CASES

Case 1. A young woman of average height but above-average weight for an adult female entered a store to buy cosmetics. The intended purchase was out of her reach, high on the rear wall of the unit, so she stood on the bottom shelf, which immediately collapsed, bringing the whole unit on top of her and breaking her leg.

Measurements indicated that the item was beyond the reach of more than half the adult female population. The only shelf was about 12 inches high and 15 inches deep, and the products were hung on hooks connected to the rear wall of the unit. The shelf had a continuous metal edge, which looked like a step. There was no warning regarding the lack of the shelf's structural integrity, although the assembly manual cautioned people setting up the units not to step on the shelf.

The defense expert told the court that the customer behaved in an unusual and unpredictable manner. The plaintiff's expert argued the importance of the consideration of "foreseeable misuse" in structural design and, failing that, the need for a strong indication that "the shelf was not designed to bear the weight of a person" by the incorporation of a small guard or prominent warnings, which are commonly seen in other, similar stores.

Case 2. In another retail store accident, an older female customer fell down some steps and broke her wrist. The checkout desk in this clothing store was on a platform about 3 feet above the floor level so the attendant could monitor customers' behavior. The area in front of the checkout desk was about

15 feet wide and 4 feet deep, and there were five steps down to the floor level. There was a handrail at one end of the platform.

On the day in question, the platform was very crowded, and the lady turned, placed her foot over the edge of the top step, and fell. The plaintiff's attorney argued that this type of customer was typical in this store and had no alternative other than climbing the steps to purchase an item.

Case 3. A middle-aged man walked into a fitness center, and the attendant pointed him toward the weight-training machines. The customer selected the 4 Way Neck Machine and broke it – his neck, not the machine! These machines are often used by football players, and some have selectable stops to limit the range of motion, although it is not easy to describe the range(s) of motion of the complex, multijoint cervical spine. The mass of the weight to be moved was greater than the mass of the user's head, and it was possible to move the head more quickly than the machine, which would "catch up" with a forceful blow.

The key to the design of both products and operations is to anticipate and accommodate variability.

Apart from the fundamental design flaw in the machine, there were issues of failure to instruct and the absence of warnings. The clinical evidence clearly indicated the association between the activity and the injury.

Case 4. A farmer drove his pickup truck into a country garage. He asked for a new tire and said that he would replace the old one when he got back to the farm; he was accustomed to changing tires. After a lot of soap and about 80 psi, the tire exploded and broke his arm. He had been trying to put a 15-inch tire on a 15-and-a-half-inch rim. There were three defendants in this case: the vehicle manufacturer, the tire manufacturer, and the garage owner.

Case 5. An elderly couple was driving home late at night. The wife reclined the passenger seat to take a nap while still wearing her seat belt. The husband also nodded off and drove into the back of an unlit parked truck. The wife "submarined" and became a quadriplegic following severe damage to her neck.

The plaintiff's attorney argued strongly that there should be an interlock to prevent reclining the seat while driving and at least a conspicuous warning to inform the passenger of this dangerous situation. The defense expert pointed out that there was a warning in the owner's manual, that it was practically impossible to warn against all operational failure modes in the front seat of a car, and that "it was clear and obvious" that the seat belt would not work with the seat in the reclined position.

Case 6. A 16-year-old girl lived on a farm where her brothers had created a course around which to ride their three-wheeled all-terrain vehicle (ATV). The girl went for a ride and attempted to copy her brothers by driving over a large hump of dirt. She leaned backward and the vehicle flipped and crushed her face. The plaintiff's expert presented evidence regarding the dynamic and operational instability of these vehicles and added arguments about the absence of warnings and recommended training regarding this foreseeable failure mode.

THEIR DAY IN COURT

These six cases indicate that the plaintiff was "unusual" in some way – young, old, inexperienced, untrained, tired – or behaved in an "unusual" manner – hurried, inattentive, distracted, careless, not cautious, and so on. All these variable characteristics and behaviors are typical in a human population, and the degree of departure from "average" probably contributed to the accidents to some extent. The key to HF/E analysis is to recognize this variability; the key to the design of both products and operations is to anticipate and accommodate this variability.

Situation awareness (SA; Endsley, 1995), a factor in all six cases, is constrained by the amount of relevant (and irrelevant) information available, the time available, the experience of the individual, the level of stress at the time of the incident, and various other motivators associated with the action. For example, self-imposed or externally imposed time constraints will affect the use of information from operational memory and its application to the perceptual and decision processes.

In the following six cases, the plaintiff was somewhat hurried, and the failure mode was not central to the task objective. In all the cases, it is clear that the plaintiff did not consider the failure possibility.

Case 1. The young lady who stepped on the shelf to reach a cosmetic product was seriously injured. Though above average in weight, she was representative with regard to height and therefore representative of the intended cosmetics-buying population. The item of interest was beyond her reach, as demonstrated by the application of anthropometric evidence. There was no warning that the shelf was unsafe and no guard to discourage its use as a step.

Did the shelf contravene the "foreseeable misuse" rule? Should the shelf have been constructed to accommodate the weight of a customer, and if so, what should have been the load limit in this case? This problem has been addressed in many large retail chains by the placement of guards on the front edge of the bottom shelf and a warning to customers to seek help to access items out of their reach. In this case, the argument that the plaintiff was truly representative of the intended user population and exhibited foreseeable (mis)behavior carried the day.

Case 2. The elderly woman who fell down the steps was only slightly injured. She, too, was representative of the intended user population: The garments in this shop were intended to be bought by women of all ages. The raised platform was

a reasonable security intervention, but there are regulations about accessible handrails. In this case, the handrails were at either end of a 15-foot platform and not accessible in the crowded conditions. Should this operational factor have been considered? Given the notorious perceptual contributions to falls on stairs, should there have been clearer edge markings?

A likely contributory factor to this accident was the age of the customer and the cognitive, operational memory, and SA decrements that occur with advanced age. Should the designer and operator of the store have recognized this variability of the expected customers? Perhaps this accident also could have happened to a younger person because of distraction or forgetting.

In another twist in this case, the plaintiff's attorney sought an exorbitant sum because he thought he had a winning case and expert. Although this issue may be beyond the scope of the HF/E specialist, it probably had a significant bearing on the decision of the court in favor of the defendant.

Case 3. The fitness center customer fractured two cervical vertebrae on the neck machine; the circumstances of the accident and the X-ray evidence clearly showed this to be the case. But the defense expert testified that the damage could not have happened in this way to normal tissue.

This type of machine is widely used by football players but did not have range-of-motion stops, so there are certainly operational skills to be taught before using it. Why would an inexperienced person who had just walked into the fitness center for the first time not be trained or cautioned about the dangers of weight-training equipment? How does the perception of risk (the range of motion and forces associated with the equipment) apply to this situation? Why did the organization's managers not train and monitor the behaviors of their employees? Could the likelihood of an accident have been reduced by strategic placement of instructions and warnings? The court found in favor of the equipment manufacturer.

Case 4. This wheel–tire size mismatch issue has arisen on numerous occasions. Should the garage owner have been more careful in matching the wheel and tire? Should old farmers be expected to be aware of the two different wheel sizes?

The level of specific experience of the plaintiff was considered when he bought the wheel. The cause of this event may well have been the failure to perceive the difference in size between two objects that were presented at different times in distracting conditions. Is it possible to add readable labels and warnings of every failure mode on a wheel or tire? Should the farmer have stopped adding air (another perception issue) well before the tire exploded, or was he too intent on the task at hand to take notice of the unusual difficulty? What is the responsibility of the wheel and tire manufacturers in guarding against this predictable failure mode?

In this case, the wheel and tire manufacturers were exonerated of blame. The garage owner, on the other hand, refused a preverdict settlement. When found guilty, he had to pay a substantial fine, which resulted in bankruptcy.

Case 5. The "failure to warn" argument in the case of the reclined seat raises interesting issues about the effectiveness of warnings and the counterproductive issues caused by a proliferation of warnings. It is not feasible or acceptable to plaster a car with warnings against every possible failure mode, so car companies select only those prevalent and serious failure modes to receive warnings; the rest go into the owner's manual.

Human errors occur all the time, but for the most part, people recover and learn from these errors.

Should the designers have addressed the problem with a recliner interlock and radar braking? Should the passenger have recognized the biomechanical problem resulting from reclining the seat? (Many people, including engineers, canvassed after this case did not appreciate the hazard.) Given that the effectiveness of the seat belt is related to the amount of recline, at what stage of recline would the passenger recognize the problem? This is another perceptual problem. The case was settled out of court.

Case 6. The young girl whose face was badly injured when the ATV flipped over wanted to copy her two older brothers. She had seen them ride around the yard and over the hump many times. But because of her lack of training, she did not recognize the problem that resulted when her center of gravity moved backward over the rear axles as she went up the slope. Her level of SA in this time-constrained activity was probably affected by her ability to access all relevant information for the task at hand.

Most three-wheeled ATVs have been replaced by more stable four-wheeled vehicles, but even those are notorious for rolling when driven over rough terrain. What does "all-terrain" mean? Should the 16-year-old or her brothers have perceived the risk? Should the manufacturer have provided formal training? Should the vehicle have carried a warning about this failure mode? This case, too, was settled out of court.

PROBABLE CAUSE AND VARIABILITY: OUR RAISON D'ÊTRE AND OUR ACHILLES' HEEL

Is the probable cause the same as the "root cause" – the first falling domino – or is it a failure in one element of the set of complex prevention or mitigation defenses? What about "latent" hazards? Human errors occur all the time, but for the most part, people recover and learn from these errors. Thus, it is the challenge of the HF/E forensics specialist to describe human error and then move on to identify where, in the complex sea of contributory factors, prevention or mitigation of unwanted outcomes should have been recognized and designed into the system to obviate the probable cause.

All accidents are complex and clouded in variability; this is the raison d'être and the Achilles' heel for those of us who are HF/E forensic professionals. On the other hand, the courts want clear and concise descriptions of probable cause and relevant contributory factors. But even experts are human and exhibit variability in experience, perception, operational memory, and SA. There is the strong potential for bias, given the adversarial context, which can lead to variable weighting of complex items of evidence.

We rarely deal with clear-cut cases; they are usually settled out of court. Given these operational challenges, we should always refer to our code of ethics and "not allow the adversarial system of jurisprudence to affect the quality or integrity of (our) practice"(HFES, 2009).

REFERENCES

Edwards, E. (1988). Introductory overview. In E. L. Weiner & D. C. Nagel (Eds.), *Human factors in aviation* (pp. 1–26). San Diego, CA: Elsevier.

Endsley, M. R. (1995). Towards a theory of situation awareness. *Human Factors*, *37*, 32–64.

Hale, A., & Heijer, T. (2006). Defining resilience. In E. Hollnagel, D. E. Woods, & N. Leveson (Eds.), *Resilience engineering* (pp. 35–40). Aldershot, UK: Ashgate.

Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.). (2006). *Resilience engineering*. Aldershot, UK: Ashgate.

Human Factors and Ergonomics Society. (2009). Code of ethics, Article V: Forensic practice. In *HFES 2008–2009 directory and yearbook* (p. 436). Santa Monica, CA: Human Factors and Ergonomics Society.

Peacock, B., & Laux, L. (2005). "Warning: Do not use while sleeping." The role of facilitators. *Ergonomics in Design*, *13*(4), 5–29.

Reason, J. (1990). *Human error*. Cambridge, UK: Cambridge University Press.

Weigmann, D. A., & Shappell, S. A. (2003). *Human error approach to aviation accident analysis*. Aldershot, UK: Ashgate.

Brian Peacock *is an adjunct professor at the National University of Singapore and SIM University, where he teaches ergonomics, safety, and industrial engineering. He previously held positions in academia in various countries, at General Motors, and at NASA. He has published on a wide variety of topics, including the books* Automotive Ergonomics, Statistical Distributions, *and* The Laws and Rules of Ergonomics in Design. *He is a certified professional ergonomist, licensed professional engineer, and licensed private pilot.*

DOI: 10.1177/1064804612445007