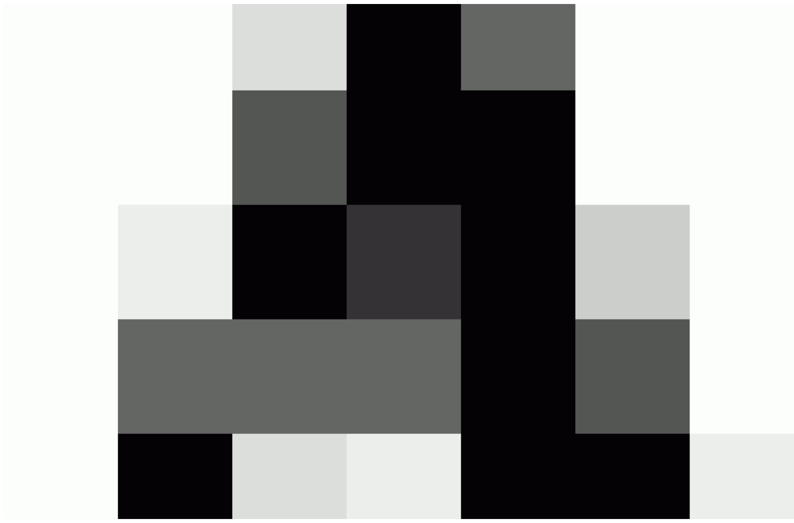
Dynamic Chiropractic



WHIPLASH / NECK PAIN

Crash Partners: Death Risk Based on Relative Vehicle Masses, Sizes, and Types

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In this brief review I will attempt to put some perspective on the relative risk one takes in driving passenger cars of varying sizes and masses within our current heterogeneous fleet of vehicles. This includes, in addition to very small cars, large vans, pickups, and sport utility vehicles (SUV). It's a good idea to consider these issues when considering the purchase of a new family vehicle. In a very real sense, your family's lives are at stake. As an illustration, if the vehicle you crash into weighs 50 percent more than yours, your family's risk of death in that crash is 3-6 times greater than the occupants of the heavier car. If you are driving a mid-sized passenger car and you are struck on your driver's side door in a side impact crash by a larger SUV, your risk of death is close to 50 times that of the other driver. This is food for thought, perhaps, for parents purchasing that first car for a teenager with precious little driving experience who wants that cute little Geo Metro.

Size Does Matter

One can derive a kinetic energy equation from Newton's Second Law of Motion: F=ma, where force *(F)* is equal to mass *(m)* times acceleration *(a)*. From this we get: $KE=1/2mv^2$, where kinetic energy *(KE)* is equal to /one-half mass-times-velocity *(v)* squared. The fact that velocity is exponential is important because it means that the kinetic energy of a crash at 40 mph is not simply twice that of a 20 mph crash-it is four times as much. And, as concerns this paper at least, one can easily begin to see where I am going with mass. Essentially, the crash partner (each of two or more vehicles in a crash) with the least kinetic energy is at a disadvantage. However, there are other factors that determine the relative risk between crash partners.

Crashworthiness and Aggressivity

Terms worth knowing here are *crashworthiness and aggressivity.* Crashworthiness is a measure of a vehicle's ability to perform well in a crash. In other words, the occupants are relatively well protected, and their risk of serious injury or death is lowest when crashworthiness is highest. Aggressivity, on the other hand, is a measure of the vehicle's ability to be harmful or dangerous to the occupants of its crash partner. Accordingly, the safest crash would be one in which both cars had high crashworthiness and low aggressivity.

Newer passenger cars are built with a unibody construction. This characteristic provides some advantages and disadvantages in terms of these two issues. Pickup trucks, vans, and SUVs are typically built on the older frame rail chassis, and this method of construction allows their mass to be transferred longitudinally into their crash partners more easily - a distinct disadvantage for the crash partners. Making this longitudinal frame rail construction issue even more dangerous is the disparity in the ride heights of these longitudinal components. So anyone struck from the side is at a disadvantage compared to the striking vehicle. The fatality risk of the driver of a mid-sized passenger car struck on his door by another mid-sized passenger car is in the neighborhood of six times that of the striking driver. But that person's risk when struck by a full sized-van, pickup truck, or SUV approaches an order of magnitude over that of the other driver!

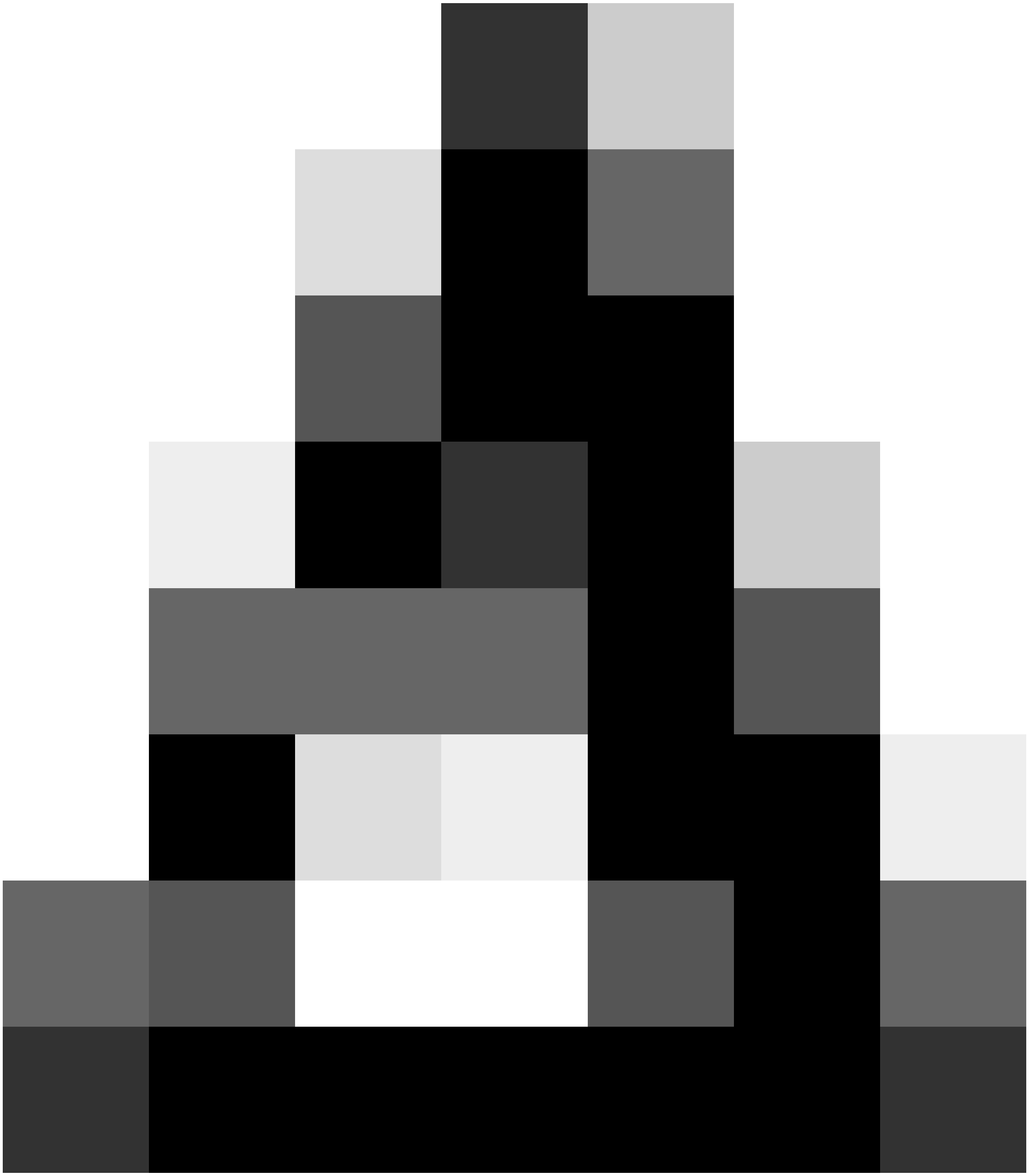
When one passenger car strikes the side of another passenger car, the longitudinal component of the striking (bullet) vehicle typically aligns with the struck (target) vehicle's doorsill: (the stiffest portion of that car). That provides the target vehicle's occupant with the most protection. When an SUV or larger pickup truck strikes the passenger vehicle from the side, its longitudinal components are higher than the doorsill of the passenger car typically, and more easily invade the occupant compartment. Door panels are relatively soft sheet metal and offer very little protection in this kind of crash.

Stiffness

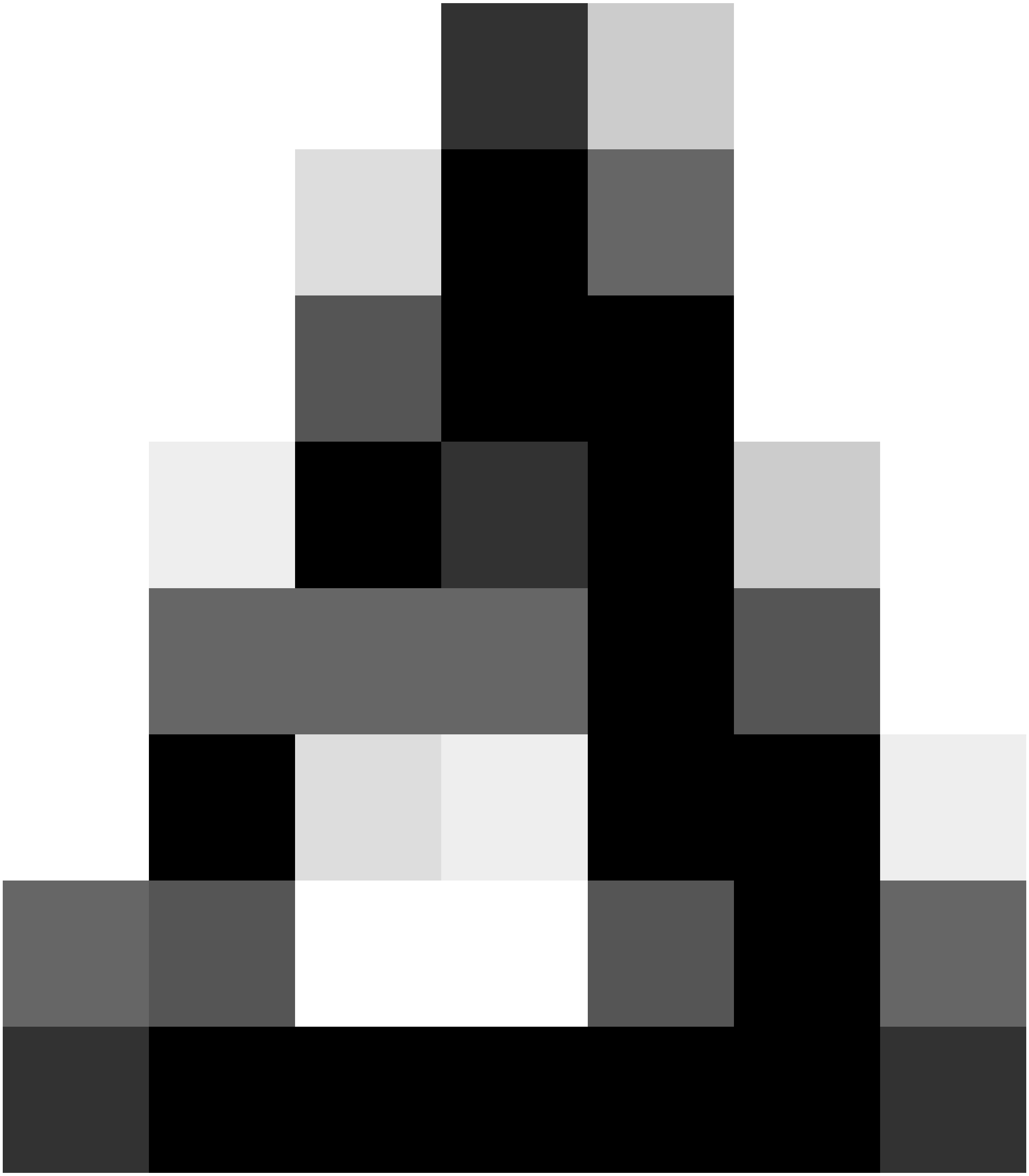
Another problem encountered by designers is stiffness. If we make a car that crushes very gradually and uniformly, the occupant can *ride down* the crash with less risk of injury. This is the idea behind the barrels of sand or water one sees on the highway turnoffs. If you hit these barrels, sand or water gushes out as your vehicle crashes into more and more of them. This increases the duration of the crash. This relationship can be appreciated by the simple equation:

$a=$

v/



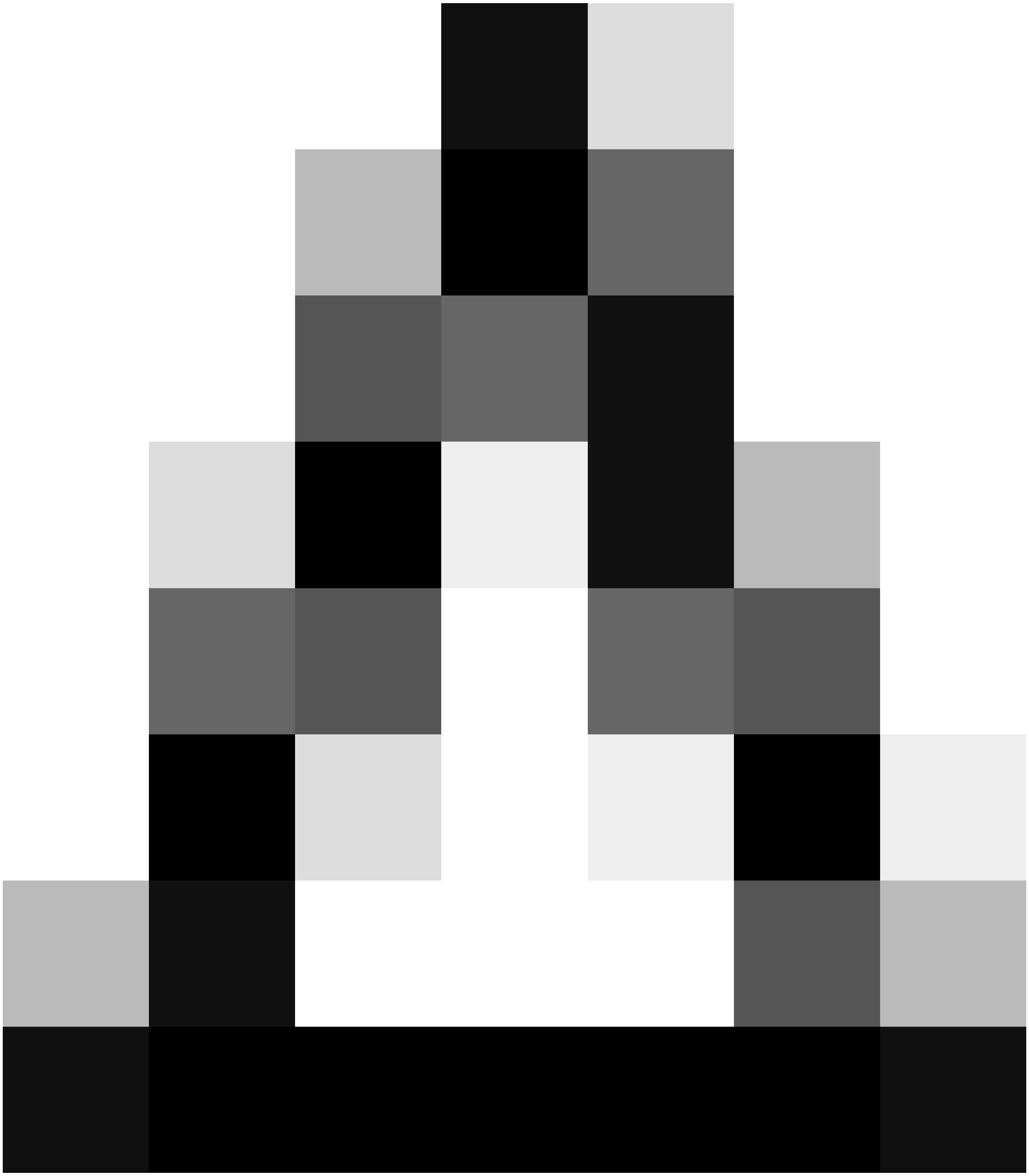
v/



t, where acceleration (a) is equal to the change of velocity (

Δ

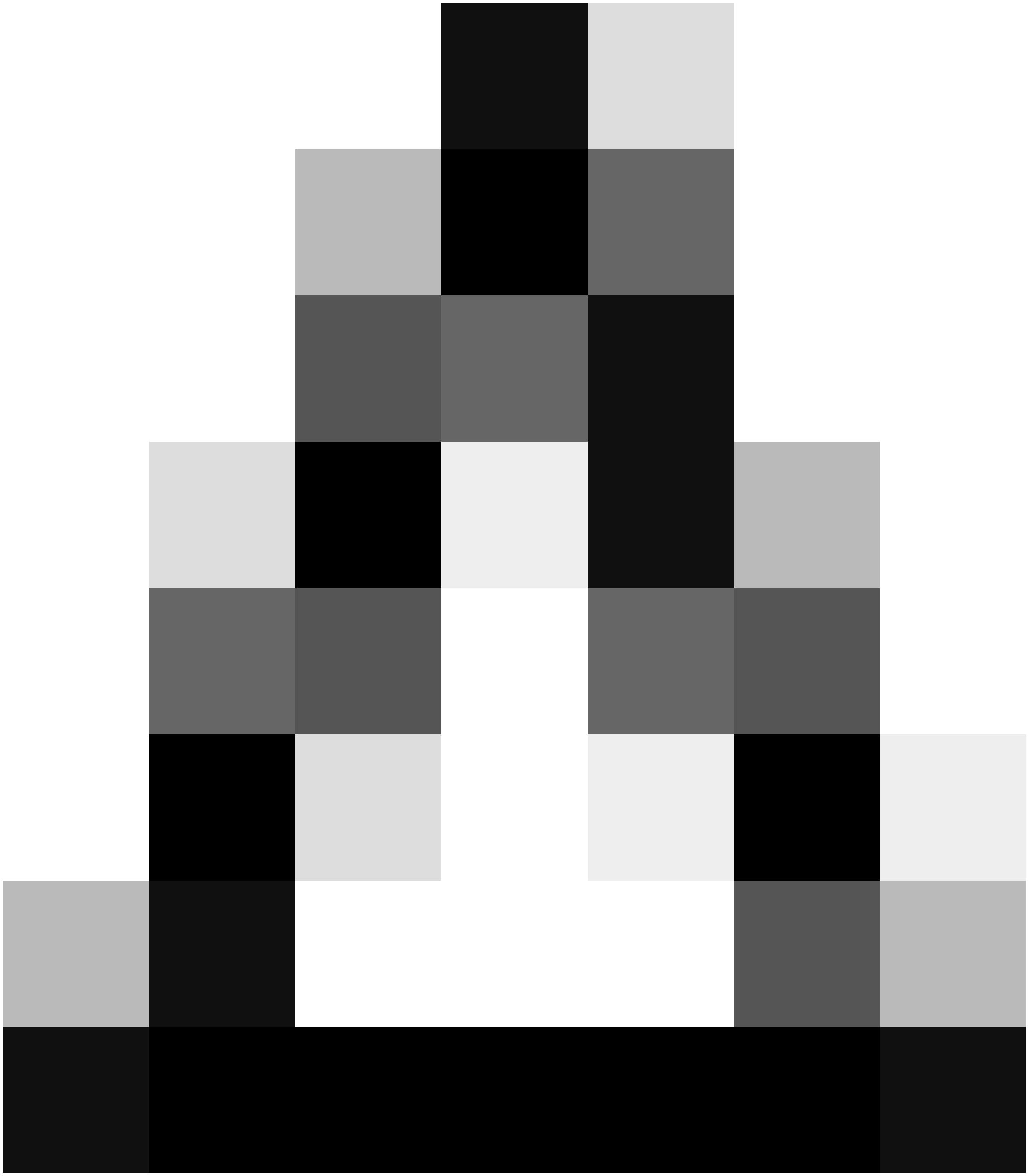
v), divided by the change of time (



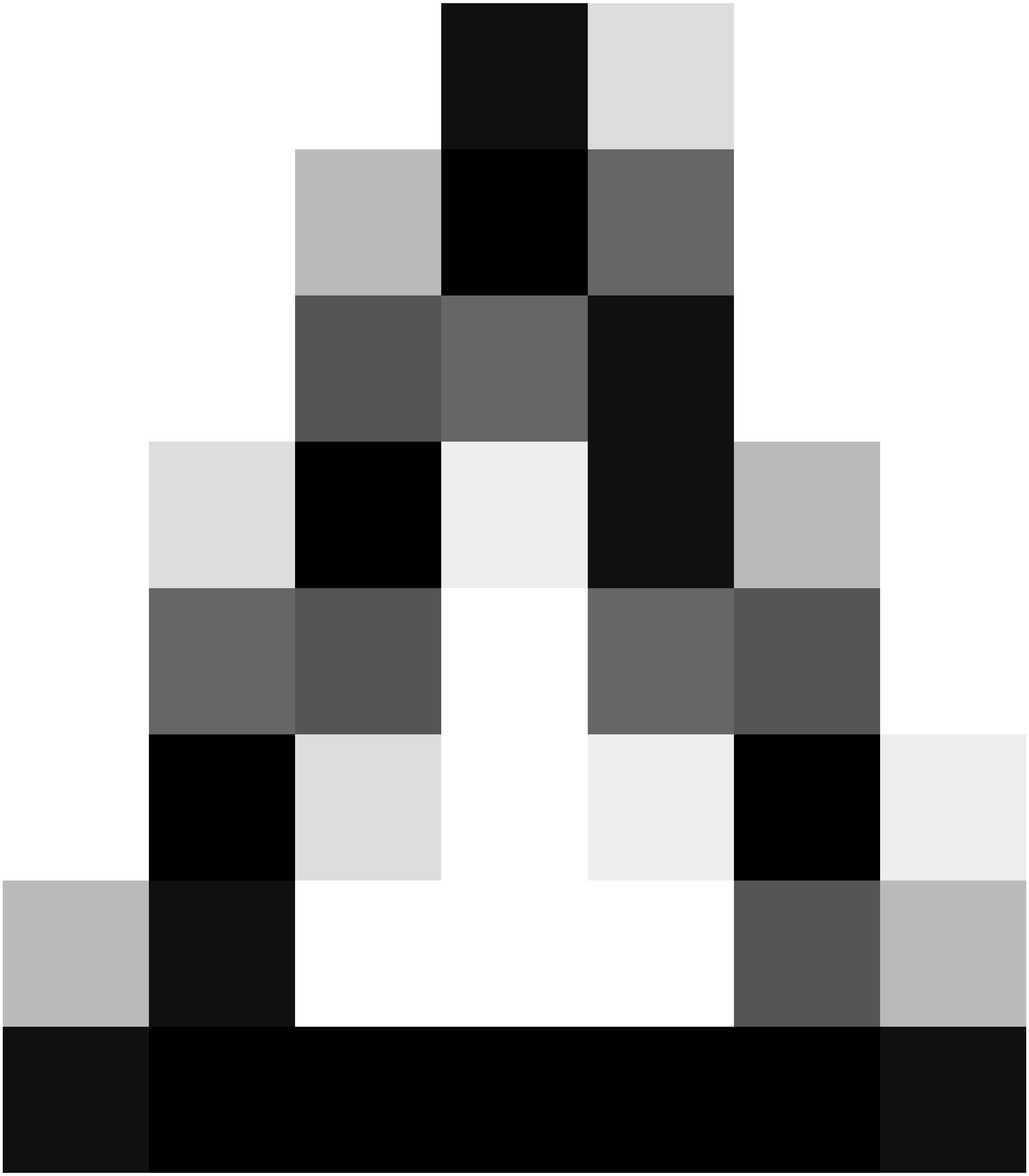
t) or the total duration of the crash). Spreading the crash out over a longer duration effectively lowers the acceleration and, consequently, the risk to the vehicle's occupants. We see this effect of "ride down" everywhere. Stunt people, for example, jump off high buildings and land on giant air mattresses. As the stuntperson loads the mattress with his or her mass, air is displaced out of vents and the person decelerates slowly without injury. Hitting the pavement, on the other hand, gives an extremely short duration deceleration - with predictable results.

In a larger vehicle, such as a full-sized passenger car, there is plenty of room for the engine and other essential parts under the long hood. In fact, one can crush about two feet of relatively soft bumper, bumper struts, horns, grillwork, etc., before hitting the relatively stiffer engine block. Crashing frontally into a barrier or other vehicle, we are afforded precious ride down. In a smaller car, however, this luxury of space is severely limited and designers must make the car relatively stiffer to allow the car to withstand the mandatory barrier crash tests without having the engine invade the occupant compartment. The acceleration to the driver of a very small car striking a rigid barrier is much higher than that of the driver of the large car striking the same barrier at the same speed. This difference has to do with stiffness, not mass.

Ride down, of course, also has applications in low-speed crashes since, with little vehicle crush, we are afforded relatively little ride down. We can say that low-speed crashes without property damage are less "plastic" and more "elastic" in nature. Hence, the inverse relationship between property damage and risk for occupant injury in low-speed, rear-impact crashes (LOSRIC). Recent large studies in Germany, for example, have demonstrated that the majority of whiplash injuries occur in crashes with



vs of between 6 mph and 12 mph. My experience, and that of other crash test researchers, has been that with good alignment, passenger cars can collide repeatedly in crashes producing



vs of 5 mph to 7 mph with little or no resulting damage. From this, one would conclude that a very large proportion of these injuries might occur in crashes with little or no property damage. This is of particular significance, in light of the single most common argument mounted by those defending injury claims: "The plaintiff couldn't have been injured because the vehicle damage was minimal."

So, the most important factor in safety is mass. The second and third factors are vehicle ride height and the resulting crash partner compatibility issue mentioned above, and stiffness. For every million passenger cars weighing 3,500-3,999 pounds, 45 deaths occur in the other cars with which they collide. For every million SUVs in the same weight class, 76 deaths occur in their crash partners. The rate for pickups is even higher, at 87.

On the other hand, we have the issue of statistics and probabilities. Getting attacked by a shark while swimming, or struck by lightening while golfing are horrific, but are rare events. As a result, (unless one swims with Richard Dreyfuss or golfs with Lee Trevino) we don't normally have to spend a lot of time thinking about such risks. Crashes with SUVs and pickup trucks account for only about 11 percent of injuries; 16 percent of the deaths in occupants in the lightest cars. So, if car-to-car crashes are the highest source of serious injury or fatality, the important issues again are relative mass and stiffness.

NCAP and Euro NCAP

The current Federal Motor Vehicle Safety Standards require crash testing at 30 mph. There are no higher speed standards, nor are there any specific low-speed crash test or crashworthiness requirements (aside from a bumper standard, which is not a safety standard). Both, however, have been proposed. The New Car Assessment Program (NCAP) and its European cousin have been instituted in the interim, to attempt to encourage manufacturers to "beefup" the crashworthiness of vehicles at slightly higher crash speeds and under somewhat more challenging conditions, such as crashing into offset deformable barriers. These tests are not mandatory. A star system rewards manufacturers for good marks based on the performance of the cars in these tests, with five stars representing highest performance, and one star representing a car that you wouldn't buy for your family.

This NCAP seems to have had mixed results. The cars have predictably become more crashworthy under more challenging conditions. Manufacturers have successfully beefed-up construction for higher-speed crashworthiness. Unfortunately, there has been an unforeseen trade-off: they have become progressively less crashworthy at lower speeds where, ironically, a greater number of crashes actually occur. There are now several studies pointing to this finding. Another unrelated reason for this increase in injury risk in LOSRIC is that the seat backs have become stiffer. Ultimately, in my view, it boils down to one thing: If you make a 30-mph crashworthiness regulation, manufacturers begin here, and design their cars with performance at this speed prioritized. If you increase it-even with nonobligatory tests-they will reprioritize performance at the new level. If we are to have crash safety also in low-speed crashes, we will have to develop and implement a low-speed regulation or safety standard. In that regard, the Europeans are way ahead of us.

For more information about the crashworthiness and crash test performance of specific vehicles, go to the websites of the National Highway and Traffic Safety Administration (NTTSA), and the Insurance Institute for Highway Safety (IIHS) at www.NHTSA.gov and www.IIHS.org, respectively.

What Crash Speeds Are Safe?

In a word - none. However, my experience as a former paramedic was that drivers are frequently astonished by the extent of injuries in crashes at relatively low speeds. This may be one reason for low seat belt compliance in this country. Drivers seem to believe that in a 25-mph crash, they can simply brace against the steering wheel. Simple physics argues against this. 25-mph is the speed one reaches in jumping from a height of 21 feet, which is close to the height of a second-story rooftop. Ride down will soften the load to a degree in a frontal crash, but in a near-side impact, the bullet vehicle will strike you at very nearly the closing speed of the crash. Your vehicle will not significantly slow down the bullet vehicle by the time your shoulder and head strike the door and window or B pillar. This really would be the equivalent to dropping from 21 feet and landing on your side in that relatively hard environment. As they say: "That's got to hurt!" Not surprisingly, even at the seemingly slow speed of 25 mph, near side impacts result in serious injury or death almost half the time.

Handling Characteristics

One last issue is the vehicle's stability on the road. Pickup trucks and utility vans, especially when heavily loaded or completely unloaded, have poor weight distribution and handling characteristics and will tend to lose traction (i.e., oversteer) before the typical passenger car. This is made worse by their higher center of gravity, which increases the likelihood of rollover or unplanned exit from the roadway. Thus, although they are high on the aggressivity scale, this fact does not imply they are relatively safer overall than passenger cars. While a passenger car may successfully swerve to avoid an object in the road or another vehicle, the SUV, van or truck is more likely to lose control under the same hard steering or braking condition. As a result, they are more likely to crash, overturn, or run off the road.

The Bottom Line

One should conclude from all of this that the safest vehicles, overall, are larger passenger cars. They offer the best mix of mass, stiffness, and safe handling to protect you and your family. And, of course, safety comes at a price. There generally is a direct relationship between crashworthiness and the vehicle's cost.

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