Human Factors Expertise in Safety Litigation

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Abstract

We present a formalized structure for a human factors expert witness to follow in presenting testimony in the course of civil litigation related to safety. Our goal is that every human factors specialist, relying on the same body of scientific knowledge, analyzing the same evidence, and following this organization of content, would reach the same conclusion. We suggest a seven step process, each based on the science of human factors. First, in the context of an accident/injury, what was the dangerous condition? Second, what could the plaintiff have done to remove the danger or reduce the severity of the accident? Third, what could the defendant have done to remove the danger or reduce the severity of the accident? Fourth, what did the plaintiff do and not do? Fifth, what did the defendant do and not do? Sixth, based on our analysis of the danger, potential ways it could have been avoided or mitigated, and the actual actions taken, what are our opinions as to the factors that caused the accident. Seventh, what are our opinions regarding any conflicting testimony, evidence, or argument from opposing counsel. This structure provides a clear, science-based, chain of reasoned logic from description of accident to the expert opinion proffered as to the contributing factors of the cause of the accident: a sequence helpful to judge and jury alike. To illustrate, we apply these seven steps to five actual cases.

Introduction

Neither the legal literature nor the human factors research literature has defined how human factors specialists can use their expertise to analyze and offer opinions about safety issues in litigation. Two excellent video tapes of recent mock trials (HFES, 1999) provide examples, but not a formalized structure. Our intent is to develop a set of procedures to follow in preparing an expert opinion such that every human factors specialist, relying on the same body of scientific knowledge and analyzing the same evidence, would reach the same conclusion.

In civil cases, when an accident occurs, the legal issue is to allocate responsibility for the accident, which is entirely the province of the trier of fact (jury or judge). Human factors experts use their scientific knowledge to define the cause of the accident by ascertaining whether, and in what ways, one or both parties could have prevented the accident. The trier of fact can then draw on this human factors analysis in reaching its decision as to responsibility.

Our paper has three sections. First, we describe and define the discipline of human factors. Second, we present the general structure and sequence of a human factors analysis as applied to the evidence available from accident cases. Third, we apply that structure in detail to five actual litigation cases. In each, we were retained to perform a human factors analysis in order to offer opinions regarding the cause of the accident, and whether either party could have acted so as to avoid the accident or injury.

Many lawyers (including frequently the ones who retain us) do not know much about the discipline of human factors, and have no clear idea what contribution we can make to the case at hand. The description and definition of the field is critical to establish the scientific basis on which we analyze the case in question to draw our conclusions.

What is Human Factors?

Human factors is dedicated to the task of shaping technology to benefit humankind. It is a scientific discipline that contains a body of knowledge about the capabilities and limitations of human beings, especially as those apply to human interaction with the natural and the constructed environment. Human factors has acquired this body of knowledge and continues to update it through scientific research and experimentation.

Equally importantly, the discipline of human factors applies this knowledge to the design and operation of equipment, work and public places, and living environments, for the purpose of allowing people to be safer, more productive, and happier. (Since the kinds of cases on which we are retained rarely involve being more productive or happier, we continue with respect to safety issues only.)

Concerning safety, the discipline of human factors provides techniques and evaluation procedures based on scientific knowledge and research that: (1) identify conditions that are dangerous and unsafe, with potential for injury; (2) identify procedures to remove dangers and reduce injury potential through design, construction, maintenance, instructions, training, warnings, regulations, and laws; and (3) identify the actions or lack thereof that the parties took that contributed to the accident or their injuries. The discipline includes a commitment to communicate this scientific knowledge generally, so that designers, manufacturers, providers, operators, enforcement agencies, and individuals can implement it to define and meet a standard of care to their workers, customers, users, and themselves, that creates a safer environment and prevents injuries.

The Structure of a Human Factors Analysis of Safety Issues

We follow a seven step process. The first concerns the context of the event in which an accident/injury occurred: (1) What was the dangerous condition? (If there wasn't one, there would be no litigation.) Dangerous conditions are likely to produce accidents, regardless of reasonable attentiveness or forewarning: slippery ground, obscured obstruction, inadequate lighting, unexpected change in support, sharp edges, and the like. Our first task is to identify those conditions, based on the body of knowledge of human factors. The next two steps

concern potential actions of the parties. (2) What could the plaintiff have done to remove the danger or reduce the severity of the accident? (3) What could the defendant have done to remove the danger or reduce the severity of the accident? The next two steps concern actual behavior. (4) What was and was not actually done by the plaintiff? (5) What was and was not actually done by the defendant? The final two steps concern our expert opinions. From the analysis of the danger, the potential ways in which the danger could have been mitigated, and the actual actions taken: (6) we offer our expert opinions as to the causation of the accident in terms of what contribution each of the parties made. A proper analysis anchors the basis for each opinion in the science of human factors. (7) When conflicting or inconclusive testimony or evidence has been presented, or when opposing council argues for a different causation, we offer our opinion as to the best resolution, based on a human factors analysis of the data available. It is critical that the human factors expert acknowledge and address each of these uncertainties. If we don't, the opposing council certainly will!

We now consider five cases in detail. For each we describe the circumstances of the case, the steps of the analysis we performed, and the opinions we offered.

Case 1: Slip and Fall on an Icy Walkway

Case Summary. The weather was threatening but dry, and just above freezing when a man (the plaintiff) arrived at a bowling alley one late afternoon in winter. Three hours later, he went out the same door accompanied by a friend, not to leave, but to look at the weather conditions: his friend had told him that it was very foggy and beautifully eerie outside. When they stepped out, it was raining, the temperature was below freezing, and visibility was no more than 100 feet. The doorway opened onto a ten foot long, four foot wide concrete covered walkway with building walls on either side. The roof stopped a foot short of two concrete steps that descended to the parking lot. Water was dripping down on the last foot or so of the walkway from the roof, and the currently falling rain was also wetting the last few feet of the walkway. The walkway and the two steps down to the parking lot were illuminated by lights on the underside of the roof. The plaintiff walked through the door, down the walkway, intending to stop at the end, and not go down the steps. However, just as he reached the end, his feet went out from under him, and he fell to the side, seriously injuring his face and head. His friend witnessed the accident. The plaintiff sued the owner of the bowling alley, alleging that the owner had failed to remove the icy conditions on the walkway/steps, thereby causing the accident.

We were retained by the plaintiff. The evidence available to us included our visual inspection of the scene, and six depositions: from the plaintiff, the friend who saw the plaintiff fall, another customer who exited the building within minutes of the accident, the owner of the building (who was not on the premises on the day of the accident), the night manager on duty the night of the accident, and the maintenance man responsible for checking the walkways that night. All depositions were obtained about one year after the accident.

1. What was the dangerous condition? The plaintiff, the friend, the customer, the manager, and the maintenance man each testified there was ice present on the walkway at the time of the accident. Further, the plaintiff, friend and customer each testified that they could neither see nor feel any de-icing substance underfoot. Human factors research has demonstrated that ice on walkways, in the absence of a de-icing procedure, reduces tractive friction, thereby increasing the chances of a slip and fall. Thus, a dangerous condition existed.

2. What could the plaintiff have done to avoid the accident? He could have used extra caution after he noticed the rain and felt the freezing temperature.

3. What could the defendant have done to avoid the accident? Human factors research has identified a number of ways to reduce slip and fall dangers under icy conditions, many of which are incorporated into building codes and legal standards. The owner could have made structural changes since icing occurs around his building every winter: he could have installed handrails along the sides of the walkway to provide extra stability in slippery conditions; he could

have extended the roof so that wind-blown rain could not fall on the walkway; he could have provided a gutter along the edge of the roof to prevent water from dripping on the end of the walkway and steps; he could have used a non-slip grid surface on the walkway, so that even in slippery conditions, the surface continued to provide sufficient traction; and he could have installed improved lighting so that pedestrians could have a better chance to distinguish between a wet and an icy coating on the walkway. Further, in response to the danger that particular night, he could have instructed his staff to close the exit and required customers to use a safer one; he could have posted a warning at the exit to alert his customers to be extra careful in the icy conditions; he could have placed de-icing compound on the walkway as soon as it was clear that ice was going to form; and he could have set up standard procedures to insure that his instructions were followed.

4. What did the plaintiff actually do? Based on his testimony and that of the witness, the plaintiff used normal caution.

5. What did the defendant actually do? Based on our inspection, the defendant had not installed any of the structural changes (i.e., railing, roof extension, gutter, pavement grid, or better lights) at the time of the accident. The plaintiff, friend, customer, night manager and maintenance man testified that the exit remained open and no warning sign was provided. The plaintiff and friend testified that while the walkway was lit, the lighting was not sufficient to see if the water was frozen, freezing, or just wet. The plaintiff, friend, and customer testified that no de-icing compound was present on the walkway at the time of the accident. The night manager testified that he did not ask anyone to apply de-icing compound. The maintenance man testified that he did apply de-icing compound that night, but after a year's lapse, he could not remember whether he did so before or after the accident. The night manager, the maintenance man, and the owner each testified that there were no written instructions regarding procedures to follow in icy conditions, and no procedures to monitor that instructions were followed.

6. Human factors causation analysis. All evidence, based on inspection and testimony, indicated that the defendant allowed a dangerous condition to exist and to continue, and failed to alert customers about it. Neither structural intervention on the one hand, nor temporary measures on the other that constitute a standard measure of care in public spaces where slippery conditions may occur were followed. Therefore, the owner's failure to prevent the dangerous condition, and failure to mitigate it when it occurred, caused the accident. Further, it was our opinion that the plaintiff did not expect to encounter dangerous footing, had no reason to expect to, and therefore no reason to use extra caution. Therefore, his behavior did not contribute to the cause of the accident.

7. Inconsistent Evidence. None was presented. Specifically, there was no evidence that the plaintiff had ingested any alcohol or drugs that evening, or that he was incautious in any way when he walked down the walkway.

Case 2: Pedestrian-Automobile Collision on a Rural Road

Case Summary. A wife (the plaintiff) and her husband were walking along the dirt shoulder of a rural residential road on a clear, dry night, each with a dog on a leash. There were no sidewalk, no curb, no street lights, and only minimal lighting from the widely spaced and well setback homes along the road. The road was straight with unobstructed visibility in both directions. The posted speed limit was 25 mph. Traffic was intermittent. Beyond the edge of the pavement a dirt shoulder ranged in width from four to ten feet. The dirt shoulder was deeply rutted with six to eight inch deep tire tracks that were entirely dry and caked. The couple was walking south facing oncoming traffic; the husband in front, with his dog leading him by a few feet; the wife behind him with her dog leading her by a few feet. They talked off and on as they walked and attended to the dogs. A car driven by the defendant approached the couple from the south, hit the plaintiff with the outside corner of the right front fender, and knocked her to the ground. She sustained substantial injuries. The defendant braked so hard that his rear wheels locked, leaving skid marks on the pavement. Other than the husband, there were no witnesses.

The plaintiff sued the defendant, alleging that he had failed to operate his car in a safe manner, thereby causing the accident.

We were retained by the defendant. The evidence available to us included our visual inspection of the scene, and five depositions: from the plaintiff, her husband, the defendant, the police officer who arrived at the scene about six minutes after the accident, and an accident reconstruction expert retained by the plaintiff. All depositions were obtained at least a year after the accident.

1. What was the dangerous condition? The absence of a curb and a sidewalk requires pedestrians and cars to occupy portions of roadway in close proximity. The paved portion belongs to cars, and pedestrians must exercise extra caution in using it, if they use it at all; beyond the edge of the shoulder belongs to pedestrians, and drivers must exercise extra caution in using it, if they use it at all. The immediate shoulder, extending a few feet from the edge of the pavement, is space shared by both cars and pedestrians. The sharing creates the potential for accident. In addition, the night time makes the shared space more dangerous for either pedestrians or cars to use. Human factors research has demonstrated that all of these factors make use of this shared space by either party dangerous. Further, with respect to the pedestrians, the uneven rutted dirt shoulder makes control of walking harder, and the presence of dogs and partner require attention away from safety.

2. What could the plaintiff have done to avoid the accident? Research has identified a number of potential actions by pedestrians that reduce the chances of an accident in circumstances like these. The pedestrian could walk facing traffic; she could avoid the dirt shoulder altogether; she could avoid this kind of roadway at night; she could wear reflective clothing; she could carry self-illuminating lighting; she could be attentive to all oncoming traffic; she could be extra attentive to oncoming traffic when she encountered the rough footing which itself required extra attention; and she could be extra attentive to oncoming traffic because her dog and husband's presence required extra attention. Each of these "coulds" is based on responses identified by human factors that would mitigate this kind of dangerous condition, and reduce or eliminate the chance of an accident and injury.

3. What could the defendant have done to avoid the accident? Based on research, the driver could use his headlights to illuminate the road and shoulder in front of him, and so pedestrians could see his approach; he could drive at a speed prudent for these conditions; he could stay on the paved roadway and avoid driving on the dirt shoulder; and he could use extra care in watching for pedestrians who might be on or near the paved roadway. Each of these "coulds" is based on responses identified by human factors that would mitigate this kind of dangerous condition, and reduce or eliminate the chance of an accident and injury.

3. What did the plaintiff actually do? Based on the evidence contained in the depositions of the plaintiff and her husband, the plaintiff did walk in the direction of traffic, which helped reduce the risk of an accident. However, based on these same depositions, plus our analysis of causation (see below), she performed none of the remaining actions that would have reduced the danger: she walked on the dirt shoulder (by her testimony), following a route either immediately along the edge of the pavement (by her testimony), or actually on the pavement itself (based on our analysis of causation though denied in her testimony); she did not wear reflective clothing or carry self-illuminating lighting (by her testimony and that of her husband); she struggled to maintain her pace and footing in the deep ruts rather than abandon the shoulder altogether (her testimony); and she was not attentive to oncoming traffic (she testified she was aware of a car approaching from a great distance off, but then did not pay any attention to the car thereafter, and did not even see it immediately before it hit her).

5. What did the defendant actually do? By the defendant's testimony, as well as that of both the plaintiff and the witness, the driver's headlights were on and operating normally. By the defendant's testimony, as well as the analysis of the skid marks made by us, by the police investigation, and the plaintiff's accident reconstruction expert, the defendant's speed was

between 25 and 30 mph. The defendant testified that his wheels did not cross over the edge of the pavement onto the shoulder; our analysis, as well as that of the police investigator, concurred, although the plaintiff's expert argued that the skid marks were consistent with the defendant's car being off the road in the vicinity of the accident. Finally, by the driver's testimony, he was not extra attentive to the possibility of pedestrians on this road, and he did not see either pedestrian at all prior to the collision with one of them.

6. Human Factors Causation Analysis. The critical determination was whether the collision occurred on the pavement or on the dirt shoulder. Seven different pieces of evidence suggest that all the wheels of the car were on the paved surface of the road prior to and at the instant of the collision. First, the police investigator reported, and the photographs taken right after the accident support, that there were no fresh tire marks in the ruts, no dirt track on the road, and no dirt on the tires of the car. Second, the 30 foot skid marks were on the pavement and angled slightly to the left away from the shoulder, with the left hand mark crossing over the center line of the pavement. Given the speed of the car, the trajectory of the skid marks, and the location of the woman's body after it was thrown, these marks are consistent with the car being in its proper lane at the time of the collision. Third, the driver testified that he did not hear or feel any vibration or pull on the steering wheel to suggest he was off the road. Fourth, the husband and the plaintiff testified that they did not hear any change in the sound of the car or its tires as it approached them. Fifth, the husband testified (and stated to the police at the scene) that he saw the car approaching from a distance, maintained awareness of it as it got closer, saw it pass him while on the pavement, and felt no danger for himself or his wife (who was behind him and closer to the road by his testimony and hers) as it passed. Sixth, given the separation of husband and wife of less than ten feet along the length of the road (by both their testimonies), the car would take less than ¼ second to travel from husband to wife at its estimated speed. If the car was on the road when passing the husband, and then had left the road by the time it reached the wife, then by our analysis, both the turning rate and the centrifical force would leave skid marks on the road toward the shoulder, and carry the car further onto the shoulder. There were no such skid marks and no evidence of tire tracks on the shoulder, so the car did not leave the road after it passed the husband but before it reached the wife. Seventh, physical evidence from damage to the car showed the impact occurred at the right front corner of the right fender (considered from the point of view of the car). The woman also contacted the right side view mirror, which was broken and bent back against the door. By our reconstruction analysis, and that of the plaintiff's reconstruction expert, the path of the woman's body would be forward and to the right of the car following this impact. However, while her body came to rest mainly on the shoulder, her legs and feet were on the pavement. Therefore, the collision had to have occurred to the left of where she came to rest (again, from the point of view of the car), that is, on the paved road itself.

7. Inconsistent evidence. The plaintiff testified she never feared the car would hit her, and that her feet never left the dirt shoulder. The defendant testified that he never saw the plaintiff, yet he was driving carefully. The plaintiff's expert testified that based on his analysis of the skid marks, the car could have been off the pavement, and yet the defendant testified that his wheels never left the pavement. A responsible scientific analysis must address these inconsistencies.

Why didn't the woman see that she was about to be hit? The woman testified that she was not attending to the car, did not track its approach after she first had noticed it some distance down the road, and did not see it about to hit her. How is this possible? We offer two human factors explanations. First, in the absence of nearby street lighting, or any other lighting, the approaching headlights are a strong glare source, and without any context or reference, a pedestrian on or near the pavement would be unable to estimate the exact trajectory of the car. Further, she testified that she was attending to her footing, and was probably looking down at her feet, not toward the road. This focused attention away from the roadway would interfere

with her tracking the approach of the car. Second, the woman testified she suffered a serious concussion from the collision. This is consistent with her testimony of having no memory of the moment immediately preceding the accident. It is possible that she was aware she was about to be hit, but lost that memory as a result of the concussion and now testifies that she was not aware of the car about to hit her at all.

Could the woman actually have been on the pavement and yet testify that she was still on the dirt shoulder? From her testimony regarding her attention to her footing through the deep ruts, it is possible that the ruts caused her to sway over the edge of the pavement, or actually step out onto the pavement at just the instant the car was upon her. Given the concussion and subsequent memory loss, she could have been on the pavement, or positioned over the pavement and not remember this fact at all.

Why didn't the driver see her before hitting her? Human factors research points to several factors. In the absence of reflective clothing and a flashlight, the two slowly walking pedestrians would be difficult to see, and could have easily been mistaken for bushes, rocks, or other stationary objects along the roadside. But what about just at the moment of impact, when by our analysis, the plaintiff must have been walking on or at the very edge of the pavement in plain view? Research evidence regarding the normal scan pattern used by attentive drivers shows that their eyes dart from side to side, and from near to far distance. These glances continually take focused vision away from the portion of the roadway directly in front of the car for a second or so at a time, followed by a return straight ahead look. This pattern could have meant that at the very instant when the pedestrian would have become visible to the driver, he was looking elsewhere. A second of his looking left, or way down the road, would have been sufficient for the woman to step into his path and be hit before he was aware she was there.

How can several reconstruction experts disagree about the location of the car at a particular point in time? The plaintiff's expert testified that in his opinion, the car could have been off the pavement prior to the collision, based on the location of the skid marks. However, the police investigator testified that the skid marks were consistent with the car being on the pavement. We reached the same conclusion, especially in light of the absence of testimony to the contrary by the husband and by the defendant, the absence of disturbance of the ruts, absence of dirt on the tires and pavement, and by the location of the body. The plaintiff's expert also testified that he had never read the depositions of the plaintiff, the husband, or the police investigator, and therefore was not aware that his conclusion was inconsistent with so much evidence. The skid marks in isolation from other evidence were consistent with several potential locations of the car at the point of impact, including on the dirt shoulder, on the edge of the pavement, down the center of the northbound lane, or even down the center line of the road. Taken in conjunction with the other available evidence, these alternative locations are reduced to only one: on the pavement.

Based on our human factors analysis, this collision occurred while the car was on the paved roadway, and not on the dirt shoulder. Therefore, prior to the collision, the woman must have leaned over the paved surface or have actually stepped onto it, in either case into the space reserved for the car. In our opinion, based on the evidence, the plaintiff's actions placed her in the dangerous situation. Further, no evidence suggests unsafe behavior by the defendant.

Case 3. Tenant's Death in an Apartment House Fire

Case Summary. A resident (the plaintiff) died in a fire in an apartment building. About 6 AM, a passerby noticed smoke, entered the building and pounded on each door, shouting in obviously drunken speech that the building was on fire. Several occupants on the first two floors left the building. Some did not. On the third (topmost) floor, he awakened the plaintiff's next door neighbor, who woke his girl friend, told her to get dressed fast, and escorted her and the drunken man (who was never seen again) downstairs. The neighbor told his girl friend to pull the fire alarm as she passed it on the second floor. The neighbor rushed back to the third floor to

alert everybody there to evacuate. The first door on which he pounded was the plaintiff's. The plaintiff responded (without opening the door) that he would come out quickly. The plaintiff then returned to the back bedroom where he told his roommate there was a fire. Both men got dressed. There was now a lot of smoke in the apartment, so the roommate got towels in the bathroom, wet them, and they each put the towels over their mouths. Because of low visibility, they walked single file through the apartment to the front door, the plaintiff first with his roommate's hand on his shoulder. When they reached the door; the plaintiff touched it for heat, opened it, and stepped into the corridor. The door immediately blew shut, and the roommate unsuccessfully struggled with it from the inside. By this time, flames were visible in the ceiling, so the roommate ran back through the bedroom, grabbed the sheets off the bed, and started to tie them together to exit from the balcony. At that moment, a fireman arrived and rescued him. The plaintiff's body was found in the corridor between his door and the stairwell. The plaintiff's estate sued the apartment house management, owners and designers for causing his death.

We were retained by the plaintiff. The evidence presented to us included all of the appropriate building and fire codes, and six depositions: from the roommate, the next door neighbor, the neighbor's girl friend, the on-site manager, the chief of management, and the service manager of the company that services the fire alarms. All of the depositions were obtained at least a year after the fire. All evidence regarding the behavior of the plaintiff came from the testimony of the plaintiff's roommate and his next door neighbor.

1. What was the dangerous condition? According to all testimony and physical evidence, a fire started in the building, which spread very rapidly and destroyed the building. According to the testimony of the on-site manager (based on what he read from the fire marshal's report), the fire spread from a barbecue grill on a second floor balcony throughout the second floor to the third floor and roof; upon reaching the third floor, it engulfed the top half of the building in less than two minutes.

2. What could the plaintiff have done to avoid his death? Human factors research has identified a number of factors that improve the personal safety of people inside buildings during fires. In this case, the plaintiff could have responded promptly and appropriately when first alerted to the dangerous condition by performing the following; he could alert those people within his purview so they could escape; he could attempt to exit the building himself quickly; he could follow all instructions provided; he could avoid panic or irrational behavior; and he could avoid any attempt to fight the fire, collect valuables, or delay his departure. All of these are standard procedures to be followed by people in a fire; all have been validated by human factors research as being the safest response.

3. What could the defendants have done to avoid their tenant's death? Human factors research, much of which has been incorporated into building and fire codes, has identified a number of factors that reduce the chances of injury from fires. With respect to structural factors, the building could have been designed to reduce rapid spread of fire; it could have been constructed of relatively non-flammable materials; automatic fire doors, automatic sprinklers, and automatic lighting for when the power goes off could have been installed. With respect to warnings, the owners could have installed automatic fire alarms, manual fire alarms throughout the building, and automatic smoke detector alarms in every room; and they could have established procedures to validate the operational status of those alarms. With respect to training, evacuation instructions and warning placards could have been posted on every floor, fire drills could have been held, and on-site personnel could have been trained to assist and speed evacuations and reduce panic during fires. With respect to fire hazards, rules restricting balcony fires and storage of flammable materials could have been established, with procedures to enforce them.

4. What did the plaintiff actually do? Based primarily on the testimony of the plaintiff's roommate, and secondarily on that of his neighbor, the plaintiff responded promptly and appropriately to the information that there was a fire, without delay and without panic, and

quickly attempted to exit the apartment (and building). Once he heard the message through the door, even though there was no evidence of fire in the apartment at that moment, his roommate estimated only 45 to 60 seconds elapsed between the plaintiff's first trip to the door, and their reaching the door together to leave. He did dress (as did his roommate), but he took nothing with him (and nothing was found with him out in the corridor). When evidence of fire became obvious, they took precautions to protect their breathing, and held on to each other so not to become separated. The plaintiff also felt the door to see if it was safe to open it. Each of these behaviors (dressing, towels, walking together, and feeling the door) indicate goal directed behavior to exit the building, and the absence of panic or irrational behavior.

5. What did the defendants actually do? There were no fire doors, no automatic sprinklers, no automatic fire alarms, and no automatic lighting installed in the building (from the testimony of the on-site manager). No alarm went off in the building at any time (according to the testimony of the neighbor, his girlfriend, the roommate, and the on-site manager). Several manual fire alarms failed to operate: the neighbor's girlfriend testified that she pulled the manual fire alarm on the second floor landing, and nothing happened; and the next door neighbor testified the drunk had told him that he pulled several manual alarms in the building without avail. The roommate testified their smoke alarm did not go off, even when visibility in the room dropped to near zero from smoke. The on-site manager and the chief of management testified that the procedures for insuring the periodic testing and continuous safe operation of the fire and smoke alarms were handled by their own staff, but no check-off procedures were in place, and there was no paper trail covering the past three years regarding inspection, testing, or repair. The service manager of the company that serviced the building's fire alarms testified that they serviced the alarms a year earlier. The company made inspections, tests and repairs only when the building management specifically requested the company's service: there was no maintenance or service contract in place. The management testified that they had never held a fire drill, and had posted no signs or placards in the building about what to do if a fire were reported. The management also testified that there was a rule prohibiting barbecue fires on balconies, but the neighbor, his girlfriend, and the on-site manager testified that the rule was not enforced, and there were barbecue fires somewhere in the building most weekends. Finally, the on-site manager, neighbor, neighbor's girl friend and roommate all testified that there was no on-site management personnel on duty at the time of the fire, and the manager testified that none of their personnel have ever been given training in how to ensure the safety of their tenants during a fire.

6. Human factors causation analysis. In our opinion, the plaintiff responded appropriately to the dangerous condition, and did not contribute to the cause of his death. However, the defendant contributed to the danger by failure to provide a safe structure, by failure to provide adequate alarms, by failure to insure the alarms were working, by failure to alert tenants to what they should a fire occur, and by failure to enforce rules prohibiting barbecue fires on balconies. Specifically, it is our opinion that if a fire alarm and /or a smoke alarm had sounded even a minute earlier than the neighbor's alert, the plaintiff and his roommate would have been able to exit the building safely.

7. Inconsistent Evidence. The defendant could question the time estimate of the roommate and the appropriateness of the actions of the plaintiff.

The roommate testified that only 45 to 60 seconds elapsed between the plaintiff's first and last trip to the front door. Human factors research has shown that people's estimates of elapsed time are not necessarily accurate, and especially so during times of great stress. Further, given the 30 feet from door to bedroom, the activities performed in the bedroom (talking to the roommate, putting on pants, shirt and shoes while roommate was doing the same), waiting while the roommate got and wet towels, placing the towels over their faces, and then walking the 30 feet back single file through the smoke, it is likely that the actual elapsed time between when the plaintiff was first warned and when he finally exited the apartment may have

been somewhat longer than a minute. However, our opinion is that the sequence and speed of the plaintiff's actions were appropriate to the threat. Our opinion would not change if independent determination showed that the elapsed time was longer than one minute.

Should the plaintiff have exited the apartment immediately when the neighbor first warned him of the fire? If he had, he would presumably have survived, since the neighbor survived. An immediate exit by the plaintiff might have meant a failure to adequately warn his roommate, so human nature (also a province of human factors) suggests an immediate exit to be both unlikely and inappropriate. Should the two men have exited without stopping to dress? Our opinion is that in the context of a building being on fire, and the presence of the neighbor in the hall, a natural reaction would be to cover one's feet and body to protect it from heat and sparks.

Therefore, neither an analysis of the elapsed time nor of the activities performed suggest any change in our opinions as to the causation of the death of the plaintiff.

Case 4: Chain Binder Hits Man in Eye

Case Summary. A young man (the plaintiff), an auto mechanic by trade, was hired by his uncle (the defendant) to help him load logs on a trailer and transport them to a storage area. After stacking a load of logs on the trailer, they threw chains over the top, and attached the chains to lugs on either side of the trailer. They used a chain binder to tighten each chain, with which by pulling down on the handle of the binder, the slack can be taken out of the chain so the logs are held tightly. On the first load, both men used chain binders to secure the logs. On the second load, as the plaintiff pulled down on the handle of one of the chain binders, his hand slipped and the handle flew back, hitting him in the head and eye, causing substantial injury. The plaintiff claimed the defendant caused the accident by failing to provide adequate training in the use of a chain binder; and by failing to provide a cheater bar to extend the handle, which would have made it easier to pull on the handle and tighten the chain.

We were retained by the defendant. The evidence available to us included the specific chain binder that hit the plaintiff, and three depositions: from the plaintiff, the defendant, and a mechanical engineer familiar with the design and operation of chain binders. All depositions were taken at least a year after the accident.

1. What was the dangerous condition? We examined the proper procedure to be followed to tighten a load with a chain binder. An operator should, after attaching the two ends to the chain, pull its handle downward toward him, moving or backing up to keep his body out of the path of the handle as he pulls it past its center point where it locks in place. A dangerous condition exists whenever the equipment is used improperly, and especially for the user who remains in the handle's path.

2. What could the plaintiff have done to prevent the accident and injury? According to human factors research, the operator of a new piece of equipment should have some aptitude with respect to the equipment, should familiarize himself with its properties and functions, including safe operations, should have it explained to him, should be trained on its use, and should practice using it under supervision until he is proficient. Then, during use, he should insure that he is following all directions and procedures involving both functioning and safety.

3. What could the defendant have done to prevent the accident and injury? As the person experienced with the equipment, the defendant could have closely supervised the plaintiff when he first started to use it; he could have provided training; and he could have furnished a cheater bar to the plaintiff.

4. What did the plaintiff actually do? According to the testimony of both the plaintiff and the defendant, the plaintiff told his uncle that while he had never used a chain binder before, he was familiar with its operation, understood all of its functions, and specifically understood the importance of keeping his head and body away from the path of the handle. Further, the plaintiff both observed his uncle using the chain binders on the first load and used them himself.

According to both their testimonies, the plaintiff never asked for more training, never asked for assistance or explanation, and never asked for a cheater bar.

5. What did the defendant actually do? According to the testimony of both the defendant and the plaintiff, the defendant demonstrated the use of a chain binder on the first chain, and then watched the plaintiff use it on several more chains. Further, according to the testimony of both men, the defendant asked the plaintiff if he was comfortable using it, specifically warned him to keep his head and body away from the path of the handle; and asked the plaintiff if he wanted a cheater bar for added strength.

6. Human factors causation analysis. We considered whether the plaintiff needed training, and if so, did the defendant fail to provide it. There are no federal or state regulations regarding the need for training on the use of chain binders. Our human factors analysis of the structure, function and operation of chain binders indicates that if a user with substantial mechanical aptitude and experience needs to use a chain binder to attach a load, has never used one before, and is furnished one, training by example should be sufficient. The plaintiff testified that both he had a high mechanical aptitude and a lifetime of employment as a mechanic, during which he gained familiarity with a wide range of mechanical devices similar in nature to a chain binder. The plaintiff testified that the defendant was aware of his aptitude and experience. Thus, based on our analysis, it is our opinion that the aptitude of the plaintiff, his prior usage of similar devices, and his informal observation of this device in use all meant that formal training should not have been necessary, and the lack of that training did not contribute to the accident.

Finally, we considered whether the lack of access to a cheater bar contributed to the accident. First, as the name suggests, this bar is not part of the device, and circumvents its normal usage. The designer of the chain binder specifies the length of arm that would exert an acceptable amount of force, and a cheater bar allows the user to exert much more. The mechanical engineer testified that a cheater bar is capable of breaking a chain binder, and is therefore itself a source of danger. Further, the cheater bar would not have prevented the user's hand from slipping off the bar. Whether a cheater bar is used or not, proper usage of the chain binder requires that the operator keep his body out of the path of the handle.

We concluded that the plaintiff failed to follow proper operating procedures when he was using the chain binder. It was this failure that accounted for the accident.

7. Other Evidence. We and the mechanical engineer examined and testified regarding the design, manufacture, and appropriateness of using a chain binder to secure logs to a trailer. While the plaintiff did not allege that chain binders were inappropriate, we provided a human factors analysis of its design, function, and range of uses, and testified that it was an appropriate device for its intended purpose. Further, we testified that the particular chain binder involved in this accident was not defective in any way that could have contributed to this accident.

Case 5: Pedestrian Hit by Truck on a Freeway

Case Summary. A taxi broke down heading south on a six lane inter-city freeway after dark. The driver (the plaintiff) stopped in the curb lane (where no moving traffic is allowed), called his dispatcher, and was told to wait with his taxi for assistance. There was a steady stream of traffic in all three southbound lanes, all traveling at about 50 mph (the speed limit was 55 mph), with separations averaging 5-8 car lengths. After several minutes of waiting, the plaintiff suddenly walked across the first lane just after a car passed him, and continued into the second lane, where he stopped in the middle. Almost immediately he was hit by a tractor-trailer semi truck driven by the defendant. The plaintiff claimed the defendant could have avoided him, and therefore was responsible for his injuries.

We were retained by the plaintiff. The evidence available to us included our visual inspection of the accident site, the police report of the accident, and six depositions: from the policeman who answered the 911 call; the plaintiff; the defendant; the driver of a car in lane 1 behind whom the plaintiff walked; a second driver in lane 1 who saw the plaintiff as the truck

passed over him; and a driver in lane 2 directly behind the truck who stopped before also running over the plaintiff. We also were given the specifications of the truck, the contents and distribution of its load that night, its gross weight, and the results of a mechanical inspection made just after the accident.

1. What was the dangerous condition? By design and by law, pedestrian traffic is not permitted either along or across this freeway. A pedestrian walking in the traffic lanes of a freeway is in a dangerous situation because drivers do not expect to encounter him, there is nowhere the driver can safely swerve to avoid him, there is nowhere the pedestrian can safely move in order to avoid cars, traffic may be moving at high speeds which do not allow drivers to stop quickly, and the high speeds create an additional dangerous condition if a driver does try to stop quickly. For all of these reasons, human factors research has demonstrated that any pedestrian on freeway lanes with ongoing traffic creates a highly dangerous situation for himself and for the drivers.

2. What could the plaintiff have done to avoid the accident? He could have left the freeway by climbing over the guard rail; he could have remained inside his taxi; he could have stood next to it on the curbside; he could have faced away from the oncoming lights, so they could not blind him or hypnotize him; and he could have refrained from walking out into traffic.

3. What could the defendant have done to avoid the accident? The truck driver could have attempted to bring his truck to a stop before he hit the plaintiff; or he could have turned into one of the two adjacent lanes so as to miss the plaintiff.

4. What did the plaintiff actually do? The plaintiff testified that he was blinded by the glare of the lights of the oncoming traffic, and hypnotized by the repeated ebb and flow of light. He testified that he does not remember, and was not aware, that he had walked perpendicularly away from his taxi out into the flow of traffic. All of the other witnesses testified that he did walk out into the middle of lane 2.

5. What did the defendant actually do? The truck driver testified that he saw the man standing next to his taxi, and then saw him start walking rapidly into lane 1. The truck driver testified that he immediately initiated hard braking, sufficient to stop the truck as quickly as possible. He further testified that he hit the man just as the man reached and stopped in the center of lane 2. The truck driver testified that he did not attempt to change lanes because he did not have enough time.

6. Human factors causation analysis. Based on the testimony of all witnesses, the plaintiff moved into the traffic on the freeway under his own volition, thereby placing himself at great risk. We then analyzed whether the defendant could have avoided the accident, either by stopping in time, or by swerving into another lane. All drivers (including the defendant) testified that travel was at about 50 mph. At this speed, this truck and loaded trailer requires six seconds to stop as quickly as possible without losing control through over-braking. Perception and reaction time for the driver (if he is normally alert and attentive) add another half second. Add to this reaction time the driver's uncertainty and surprise about what the plaintiff intended to do. By our calculations of the walking speed of the plaintiff, and the distance from his taxi to the middle of lane 2, he reached the point of collision in 3.5 seconds, once he began walking. Since the defendant testified that he began braking as soon as he saw the man begin to walk, he needed at least six seconds to complete an action for which he had less than four seconds available. Therefore, it is our opinion that the defendant was physically unable to stop his truck in time to avoid hitting the plaintiff.

Could the defendant have swerved out of his lane? The truck is 8 ft wide; the lanes, 15 feet. Moving the truck 15 feet from the middle of lane 2 to the middle of lane 3, once the steering movements are initiated, takes 3 to 4 seconds, depending on how much centrifical force the driver is willing to exert on his truck and load. That decision to change lanes depends on (a) the truck driver's assumption that the plaintiff will continue into lane 2, but (b) he will not continue further into lane 3; (c) detection that lane 3 is clear and he has room to pull over into it;

(d) he cannot avoid the plaintiff unless he swerves; (e) he can swerve fast enough and far enough to avoid hitting the plaintiff. This decision is complex, and given its complexity, human factors research suggests it would take at least a second to complete, and is more likely to require two to three seconds, especially if the parallel traffic is close and its spacing is difficult to judge. Once the decision to move over a lane is made, a quarter second is needed to initiate wheel turning, and 3 to 4 seconds to complete the turn. By this analysis, the truck would still have hit the plaintiff even if the driver had decided to change lanes.

In our opinion, given this evidence and our computations, once the plaintiff began his trajectory into the road, the truck driver could neither have stopped nor swerved in time to avoid the collision, even under the very best of assumptions. Therefore, in our opinion, the truck driver did not contribute in any way to the cause of the accident. The plaintiff caused the accident by walking into the moving lanes of the freeway.

We reported our findings and opinions to the plaintiff's lawyer: by our human factors analysis, his client was the one responsible for his accident. The plaintiff withdrew his suit.

Conclusion

A complex task faces a human factors specialist who testifies as an expert witness. The content of the field itself is not understood and must be explained to lawyer, judge and jury. The scientific basis for the knowledge of the expert, as this knowledge differs from opinions held by lay people, is appreciated by human factors specialists, but not many others. Obviously everybody knows an icy sidewalk is slippery and a pedestrian is more likely to fall when the pavement is icy than when it's not. What additional knowledge is provided by the human factors specialist? In what way is this knowledge derived from science? We offer a set of steps designed to explain the content of the field and the procedures by which an expert draws opinions based on evidence.

Our intent is to develop a structure sufficiently general to apply in all 50 states, and in all civil litigation issues involving safety. Further, our hope is to make the sequence from accident description to opinions about cause so transparently linked to human factors science that any suggestion that the expert witness is a hired gun becomes indefensible: the opposing counsel will no more consider raising this smoke screen than challenging the credibility of testimony about ballistics, finger prints or DNA.

References

The Forensics Professional Group of the Human Factors and Ergonomics Society (1997). Mock trial: how human factors experts contribute to civil litigation. Case 1: A pedestrian's encounter with a tripping hazard. A 73 minute video tape of the presentation at the 41st Annual Meeting of the Human Factors and Ergonomics Society, Albuquerque, NM, September, 1997.

The Forensics Professional Group of the Human Factors and Ergonomics Society (1997). Mock trial: how human factors experts contribute to civil litigation. Case 2: Adequacy of warning systems to address product hazards. A 62 minute video tape of the presentation at the 41st Annual Meeting of the Human Factors and Ergonomics Society, Albuquerque, NM, September, 1997.

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