

Target Risk 3

Risk Homeostasis in Everyday Life



Gerald J.S. Wilde
complimentary copy

[Version 2014.03.20]

The concept of homeostasis

“*Target Risk 3: Risk Homeostasis in Everyday Life*” is the third, revised and enlarged edition of “*Target Risk*,” which was originally published by PDE Publications in 1994 in Toronto (ISBN 0-9699124-0-4) as well as made freely available on the internet. The second edition appeared in print only, published by PDE Publications in Toronto (ISBN 0-9699124-3-9). Cover Picture: Robert Delauney, *Disque*, Paris (1912). Current text formatted for A4 printing.

Dr. Gerald J.S. Wilde is Professor Emeritus of Psychology at Queen’s University in Kingston, Ontario, Canada. Born in the Netherlands in 1932, he received his doctorate (cum laude) from the University of Amsterdam in 1962. He was visiting professor at the City University of New York 1964-65, and chaired research groups of the OECD and NATO/CCMS. He has been active in research and transportation safety since the late 1960s and has received visiting scientist’s awards from the governments and other safety-related agencies in Australia, Austria, Brazil, Canada, Chile, Finland, France, Germany, Ireland, Italy, Ivory Coast, Japan, Mexico, the Netherlands, New Zealand, Spain, Sweden, Switzerland and the USA. His teaching and research interests include psychological ergonomics, skill acquisition, mass media messages and behaviour change, human behaviour in transportation, and the psychology of risk taking.

The concept of homeostasis

Dedicated by a boyhood friend to the memory of Damiaen van Doorninck, Jacques Jansen, Hans Cohen and Izaïc Gosschalk, who fell fatal victims to the violence of fascists during World War II, and in lasting gratitude to the Canadians who delivered Deventer, their hometown in the eastern Netherlands, from Nazi tyranny on the tenth of April in 1945. All are immortal: the dead live on in the lives of the living.

The concept of homeostasis

TO TAKE A RISK: to expose oneself to potential loss.
[from Latin risicare = to navigate around a cliff or rock]

TARGET RISK: the level of risk a person chooses to accept in order to maximize the overall expected benefit from an activity.
[Synonyms: accepted, preferred, tolerated, desired risk; set-point risk]

HOMEOSTASIS: a regulating process that keeps the outcome close to the target by compensating for disturbing external influences. For example, the human body core temperature is homeostatically maintained within relatively narrow limits despite major variations in the temperature of the surrounding air.
[from Greek homeo = matching, similar, and stasis = condition, state of affairs]

RISK HOMEOSTASIS: the degree of risk-taking behaviour and the magnitude of loss due to accidents and lifestyle-dependent disease are maintained over time, unless there is a change in the **target level of risk**.

The concept of homeostasis

1 INTRODUCTION.....	8
2 THE CONCEPT OF HOMEOSTASIS	15
2.1 <i>Thermostatic control.....</i>	16
2.2 <i>Homeostasis does not mean constancy.....</i>	17
2.3 <i>The set point rules supreme</i>	20
3 TOWARD A COMPACT THEORY OF RISK TAKING	23
3.1 <i>Taylor's study.....</i>	24
3.2 <i>Some possible consequences.....</i>	26
3.3 <i>Replicating Taylor's findings.....</i>	27
3.4 <i>The French connection</i>	28
4 THE THEORY OF RISK HOMEOSTASIS.....	35
4.1 <i>The target level of risk</i>	35
4.2 <i>The perceived level of risk</i>	42
4.3 <i>Ongoing adjustment action.....</i>	43
4.4 <i>The resulting accident toll</i>	44
4.5 <i>Skills that influence road-user behaviour.....</i>	46
4.6 <i>Individual differences in skill.....</i>	47
4.7 <i>Homeostasis is generated by the actions individuals.....</i>	50
4.8 <i>Conceptual underpinnings and wider extensions</i>	52
5 DEDUCTIONS AND DATA.....	57
5.1 <i>Cross-sectional and longitudinal accident data.....</i>	81
5.2 <i>The accident rate "per km driven" as distinct from "per head of population"</i>	62
5.3 <i>A historical note on what happened between 1870 and 1910.....</i>	67
5.4 <i>Traffic accidents and the state of the economy.....</i>	68
5.4.1 <i>Additional analyses of unemployment rates</i>	71
5.4.2 <i>New questions arising</i>	75
5.5 <i>Is there no counterevidence?</i>	78
6 INTERVENTION BY EDUCATION	85
6.1 <i>Education.....</i>	85

	The concept of homeostasis	
6.2	<i>Training.....</i>	87
6.3	<i>Lulled into an illusion of safety.....</i>	92
6.4	<i>Warning signs</i>	xxx
6.5	<i>Mass media messages for safety and health</i>	97
6.5.1	<i>Yardsticks of effectiveness.....</i>	97
6.5.2	<i>Message components</i>	101
7	REMEDY BY ENGINEERING?	109
7.1	<i>The Munich taxicab experiment.....</i>	109
7.2	<i>Airbags, studded tires and parachute ripcords.....¹ .</i>	xxx
7.3	<i>The wheels of misfortune</i>	115
7.4	<i>Traffic lights.....</i>	117
7.5	<i>Visibility.....</i>	120
7.5	<i>Motor-vehicle manufacturing regulations</i>	121
8	ENFORCEMENT ACTION	125
8.1	<i>Drinking and driving.....</i>	125
8.2	<i>Mandatory seatbelt wearing</i>	130
8.3	<i>The Nashville crackdown-slowdown study.....</i>	135
8.4	<i>The road safety record of Japan</i>	137
9	RISK HOMEOSTASIS IN THE LABORATORY.....	139
9.1	<i>Brinkmanship.....</i>	144
9.2	<i>Are you taking too much risk or too little and how can you tell?</i>	147
10	INDIVIDUAL DIFFERENCES.....	155
10.1	<i>Personality, attitude and lifestyle</i>	155
10.2	<i>The unreliability of accident liability.....</i>	159
10.3	<i>Prospect and retrospect</i>	163
10.4	<i>Demographic characteristics.....</i>	167
11	MOTIVATING FOR SAFETY AND HEALTH	175
11.1	<i>Punishing unsafe acts</i>	176
11.2	<i>Reactance, or the boomer hits back.....</i>	179
11.3	<i>Extending incentives for accident-free operation.....</i>	183
11.4	<i>Disincentives.....</i>	186
11.5	<i>Requirements for effective incentive programming ..</i>	187
11.6	<i>Comparing workers with drivers</i>	193
11.7	<i>What a government can do</i>	194
11.8	<i>The role of automobile insurance</i>	195

	The concept of homeostasis	
11.9	<i>Recapitulation</i>	202
12	FURTHER PERSPECTIVES	205
12.1	<i>Expectationism</i>	208
12.2	<i>Epilogue</i>	215
INDEX	ERROR! BOOKMARK NOT DEFINED.	

The concept of homeostasis

*In order to get to the source,
one has to swim against the current.*
Stanislav J. Lec¹

1 Introduction

Human beings can never be totally sure of the outcome of their decisions. Ergo, all decisions are risky decisions. You have already taken a risky decision by opening this text and reading the first few lines, and having done so, you are now facing another: to read on or to close it.

And what do I do as the author? It goes without saying that I would like you to read all of it, just as I wrote all of it. If you choose to read on, there is a chance, however slight, that you may afterwards feel that you could have put your time to better use. If, right now, you close it, you may later be nagged by the feeling that you missed out on an opportunity to learn something of importance to your own life expectancy, to that of your loved ones or to people in general. So, which of the two risky decisions do you take?

I chose a writing style and presentation of content that will, I hope, encourage you to read on. But, contrary to my intentions, you may judge my style too popular or too academic, the content too wide or too limited. By trying to reach large numbers of diverse readers, many a writer has in fact pleased very few, despite the vital importance of the topic to all.

So, both reader and writer engage in risk taking, although the possible consequences in this case may be relatively trivial. But there are more serious risks: those of accidents, injuries, substantial property damage, of death, disease and physical disability. It is these serious risks that form the main topic in the pages to follow.

A large number of these mishaps are the consequence of our daily actions, habits and lifestyles. We add to the probability of these mishaps every time we drive our cars, board a plane, climb a ladder, have another cigarette or alcoholic beverage, cross the street, lift a heavy object, have sex with somebody we hardly know, light a fire, go swimming or jogging, handle work tools, and so on.

When mishaps occur, they usually involve comparatively few people, but as they are so common, these “minor” disasters add up to large numbers in a nation’s statistics. Millions of people engage routinely, if not daily or even several times per day, in dangerous activities, and it is with their actions that this text is concerned. The focus will not be on the more infrequent decisions made by few people with potentially disastrous consequences for many, like deciding to go to war, to install and operate a nuclear plant, or to move dangerous cargo through a populous area.

¹Lec, S.J. (1971). *Das grosse Buch der unfrisierten Gedanken*. Munich: Carl Hanser Verlag.

The concept of homeostasis

In discussing statistics and research information on the more serious risks taken by large numbers of people, we will encounter many findings that may surprise at first. For instance, we all know that smoking cigarettes is associated with various diseases of heart and lungs, and thus with early death. And we know that stopping smoking reduces the likelihood of contracting these diseases. So you might expect a lower incidence of lung and heart disease amongst people who were told by their physician to quit smoking and who did quit. And your expectation would be right. These illnesses did, in fact, develop less often in this group.

However, if you also expected a lower mortality rate for this group, the facts prove you wrong. In one comparison between a group of quitters and a control group, the life-span of the quitters was found to be a little *shorter*!¹ The difference in mortality rates between the quitters and the control group was not statistically significant, meaning that the probability of its occurrence on the basis of mere chance was greater than one in twenty. But, surely, these findings do not confirm common popular or common scientific expectation.

This study does not stand by itself, nor does the disappointing result.² The original British experiment was replicated in the US with an intervention trial that involved sample sizes as large as some 2500 men in both intervention and comparison group. After 16 years of follow-up, there were significantly fewer deaths due to acute myocardial infarction in the intervention group, but the overall death rate did not differ significantly between the two groups.³ The participants in the intervention group were exposed to a sophisticated program involving smoking cessation, education in dietary habits for cholesterol and weight reduction, and medication against high blood pressure. They were thus given a rich *opportunity* for learning how to live longer, while the program may have failed to increase their *desire* to live longer, thereby creating the possibility that some old unhealthy habits were replaced by new unhealthy habits, and that may explain the end results.

We all know that drivers who wear seatbelts are, on average, more likely to survive a crash than those who don't. So you might be inclined to expect that laws compelling drivers to buckle up, and that increase the seatbelt-wearing rate, will reduce a nation's traffic fatality rate per head of population.

You would probably expect similarly beneficial results from the construction of more crashworthy cars and the building of more forgiving highways. But again, this is not what has been found.^{4,5}

¹Rose, G., Hamilton, P.J.S., Colwell, L. and Shipley, M.J. (1982). A randomised control trial of anti-smoking advice; 10-year results. *Journal of Epidemiology and Community Health*, 86, 102-108.

²Hakama, M., Beral, V., Cullen, J. and Parkin, M. (1989). UICC workshop on evaluating interventions to reduce cancer risk. *International Journal of Cancer*, 43, 967-969.

³The Multiple Risk Factor Intervention Trial Research [MRFIT] Group (1996). Mortality after 16 years of participants randomized to the Multiple Risk Factor Intervention Trial. *Circulation*, 94, 946-951.

⁴Adams, J.G.U. (1985). *Risk and freedom; The record on road safety regulation*. London: Transport Publishing Projects.

⁵Wilde, G.J.S. (1984). On the choice of denominator in the calculation of accident rates. In S. Yagar (Ed.), *Transport risk assessment*. Waterloo, Ontario: University of Waterloo Press, pp. 139-154.

The concept of homeostasis

To err is human. Our perceptions and reasoning are susceptible to mistakes. When looking at Figure 1.1, you will probably judge the line between the first and the second arrows (line **a**) to be longer than between the second and the third (line **b**). Measuring the two lengths with a ruler will soon convince you that your perception was wrong. If your ruler is precise enough, you will discover that line **b** is actually a little *longer*, by almost 1%.

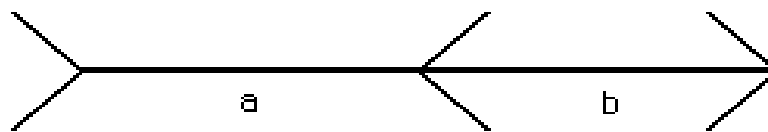


Figure 1.1: Which line is longer, a or b?

You probably are familiar with syllogistic arguments such as:

*All human beings are mortal.
Socrates is a human being.
Thus, Socrates is mortal.*

The conclusion follows from the first two statements. Now consider the two arguments below:

In many accidents, cars skid before they collide. Anti-lock brakes reduce the likelihood of skidding. Thus, installing such brakes will reduce the number of accidents.

Many intersection accidents involve cars colliding at right angles. Traffic lights reduce the frequency of right-angle collisions. Thus, installing lights will reduce the number of intersection accidents.

Because of the apparent similarity with the Socrates case, it may be tempting to assume that the conclusions in the two arguments are valid. The similarity, however, is deceptive and the conclusions are wrong. While Socrates himself—were he alive today—would be unlikely to fall victim to this trap, people often do. And people are more likely to agree with an erroneous conclusion when this fits their social attitudes and preconceptions. This is especially true for people who are not inclined to be analytical in the way they look at the world around them,¹ the “fuzzy set,” so to speak.

¹Witkin, H.A. and Goodenough, D.R. (1981). *Cognitive styles: Essence and origins*. New York: International Universities Press.

The concept of homeostasis

To err is human, but human, also, is awareness of that very fact. To the extent that this awareness helps to correct the error, further insight is gained and progress can be made. It has been said that popular wisdoms contradict each other, but then this observation itself is popular wisdom, too.

In some parts of the world, deaths due to floods in low-lying areas are a serious problem. The building of levees reduces the likelihood of floods. It might be thus expected that such constructions would reduce the number of flood victims. Once again, this is not what has been found in fact.¹

It may also come as a surprise that, in most developed countries, the mortality rates associated with violent death—which comprises homicides, suicides, and fatal accidents—remained virtually unchanged in the first three quarters of the 20th century, with the exception of war periods. These rates include fatal accidents of all types per head of population, and are corrected for historical variations in the gender and age composition of the populations concerned.² They show no clear downward trend, in spite of the massive technological, legislative, educational and medical advances made during the same period.

These observations seem difficult to believe. It also seems hard to comprehend why these rates are not much influenced by the visible progress in safety engineering, by prescriptive or prohibitive laws and their enforcement, by informing the public about risks, or by more successful medical treatment of accident victims who do not die instantly. What could possibly account for these and many other similar findings?

I suggest that all of the observations above may be explained by a relatively simple theory of human conduct in the face of risk, and that theory is the central theme of this writing. The theory can be roughly outlined as follows:

Risk Homeostasis Theory maintains that, in any activity, people accept a certain level of subjectively estimated risk to their health, safety, and other things they value, in exchange for the benefits they hope to receive from that activity (transportation, work, eating, drinking, drug use, recreation, romance, sports or whatever).³

In any ongoing activity, people continuously check the amount of risk they feel they are exposed to. They compare this with the amount of risk they are willing to accept, and try to reduce any difference between the two to zero. Thus, if the level of subjectively experienced risk is lower than is felt acceptable, people tend to engage in actions that increase their exposure to risk. If, however, the level of subjectively experienced risk is higher than is acceptable, they make an attempt to exercise greater caution.

In either case, people will choose their next action so that the subjectively expected amount of risk associated with that next action matches the level of risk accepted. In the process of executing that next action, perceived and accepted risk are

¹Clark, W.C. (1980). Witches, floods and wonder drugs. In R.C. Schwing and W.A. Albers (Eds.) *Societal risk assessment: How safe is safe enough?* New York: Plenum Press.

²Alderson, M.R. (1981). *International mortality statistics*. New York: Facts on File.

³Wilde, G.J.S. (1988). Risk homeostasis theory and traffic accidents: Propositions, deductions and discussion of dissension in recent reactions. *Ergonomics*, 31, 441-468.

The concept of homeostasis

again compared and the subsequent adjustment action is chosen in order to minimize the difference, and so forth in an ongoing manner.

Each particular adjustment action carries an objective probability of risk of accident or illness. Thus, the sum total of all adjustment actions across all members of the population over an extended period of time (say one, or several years) determines the *temporal* rate (i.e., per *time unit* of exposure to risk) of accidents and of lifestyle-dependent disease in the population.

These aggregate rates, and in particular the more direct and frequent personal experiences of danger, in turn influence the amount of risk people expect to be associated with various activities, and with particular actions in these activities, over the *next* period of time. They will decide on their future actions accordingly, and these actions will produce the subsequent rate of human-made mishaps. Thus, a “closed loop” is formed between past and present, and between the present and the future. And, in the long run, the human-made mishap rate essentially depends on the amount of risk people are willing to accept.

In short, the theory of risk homeostasis proposes that a nation’s temporal loss due to accidents and lifestyle-dependent disease is the output of a closed-loop regulating process in which the accepted level of risk operates as the unique controlling variable, and is thus *outside* the closed loop. Consequently, if we wish to make an attempt at reducing this misery, that attempt should be aimed at reducing the level of risk accepted by the population.

With this theory as a key, you now have the means to unravel the puzzling findings that have been mentioned so far. As you may have guessed, the key to understanding proposed is the following notion:

People alter their behaviour in response to the implementation of health and safety measures, but the riskiness of the way they behave will not change, unless those measures are capable of motivating people to alter the amount of risk they are willing to incur.

This concept offers a plausible explanation for the fact that the technological efforts toward flood control in the USA failed to reduce the number of flood victims. Improved impoundment and levee construction did indeed make certain areas less prone to flooding. But, as a consequence, more people decided to settle in the fertile plains, because these now appeared “safe enough.” The end result was that subsequent floods, although fewer in number, caused more human loss and more property damage.¹ In fact, *average* annual flood deaths per head of population indicate little or no change from 1906 to 1985 in the USA, nor did the dollar cost relative to gross national product diminish, because the proportion of residences located in flood hazard areas rose in response to technical improvements in flood control.²

¹Clark, W.C. (1980). Witches, floods, and wonder drugs. In R.C. Schwing and W.A. Albers (Eds.) *Societal risk assessment: How safe is safe enough?* New York: Plenum Press.

²Lave, T.R. and Lave, L.B. (1991). Public perception of the risks of floods: Implications for communication. *Risk Analysis*, 11, 255-267.

The concept of homeostasis

If one wishes to reduce the problem of excessive flow of water, it would seem more sensible to seek a solution *upstream*—for instance, in the form of reforestation or the careful maintenance of wetlands—so that more-than-normal precipitation is contained and does not run downhill.

We now have a possible explanation for the fact that a random selection of cigarette smokers who were advised to quit by their physician, did indeed reduce their cigarette consumption to a much greater extent than a comparison group. They did develop a lower frequency of smoking-related disease, but they did not live longer. In fact, their lives were a little shorter.

We now also have a possible explanation for the fact that the construction of modern multi-lane highways has contributed to a reduction in the number of road deaths per unit distance driven, while over time the number of traffic deaths per head of population remained the same or even increased. Consider the following argument:

*A river empties into the sea through a delta.
The delta has three channels, all of equal size.
Therefore, damming two of the channels will reduce the
flow of water to the sea by two-thirds.*

In all likelihood, you will not accept this argument which we will call *the delta illusion*. This isn't surprising, because it is so obviously wrong. One cannot stem the flow as long as there remain alternative routes to the destination. One cannot reduce mortality due to accidents and lifestyle-dependent disease unless *all* opportunities for premature death were eliminated by law or made impossible through technological intervention. And that, of course, can never be fully achieved. In the case above, the river would simply develop a fourth channel, or deepen or widen the third. If we wish to reduce the per capita mortality rate due to accident and lifestyles, we will have to seek a solution *upstream* in the flow of causation.

What is perhaps more surprising, then, is that safety and health authorities have traditionally told people what they should or should not do to avoid injury or lifestyle-dependent disease, without offering them the motivation to reduce risk, without offering them a reason to live longer. And what may be more surprising still is that the wisdom and effectiveness of this prevention practice is so rarely questioned. The "delta illusion" is a very powerful illusion indeed.

It is obvious that a sure way to reduce the accident rate on a particular road to zero is to simply close that road to all traffic. It is almost as obvious that road users will move to other roads and that the accidents will migrate with them to other locations. Road closure is no effective remedy. Obvious, isn't it? So why should prohibiting drinking and driving, or closing the borders to the illicit drug trade, be effective remedies? To believe so is to fall victim to the delta illusion. The chapters that follow call the traditional prevention practice into question. Specifically, it is argued that the traditional reliance on enforcement of laws, on informing the public of certain dangers, and on engineering the physical features of the human-made environment is not very productive towards greater health and safety insofar as these are dependent

The concept of homeostasis

on human conduct. An effort is made to *explain why this is so, and what can be done to improve public health and safety.

At first, this may appear to be a pessimistic exercise, but nothing could be further from the truth. The theoretical ideas, developed for the purpose of explaining the limited success of the traditional approach, also point the way to the design of effective safety interventions. Not surprisingly, these alternative interventions are aimed *at increasing people's desire to be safe and to live a healthy style of life*. Thus, as an alternative to the enforcement, educational, and engineering approaches of the past, a *motivational* approach to prevention is presented. This is an approach that offers people a reason to live longer and, therefore, to adopt safer and healthier ways of life. The documented experience obtained with this strategy to date strengthens confidence that it is considerably more effective than the traditional approaches. And because the motivational approach seems to cause fewer negative side effects than the traditional countermeasures and to be cheaper to implement, it also offers hope for a happier society throughout.

2 The concept of homeostasis

The term “homeostasis” does not refer to a fixed and invariable end result, or to an immutably fixed state of affairs, but to a particular kind of dynamic process that matches actual output to a target. Homeostatic processes control many of our bodily functions such as deep body temperature, arterial blood pressure, heart rate and blood sugar level, and they serve to provide our body cells with an environment in which they function optimally.¹ Blood pressure in our arteries, for instance, is basically controlled as follows. Pressure is created by the heart pumping blood through the arteries. Downstream from the main arteries are smaller arteries that are surrounded by circular bands of muscle. The more these muscles contract, the greater the increase in arterial blood pressure because there is greater resistance to blood flow, just as you can increase the water pressure in a garden hose by squeezing the opening at the end. Pressure is monitored by pressure sensors in the large arteries that carry blood to the brain. Signals from these sensors are sent to the brain, which in turn controls the pumping activity of the heart and the degree of contraction of the muscles around the small arteries. These muscles are made to relax as the blood pressure exceeds the target level, and made to contract when it drops below the target level.

Target levels vary as the need arises. Blood pressure is reduced during sleep, while during exercise it may be much higher. This does not mean a deficiency, let alone a breakdown of the homeostatic mechanism, but simply that the target level has been reset, because the body’s needs have changed. The same holds for fever.²

Homeostatic functions are found in many physiological and behavioural processes. It is reflected in phenomena such as hunger, thirst, appetite for salt, blood sugar and oxygen content, respiration rate, single versus multiple births in deer in response to crowding, thyroid disease and death in lemmings and arctic hare when populations become too dense for survival, the maintenance of an arousal or excitement level, chasing and fleeing behaviour in squirrels which leads them to spread out more evenly over a territory, and the balance of predator and prey population sizes.³

¹Hardy, R.N. (1976). *Homeostasis*. London: Edward Arnold.

²Langley, L.L. (1965). *Homeostasis*. New York: Reinhold.

³Begon, M., Townsend, C.R. and Harper, J.L. (2009) *Ecology: From Individuals to Ecosystems*, 4th Edition. Hoboken, New Jersey: John Wiley & Sons.

The concept of homeostasis

2.1 Thermostatic control

While homeostasis is a common feature in living organisms, this process has also been made to operate in many engineered devices such as washing machines and clothes dryers, automatic pilots, humidifiers and dehumidifiers, cruise control in automobiles, refrigerators, air conditioning units and central heating. When applied to heating or cooling equipment, the homeostatic process provides for thermostatic control and thus for thermostasis with the help of the familiar thermostat. As the operation of thermostatic control is easier to inspect than the inside workings of your body, this will serve as a practical example to illustrate the process of homeostasis in more detail.

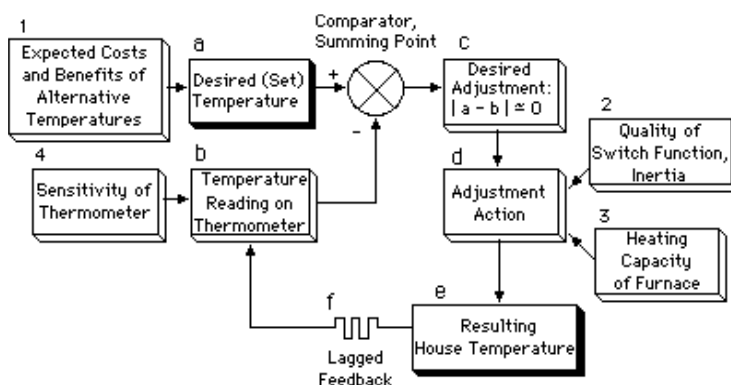


Figure 2.1: Homeostatic model relating house temperature to heating system activity and vice versa: relating heating system activity to house temperature, with the set-point (target) temperature as the controlling variable.¹

The basic features of homeostatic temperature control in a heating/cooling system are shown in the flow diagram in Figure 2.1. The operating principles may be explained as follows:

Box 1: You, the user of this control system, consider various factors in determining the preferred temperature. The temperature preferred usually is a compromise between the degree of physical comfort you ideally wish, on the one hand, and the cost of the energy needed for heating or cooling, on the other.

Box a: The preferred temperature is set on the thermostat control; this is called the set-point variable. It is a variable, because you have the choice between an entire range of set points. If energy costs go up, you are likely to choose a different

¹Wilde, G.J.S. (1988). Risk homeostasis theory and traffic accidents: Propositions, deductions and discussion of dissension in recent reactions. *Ergonomics*, 31, 441-468.

The concept of homeostasis

compromise between considerations of comfort and cost, and you set the desired temperature to a different level.

Box b: The thermostat control continuously compares the actual temperature reading of the thermometer with the set-point temperature; this comparison is made at a point in the regulating process that is called the comparator or summing point.

Box c: Whenever there is a discrepancy (symbolized as $[a-b]$) between the thermometer reading and the set point, and this discrepancy is greater than a given tolerance of, say, 2% to 5%, the generator of warm air (furnace) or cool air is activated. The purpose of this is to keep the difference between **a** and **b** close to zero and this is achieved through a temperature-sensitive switch that tells the unit to produce either warm air or cool air, or to do nothing at all.

Box d: In order to adjust the house temperature to the set point, the air being forced into the house is somewhat warmer than the set point in the case of thermostatic heating, and somewhat cooler in the case of air conditioning.

Box e: As a result of this adjustment action, the house temperature is changed in the direction of the set-point temperature.

Symbol f: Because the thermostat control is usually (and for an obvious reason) not located in the vicinity of the air vents, and because it takes some time for the altered air temperature to diffuse throughout the house and to finally reach the location of the thermometer, there is some time delay between the production of the adjusted house temperature and the reading on the thermometer. This brings the process back to Box b and starts another adjustment cycle. Hence the term “closed loop.”

2.2 *Homeostasis does not mean constancy*

An intriguing and indeed ironic characteristic of homeostatic temperature control is that, most of the time, the actual temperature is not in perfect agreement with the target temperature. Consider, by way of a simplified example, a heating system for a house that uses water circulating through a radiator. As the air temperature in the house drops due to the outside air being colder than inside, the heating system will not be activated until the inside temperature drops to the set point. It then takes some time for the radiator to warm up and to send warm air through the house. During that time the temperature in the house continues to cool. Subsequently, it also takes time for the heat to diffuse through the house and to reach the thermostat location. When the thermometer reading eventually rises to the set point, the heat generator will be shut off, but the radiator will continue to throw off heat for some time, so the house temperature will still rise temporarily.

The concept of homeostasis

It will then begin to cool off, and when the temperature drops to the set temperature the furnace will cut in. However, since it still takes some time for the radiator to warm up and to produce additional heat, the air in the house will still continue to cool off. It is worth noting that, if the actual temperature never dropped below the set-point temperature, the furnace would never be activated. Similarly, if the actual temperature never rose above the set-point temperature, the furnace would never be turned off.

Consequently, as shown in Figure 2.2, the actual temperature fluctuates around the set-point temperature. In fact, these oscillations are necessary to produce the signals to the heat generator to cut in or cut out. Stability of the *average* actual temperature over time is obtained by virtue of the occurrence of temperature unsteadiness! This apparent contradiction may be one of the reasons that the process of homeostasis is sometimes misunderstood, but it is part and parcel of its nature. A homeostatic process makes it possible to extract long-term steadiness from short-term fluctuations.

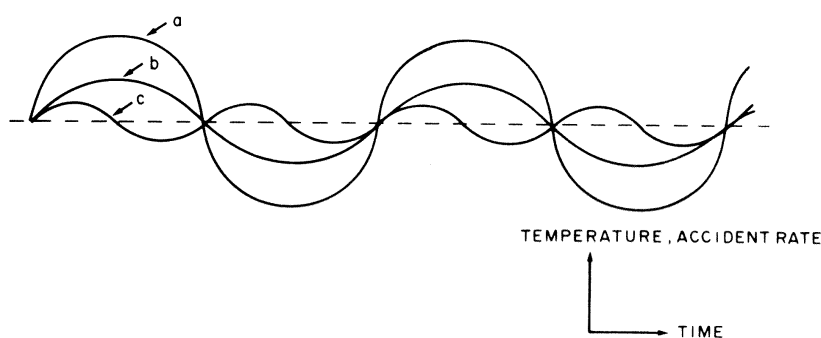


Figure 2.2: Various amplitudes and wavelengths of fluctuations of homeostatically controlled variable (solid curves) around a value that is stable when averaged over time (dotted line).¹

The magnitude (amplitude) of these variations and their frequency (how often they occur) depend upon a number of factors. One of these is the distance between the radiator and the thermometer mounted on the thermostat. The greater this distance, the larger the fluctuations will be and the longer their wavelength (i.e., the lower the frequency). In other words, the path represented by the symbol *f* in Figure 2.1 will be longer.

Other influencing factors have also been identified in Figure 2.1:

¹Wilde, G.J.S. (1982). The theory of risk homeostasis: Implications for safety and health. *Risk Analysis*, 2, 209-225.

The concept of homeostasis

Box 2: The quality of the switch function controlling adjustment action. If the switch is slow to respond or marked by high tolerance for “error”—that is, the difference between the actual and the set-point temperature—then the temperature fluctuation will show a higher amplitude and a longer wavelength (compare curve **b** with **c** in Figure 2.2). The temperature swings can be reduced if the thermostat is equipped with an *anticipator*. This is a miniature electric heater inside the thermostat casing which heats the temperature-sensing element faster than the heating system heats the house. The anticipator is activated when the furnace kicks in and turns the furnace off before the set-point temperature is actually reached. Excess of the desired temperature is thus reduced.

Box 3: The heating capacity of the furnace. Both amplitude and wavelength of temperature fluctuation will be small when this capacity is high and when heat production can be turned on and shut off immediately after the temperature reaches the set point (compare curves **a** and **c** in Figure 2.2).

Box 4: The temperature fluctuations will be small and of short duration to the extent the thermometer is more sensitive and reliable.

In passing, it is of interest to note that low tolerance for “error” and high sensitivity are not necessarily desirable. Although fluctuations in the controlled variable would be reduced in magnitude and be of shorter duration, the heat-generating mechanism would then have to be activated and de-activated in rapid succession. As this would wear out the equipment more quickly, it makes sense to make the sacrifice of accepting some degree of fluctuation in the output. In practice, a heating engineer will allow the temperature to fluctuate within limits such that the temperature changes are not noticeable or at least not uncomfortable to the user of the equipment. In other words, the difference between the peaks and the troughs in the house temperature are kept below or around the “just noticeable difference,” abbreviated as JND by psychologists.

In Chapter 4 it will be argued that there is a similarity between Boxes 4, 2 and 3 (in that order) and human perception, decision making and action. Greater precision in skilled performance can be achieved by making a greater mental effort, but at the cost of faster build-up of mental fatigue and thus at the risk of greater error at a later time.

Imagine you are driving on a perfectly straight road. You move the steering wheel in order to aim your car at a point in the distance. Since it is not possible to do this with mathematical precision, you discover, in a matter of seconds at the most, that your car is veering away from that target and you make a steering correction. Some time after that, you notice another deviation and you make another correction, and so on. Most of the time, your car is moving towards a point that is either on the left or the right of the target. You could, of course, try to reduce the magnitude (amplitude) or duration (wavelength) of the aiming errors to a bare minimum, but that would demand increased concentration and might prevent you from noticing something else that is relevant to the driving task. What you attempt, therefore, is not to minimize

The concept of homeostasis

steering error, but to keep it within reasonable limits. Here, to err is better than not to err, provided error remains within those limits.

2.3 The set point rules supreme

We get out of the car and return to our thermostat and Figures 2.1 and 2.2. We have seen that the factors represented by boxes 2, 3 and 4 in Figure 2.1 determine the size and duration of the temperature fluctuations and why this is so. The size may be large or small, the duration short or long (as sketched in Figure 2.2.), but it has not yet been stressed that, in any case, *the time-averaged temperature is independent* of the sensitivity of the thermometer, independent of the quality of the switch and of the capacity of the furnace to supply heat quickly—provided, of course, that the equipment is functioning. Boxes 2, 3 and 4 have a marked short-term, but no longer-term, effect. All they do is influence what is happening inside the closed loop.

So, what does influence the time-averaged temperature? In Figure 2.1 there is only one factor outside the closed loop and that is the set-point variable, represented by Box **a**. Accordingly, *the time-averaged temperature depends exclusively on the set-point temperature*. This is the temperature you have chosen as a compromise between considerations of comfort and costs: the target temperature. Thus, the time-averaged temperature will match the set-point temperature—once again, of course, on the condition that the equipment functions.

There is, finally, one more feature to homeostasis that I would like to call to your attention, and that is the notion of “negative feedback.” The adjustment action of the furnace (Box **d** in Figure 2.1) obviously determines the radiator temperature. However, the radiator temperature also determines the adjustment action of the furnace (by activating or de-activating it), and it does this through the feedback loop:

Box **e** → Box **b** → Box **c** → Box **d**

We are dealing with a two-way process, with mutual dependency and thus with circular causation: Box **d** controls Box **e** and Box **e** controls Box **d**. They are linked together by a process of “each one feeding the other,” and this feedback is called *negative* because the feedback *reduces the error*: a high radiator temperature will cause the furnace to be turned off and a low radiator temperature will lead to the furnace being activated.¹ As a consequence, radiator temperature will be adjusted accordingly. Homeostasis is a *self-correcting* mechanism through its use of negative feedback.

In contrast, the causation that links Box **e** to Box **a** is one-way only and linear: the set-point temperature controls the radiator temperature. Here, we are dealing with open-loop control and thus with linear causation. The same holds for the factors that

¹In control theory, feedback is called ‘positive’ when it magnifies the error, that is, when feedback increases the discrepancy between the actual and desired condition.

The concept of homeostasis

determine the desired temperature (Box 1): the causal process goes in one direction only. At these points in the control process, there is no feedback.

As we attempt to demonstrate in this report, these two features of homeostasis (the closed loop *and* the open loop) are crucial for understanding the process of accident causation, and equally important for the development of interventions that foster effective health and safety habits in the population.

*Those who have decided to swim against the current
should not expect it to change direction.*
Stanislav J. Lec¹

3 Toward a compact theory of risk taking

The idea that accident rates might be understood as the output of a self-regulating feedback process originally occurred to me, in a loose form at first, during the late 1960s. I had just read an exciting and puzzling article about some work by British psychologist Donald H. Taylor, and that article proved to be very seminal to my subsequent thinking about risk homeostasis.

At the time, with the assistance of a doctoral student, I was preparing a literature review of psychological factors in accident causation for the Canadian federal government. This was an interesting exercise. We knew, of course, that “Traffic, like God, Football, and Politics, belongs to that select group of subjects on which everyone, when the spirit seizes him, instinctively feels that he can speak with overriding authority and conviction.”² What we didn’t know, since we were novices in the scientific study of the field, was that the available literature was, and still is, extremely disconnected, fragmented and beset with a multitude of narrow views and pet solutions to the problem. Accidents have been associated with everything from mud flaps to poor eyesight, low barometric pressure, anti-social tendencies, narrow roads, driving too fast, driving too slow, alcohol use, abstinence, being young, being old, bad weather, good weather, being left-handed or in the process of getting a divorce.

Many of these factors are blessed with empirical evidence for their support, but that this blessing is rather mixed becomes apparent if one considers that the resources for the development of accident countermeasures and research are limited. If it is agreed that nothing is as practical as a good theory, one must regret the scarcity of comprehensive theories relative to the available body of findings. How can governments, social agencies and citizen groups decide where to focus their efforts in research and countermeasure development when so many divergent directions for action appear to present themselves? And what can you, as an individual, do to reduce your risk of accident? What is needed is a theory which compresses a lot of experience in a format that is concise enough to guide remedial action.

Having to write a global and coherent review forced us to seek the nature of the forest rather than the identity of the individual trees. Entering a new field while having to scan its full expanse can provide useful preventative medicine against developing that peculiar disease of experts—knowing progressively more and more about less and less, until one eventually knows everything about nothing.

¹Lec, S.J. (1971). *Das grosse Buch der unfriierten Gedanken*. Munich: Carl Hanser Verlag.

²Cohen, J. and Preston, B. (1968). *Causes and prevention of road accidents*. London: Faber and Faber, p. 13.

Toward a compact theory of risk taking

So, we were looking for the big waves, not the minor ripples. The biggest wave, we discovered, was the one described below, and it has ever since been one of the strong influences in directing my thoughts on safety and lifestyle-dependent health.

3.1 *Taylor's study*

A British psychologist, Donald H. Taylor, instructed a sample of 20 drivers to follow a preselected route that included Windsor and the western boundary of London. This route went across a great variety of road environments: urban shopping streets, suburban residential areas, winding country roads and a four-lane highway. The drivers were hooked up to a piece of equipment that measured changes in the electrical resistance of their skin.

As we all know, anxiety increases perspiration. Fortunately for those of us who are concerned about social composure, most perspiration is not visible to the naked eye, but perspiration also increases the electrical conductivity of the skin, and even minor variations in perspiration alter this resistance and are “no sweat” to be picked up by sensitive equipment that is specially designed for its measurement.

Galvanic Skin Response (GSR) is the term psychologists and physiologists use to describe this phenomenon, which is named after its discoverer, Luigi Galvani. For anybody interested in the history of science, it is a truly galvanizing experience to see his sculpture at the entrance of the University of Bologna in Italy. This is the oldest university in the western world and was established in the 11th century. By the 13th century it had some 10,000 students.

The Galvanic Skin Response can be expressed as a percentage change in skin conductance and offers a quantitative measure of the degree of fear or risk—or other arousal—experienced by a person in reaction to some event. A driver approaching a traffic light and seeing it change from green to amber may show a small GSR, but the sudden discovery of another car approaching in the same traffic lane is likely to produce a major GSR. In Taylor's study, three important variables were measured for each of forty different road sections:

(a) The Accident Rate per Vehicle-Mile. This is calculated by dividing the record of accidents over the past two years (as documented by the police) by the number of passing vehicles, and then dividing this ratio by the length of the section measured in miles. This variable represents the spatial and objective accident risk per vehicle per mile of movement through specific road sections.

(b) The GSR Rate per Mile. Total GSR activity (the combination of the number and the size of responses) is divided by the length of the section. This gives a variable which represents the spatial and subjective accident risk per driver per mile of movement through specific road sections.

Toward a compact theory of risk taking

(c) Average Speed. The average moving speed, in each separate section, for all drivers in the study.

The degree of association between these three variables was expressed in terms of correlation coefficients. Whenever two variables are perfectly and positively related, the correlation coefficient equals +1; when the association is negative and perfect, the correlation coefficient equals -1, and it will be zero when there is no association at all. For example, the correlation between body height and body weight is typically in the order of $r = +0.7$. Taylor found the following correlation coefficients (abbreviated as **r**):

Between Accident Rate per Vehicle-Mile and
Average GSR Rate per Mile. $r = +0.61$

Between Accident Rate per Vehicle-Mile
and Average Speed. $r = -0.67$

Between Average GSR Rate per Mile and
Average Speed $r = -0.75$

So, what is the significance of these findings (apart from the fact that their likelihood of having occurred by chance was less than one in a thousand)? The positive association between Accident Rate per Vehicle-Mile and the GSR Rate per Mile can be interpreted to indicate that the drivers experienced more subjective risk in road sections that were also marked by high rates of accidents in the historical records. Apparently, then, drivers on average are sensitive to conditions in which many accidents happen, and react with increased fear.

And what did they do in these conditions? The observed negative correlation between the Accident Rate per Vehicle-Mile and Average Speed indicates that in these conditions they slowed down, while they moved faster in road sections with a low accident rate per vehicle-mile.

Finally, and most interestingly, the negative correlation between Average Speed and GSR Rate per Mile in the forty road sections indicates that the drivers kept the amount of risk they experienced relatively stable over time as they drove through the various road sections. In those road sections where they experienced a lot of risk, they slowed down and thus spent more time in these locations, thereby spreading the GSR activity out over a longer period of time. In contrast, where the GSR Rate per Mile was low, they moved at higher speeds, so whatever GSR activity there was occurred in a shorter time frame. The end result was that GSR activity, or subjective risk experienced per time unit of travel, appeared to be relatively stable and independent of the particular road sections in which the driving was done, and thus independent of the accident rates per vehicle-mile of these road sections. To quote Taylor:

Toward a compact theory of risk taking

*With subjective and objective risk thus defined [i.e., not per mile or km, but per time unit of exposure to risk], the conclusion from the present data is that they are both independent of what we normally mean by variations in road conditions. A possible reason why the subjective risk should be distributed thus may be found in the driver's ability to vary his performance. To some extent at least, he can voluntarily influence the risks taken (for example, by accepting or not accepting opportunities to overtake, or simply by going slowly or fast). Provided that he has this control, there would usually be no reason why he should wish to engage in more risk on one part of the road than on another, and in fact he could be said to be performing a self-paced task. When it is considered that the major restriction on his speed is due to other vehicles, the drivers of which may be expected to be behaving in much the same way, driving could be called a "collectively self-paced task."*¹

3.2 Some possible consequences

Thus, *spatial* accident risk, objective as well as subjective, showed a heterogeneous density distribution with major variations from one road section to another. That is not surprising. But what is surprising in these observations by Taylor is that *temporal* experience of subjective risk was homogeneous from one time period to another and thus *independent* of the road section and its past accident record per vehicle/km. Apparently, the drivers managed to respond to the objective variations in spatial risk in such a manner that temporal objective risk was independent of changes in spatial objective risk.

Allow yourself a moment to go beyond Taylor's article, as I did at the time, and imagine what far-reaching implications this interpretation might have. Engineering improvements of motor vehicles and the road environment can reduce the objective spatial risk, but what happens to objective temporal risk? If drivers adjust their behaviour in response to these improvements, it is no longer logical to presume that the accident risk per time unit of driving will also be reduced. In fact, if the total amount of time people spend on the roads is not affected, the accident rate per head of population would not change at all. And if the engineering improvements make driving more attractive so that people spend more time on the roads, the accident rate per head of population will even increase. All this is possible despite, or rather because of, engineering improvements that led to a reduction in the accident rate per km driven.

Accordingly, the prospect for greater public safety is unlikely to be found in a "technological fix" because of the way people respond to such fixes. Instead, the prospect for safety is inside the human being, not in the human-made machine or human-made physical environment. Where it is located in the human being and how it may be influenced will be proposed in the chapters that follow.

¹Taylor, D.H. (1964). Drivers' galvanic skin response and the risk of accident. *Ergonomics*, 7, 439.-451, p. 448.

3.3 *Replicating Taylor's findings*

There can be no question that these ideas occurred to me because of the literature I had read some ten years earlier, when still a student at the University of Amsterdam and receiving a generalist type of education in psychology. I had the fortune of having been exposed to the writings of Norbert Wiener¹ and others on cybernetics and the essentials of control theory, and on their potential implications for understanding the human condition.

Excited and bewildered as I was by these rather unconventional but potentially very significant speculations, I grabbed the first possible opportunity to visit the author of the study that had triggered them. In this day and age of academic pressure to publish or perish, and the consequent threats to the quality and dependability of what appears in the scientific press, one wishes to check that one is relying on a serious person, and I myself have many times been subjected to inspection for that very purpose. Years earlier, a professor of surgery at the University of Amsterdam had told me that he went to scientific conferences, not primarily for the purpose of receiving the latest bit of information, but to get a personal impression of the reliability of authors whose publications he had read.

The second thing one of my students and I did was to see if we could replicate Taylor's findings while using a somewhat different method of data collection on drive in locations as far afield as Windsor in England and Kingston in Ontario. We asked our sample of drivers to give a continuous indication of the amount of risk they perceived on a rating scale from one to ten. The results of these verbal ratings were the same as the earlier findings regarding GSR: the reported amount of risk per time unit of driving was essentially independent of where the driving was done and, just as Taylor had found, less experienced drivers gave higher risk ratings than old hands at the task of driving.² This corresponds neatly with the fact that inexperienced drivers are more likely to have accidents (see Chapter 10).

Years later, another student³ produced another replication and extension of the preceding studies and found the following correlation coefficients:

¹Wiener, N. (1952). *Cybernetics*. New York: Wiley.

²Ganton, N. and Wilde, G.J.S. (1971). *Verbal ratings of estimated danger by drivers and passengers as a function of driving experience*. Report prepared for the Road and Motor Vehicle Traffic Safety Division, Ministry of Transport, Ottawa.

³Moran, A. (1982). Drivers' mental load and subjective risk estimates while driving road sections of different accident histories. *Proceedings, 15th Annual Meeting of the Human Factors Association of Canada*, pp. 72-75.

Toward a compact theory of risk taking

Between Accident Rate per vehicle-km
and Average Risk Rating per km $r = + 0.89$

Between Accident Rate per Vehicle-Km
and Average Speed $r = - 0.74$

Between Average Risk Rating per Km
and Average Speed $r = - 0.92$

Compare these findings with those in Section 3.1 above and you will see that they amply support the earlier ones. Moreover, the eleven individual drivers in this study showed considerable agreement with one another regarding the average perceived riskiness per km of the ten different road sections that were included in the study. The inter-rater reliability amounted to $r = + 0.83$. So, drivers are not only sensitive to conditions of different accident histories, but also show marked similarity in their risk perceptions. We return to this issue in Section 10.4.

3.4 *The French connection*

So far, what we have seen is that drivers are apparently quite capable of controlling their vehicles in such a manner that they keep their subjective accident risk at a more or less stable level, a level that is above zero risk. This can be seen when their momentary perceptions are averaged over the time they take to negotiate diverse road sections. Although this observation may evoke the notion of homeostasis, the full operation of a homeostatic process entails much more, as will be described in Chapter 4.

The formulation of what would eventually become Risk Homeostasis Theory (RHT) has taken a long time. A major step forward was made in the early 1970s during a sabbatical leave, that leisure of the theory class, at the then National Institute of Road Safety in Montlhéry near Paris. It was then that I had an opportunity to try to accommodate the many factors known to be associated with accident likelihood in a single comprehensive model. For that purpose, I had written the elements I felt had to be entered in such a model on separate filing cards and arranged them in various different flow diagrams in hopes that one of these diagrams might be a reasonable representation of reality. One morning, while organizing the cards, I was suddenly hit by a two-pronged idea. The first prong was the notion of a closed-loop control process between accident occurrence and driver adjustment action. Thus was born the idea that changes in driver behaviour influence the accident rate (which is obvious) *and* that changes in the accident rate influence driver behaviour (which may be less obvious). The second prong was the concept of a target level of risk, which ultimately controls the accident rate, as the *only* important causal factor.

Eureka, everything on the filing cards seemed to fall into place. But the next moment I was filled with doubt. The notion of homeostasis appeared too much of an “idealization” to account for the complexities of human behaviour and “too rational,”

Toward a compact theory of risk taking

so to speak, to hold in a world where people only have incomplete information. Could the multitude of factors that play a part in accident occurrence really be grasped in such a comparatively simple model? Weren't there numerous ways in which such a theory could go wrong? People being so different from each other in skill and motivation, each having faulty perceptions of risk, and nobody—not even the experts¹—really knowing the precise dimensions of the accident toll,² there seemed to be plenty of reasons to question the idea. On the one hand, it seemed to me that it had to be true and on the other, that it couldn't.

Wasn't it heresy to propose a theory that might suggest that obvious advances in engineering, education, legislation, and medicine have failed to reduce the rate at which people die as a result of accidents?

Making a first attempt at finding supporting evidence, I discovered some World Health Organization statistics that seemed to indicate that, although the per capita rate of traffic fatalities increased over the 20th century, the total mortality rate due to all violent death remained very much the same. As it turns out, later studies would shore this up more firmly (see Chapter 12).

For a long, long time I have swayed between the feeling of jubilation and the fear of making a fool of myself. In fact, there have been several critics who felt that I had been quite successful in doing the latter. While some made congratulatory remarks,^{3,4} the idea of risk homeostasis has been mocked as a Freudian and pseudo-scientific belief held by a morally and religiously prejudiced Dutch-Calvinist preacher (*bien étonnés de se trouver ensemble!*) who is blazing the notion of a perverse death wish.⁵ Other colourful reactions referred to the theory as “Wilde’s law of the conservation of misery,”⁶ “the devil’s idea to some in the safety community,”⁷ or wondered if it is as difficult to prove as the existence of God⁸ (which it isn’t, thank God) or wrote in the process of quoting RHT that it wasn’t worth quoting!⁹

¹For instance, in the entire country of New Zealand, during 1995, less than two-thirds of all hospitalized vehicle occupant traffic crash victims were recorded by the police. Alsop, J. and Langley, J. (2001). Under-reporting of motor vehicle traffic crash victims in New Zealand, *Accident Analysis and Prevention*, 33, 353-359.

²Hakkert, S. and Hauer, E. (1988). The extent and implications of incomplete and inaccurate road accident reporting. In J.A. Rothengatter and R.A. de Bruin, *Road user behaviour: theory and research*. Wolfeboro, New Hampshire: van Gorcum.

³Slovic, P. and Fischhoff, B. (1982). Targeting risk. *Risk Analysis*, 2, 227-234.

⁴Adams, J.G.U. (1985). *Risk and Freedom: the record of road safety regulation*. London: Transport Publishing Projects.

⁵Oppe, S. (1985). Contribution to evaluation of intermediate variables: background paper. *Proceedings, Evaluation 85*, Paris, May 20-23, pp. 317-323.

⁶Michon, J.A. (1979). Personal communication. Department of Psychology, University of Groningen NL.

⁷Blomquist, G.C. (1988). *The regulation of motor vehicle and traffic safety*. Boston, Mass.: Kluwer Academic Publishers, p. ix.

⁸Joubert, P. (1985). Comment in L. Evans and R.C. Schwing, *Human behavior and traffic safety*. New York: Plenum Press, p. 144.

⁹Evans, L. (1986). Comments on Wilde’s notes on “Risk homeostasis theory and traffic accident data.” *Risk Analysis*, 6, 103-107.

Toward a compact theory of risk taking

In another statement, the theory was rejected because "...the claim that risk per unit time is a constant is no more a theory than the claim that all people are the same height, or think they are the same height."¹ This criticism reveals a lack of understanding of homeostasis and attacks RHT on a position that is not even held by that theory. Homeostasis does not mean constancy (see Section 2.2). Another comment in the literature says: "In my view, a sufficient argument against the validity of risk homeostasis is provided by the incoherence [sic] of its 'theoretical formulation;'"² unfortunately, this critic does not explain his reasons for the "incoherence" allegation.

Others have blamed RHT for being "negative" or "pessimistic" with respect to the potential for accident prevention.^{3,4} Neither accusation seems to make much sense: there is nothing negative in saying that the sun does not revolve around the earth, as people have believed for centuries and some authorities even longer. How could being negative, in the sense of saying that something isn't true or doesn't work, ever be a scientific vice?

Contrary to the puzzling and fatalistic interpretation of RHT as "an inescapable law of risk homeostasis" that leaves no room for improvement,⁵ there is nothing pessimistic in RHT with respect to the potential for accident prevention. In the first place, it does acknowledge that the accident rate per kilometre of travel can be brought down. Secondly, it states that some accident countermeasures are unable to reduce the per capita accident rate, but also spells out how the accident rate per person in the population can be reduced by accident countermeasures of a different nature. Thus, proponents of RHT are no more pessimistic than physicians who tell their patients that a strep throat cannot be cured with bloodletting, while at the same time handing over a prescription for antibiotics.

Apart from a not-so-subtle pressure on journal editors to refrain from any further publication of the theory or even a bibliographical reference to it, perhaps the most extraordinary, and indeed bizarre reaction, was that of an editor who had invited me to write a chapter for a study guide. He did not like a large part of what I had written and replaced it with his own views. And then, unbeknownst to me, he published the text under my name. Plagiarism in reverse! Evidently, even within the academic world there are forces that would like to see the ivory tower lean in their preferred direction, the ivory becoming tainted in the process of their pushing. In case you, reader, are experiencing similar objections from your peers, here is my consolation: if your ideas are immediately acceptable to most of your colleagues, they are unlikely to be of

¹Evans, L. (1991). *Traffic safety and the driver*. New York: Van Nostrand, p. 330.

²Haight, F.A. (1986). Risk, especially risk of traffic accident. *Accident Analysis and Prevention*, 18, 359-366.

³Huguenin, R.D. (1982). Zur Problematik von Risikohomöostasetheorien in der Verkehrspsychologie. *Zeitschrift für Verkehrssicherheit*, 28, 180-187.

⁴McKenna, F.P. (1985). Do safety measures really work? An examination of risk homeostasis theory. *Ergonomics*, 28, 489-498.

⁵Graham, J.D. and Wiener, J.B. (1995). *Risk versus Risk*. Cambridge, Massachusetts: Harvard University Press, p. 37 and 226.

Toward a compact theory of risk taking

much interest. Stanislaw Lec offers another word of comfort: “People’s understanding may be slow to kindle, but it will catch on by the next generation.”¹

Wait, there is more to come. As recently as 1998, just when risk homeostasis threatened to become part of common, “mainstream” thinking in the community of accident research and prevention, RHT was put down in its place as being about as credible as the “flat earth hypothesis,”² and “entirely vacuous.”³

In contrast, a friend of mine – we had known each other since we about ten years old and he had become a computer scientist – told me: “That’s all very nice, with your book on the internet and all that, but tell me, how did you manage to write more than 200 pages on an idea that is so clear, simple and self-evident?”⁴ He, the avid alpinist he was, also pointed out to me that the very availability of modern search and rescue entices mountaineers to venture out farther.⁵ Another study shows that in response to danger warnings “climbers do assess a ‘personal’ probability of injury and incorporate the hazard warning message when choosing climbing routes,” the more skillful climbers choosing the more dangerous alternatives.⁶

But perhaps the most ironic of all reactions to my work was still another publication. That one did not at all question the validity of risk homeostasis theory, and seemed to accept it as common knowledge, but attributed it to a different author!⁷

As these “mixed”—to say the least—reactions to RHT, however, were not to occur until several years later, allow me to return to the time when I was still in sweet and wonderful France and comfortably close to the perfectly straight Eiffel tower. In addition to Taylor’s work and my much earlier exposure to cybernetics, there was another publication that I had read within weeks, if not days, of that morning in the hills of Montlhéry, and it would give me a measure of confidence in my feedback model that tries to explain the accident rate.

That publication was the Report of the Club of Rome,⁸ which was widely discussed at the time and has added a major momentum to concerns about world-wide environmental degradation and pollution. It had just appeared as a book entitled *The*

¹Lec, S.J. (1971). *Das grosse Buch der unfrierten Gedanken*. Munich: Carl Hanser Verlag.

²O’Neill, B. and Williams, A.F. (1998). Risk homeostasis hypothesis: A rebuttal. *Injury Prevention*, 4, 92-93.

³Elvik, R. (1999). Can injury prevention go too far? Reflections on some possible implications of Vision Zero for road accident fatalities. *Accident Analysis and Prevention*, 31, 265-286.

⁴Struik, H. (1997). Baak, the Netherlands. Personal communication

⁵Donatsch, P. (1997). “The helicopter will get me out for sure.” Opportunities and risks of new methods of search and rescue by air (in German). In M. and E. Landes (Eds.), *Berg ‘97 Alpenvereinsjahrbuch*, Vol. 121, pp. 173-177.)

⁶Jakus, P.M. and Shaw, W.D. (1996). An empirical analysis of rock climbers’ response to hazard warnings. *Risk Analysis*, 16, 581-586.

⁷Trepess, D. and Stockman, T. (1999). A classification and analysis of erroneous actions in computer supported cooperative work environment. *Interacting with Computers*, 11, 611-622.

⁸Meadows, D. (1972). *The limits to growth*. New York: Universe Books, p. 152.

Toward a compact theory of risk taking

Limits to Growth and it contained many examples of rather surprising feedback effects of technological innovations upon social and economic variables. One of these innovations, the so-called Green Revolution – a “technological fix” combining new seed varieties, fertilizers and pesticides – is a telling example of the occurrence of unforeseen and undesirable side effects. While this “revolution” did indeed improve agricultural yields, it led to greater rural prosperity in some countries, but greater poverty in others, because of feedback mechanisms that are easily understood after the fact, but apparently more difficult to foresee in advance. The big-scale farmers adopted the innovation first, made profits and, where allowed to do so, bought the landholdings of the small farmers. Increased unemployment among the latter, poverty, and migration to the cities were the result.

The Green Revolution produced a greater harvest yield per unit of arable soil, but not necessarily a greater prosperity per head of population. The effect of the technological innovation depended upon the nature of the human condition in which it was adopted. Because of the powerful impact that *Limits to Growth* had on me, and the obvious parallel between that book and the theory I am describing here, I have been tempted to publish my books under a title such as *The Limits to Safety*.

At any rate, my mind was made ready to conceive and even to advance, albeit at first with hesitation, the idea that safety measures that reduce the accident rate per km driven do not necessarily enhance safety per head of population and may even diminish it.

The hesitation originated not only from the fear of being plainly wrong or the threat of ridicule, but also from my strong allegiance to the applied mission of ergonomics, that is, the notion that by “fitting the task to the operator,” gains can be made in productivity, safety, health, comfort and satisfaction with the task, and all this by altering the physical features of the task environment rather than by interventions that try to change the operator. At first it seemed to me, as it must have to others, that by proposing the new views, I was guilty of disloyalty to the professed goals and methods of ergonomics. There is no need for such misgivings, because, depending upon societal goals, it can indeed make good sense to modify roads and cars in ways that reduce the accident rate per km driven, even if such interventions do not reduce the accident rate per time unit of road use (see Chapter 5).

The theory that resulted from this turmoil of conflicting considerations and inclinations I originally labeled “risk compensation theory.” And in choosing that label I clearly could have done better.^{1,2,3} The term “risk compensation” is also used to refer to extra pay for hazardous work (“danger money”), and in the current context

¹Wilde, G.J.S. (1974). Wirkung und Nutzen von Verkehrssicherheitskampagnen: Ergebnisse und Forderungen - ein Überblick. *Zeitschrift für Verkehrssicherheit*, 20, 227-238.

²Wilde, G.J.S. (1972). General survey of the efficiency and effectiveness of road safety campaigns: Achievements and challenges. *Proceedings, International Conference on Road Safety Campaigns*. The Hague, October 19-20.

³Wilde, G.J.S. (1978). Theorie der Riskokompensation der Unfallverursachung und praktische Folgerungen für die Unfallverhütung. *Hefte zur Unfallheilkunde*, 130, 134-156.

Toward a compact theory of risk taking

it strictly speaking, incorrect because, according to the theory, road users are not expected to compensate for risk in such a way as to reduce it to zero, but instead to show some form of behavioural adjustment in response to what might be called “changes in *intrinsic* risk.” These are the changes in risk that would theoretically occur under the condition that road users would not alter their behaviour in the face of interventions, for instance, if they did not decide to drive faster when cars are made more crashworthy and roads are widened.

However, risk compensation theory says that they will alter their behaviour. Thus, labels such as “conservation of risk” or “safety compensation” might have been more appropriate, but unfortunately, these do not clearly point at the mechanism of homeostasis. Quite a number of authors have referred to my work using the terms “risk compensation” or “danger compensation,” and some have made a distinction between “risk compensation” and “risk homeostasis” as if compensation were a soft-peddalling or watered-down version of homeostasis.¹ They suggest that compensation might be partial and fall short of homeostasis, that is, complete compensation. That is not what I meant. Despite the relative unfamiliarity of the word “homeostasis” and the common misunderstanding of its meaning, the term “risk homeostasis” seems to be preferable to “risk compensation,” “risk conservation” or “safety compensation.” Another possible label would be “the theory of behavioural compensation in response to changes introduced in intrinsic risk.” But, although correct, this title is rather awkward. At any rate, all four labels are merely different names for the same fare.

Ever since the publication of an OECD report in 1990, the term “behavioural adaptation” to technological safety interventions has become increasingly popular.² A problem with this term is that it does not spell out to what criterion, to what end effect, this “behavioural adaptation” is supposed to operate, nor why it should occur at all. The term “risk homeostasis” would seem more appropriate.

¹Grayson, G.B. (1996). *Behavioural adaptation: A review of the literature*. Report 254. Crowthorne, U.K.: Transport Research Laboratory.

²OECD (1990). *Behavioural adaptations to changes in the road transport system*. Paris: Organization for Economic Co-operation and Development; Road Transport Research.

*One of life's challenges is to risk it
to the optimal degree.*

4 *The theory of risk homeostasis*

The theory of risk homeostasis has already been outlined towards the end of the Introduction, and the mechanism of homeostatic control has been discussed in detail in Chapter 2. From what has been said so far, it will be clear that in attributing the causation of accident loss in a nation to a homeostatic process, I am not trying to impose a mechanistic conceptualization of the behaviour of human beings. It is rather the other way around: a homeostatic engineering device is modeled after processes that naturally occur in living organisms, and any engineered device is likely to be much less complex, less resourceful and adaptive. For one thing, living organisms can adjust to many more changing conditions, by virtue of their capacity for many more alternative behaviours, than technical contraptions. For another, living organisms learn from past experience, so they never behave in exactly the same way from one point in time to another. We do not suggest that people are thermostats. The thermostat served as an illustration of the principle of homeostasis, no more.

With the help of Figure 4.1 the theory can now be spelled out in more precise detail insofar as it applies to traffic accidents. Although this figure has been drawn to be analogous to Figure 2.1, please note that Figure 4.1 does not refer to a single individual, but to all road users in a given jurisdiction such as a city, township, county, province or nation. Similarly, Box **e** (accident loss) refers to all traffic accidents that occur in the jurisdiction over a given period of time (say, one year), and the extent of that loss is what the theory attempts to explain.

4.1 The target level of risk

A variety of factors (Box **1**) determine the extent of the accident risk that different people are willing to take during any given time period, and that the same people are willing to take during different time periods. When the expected benefits of risky behaviour are high and the expected costs are perceived as relatively low, the **target** level of risk (Box **a**) will be high. The term “target” is meant to be synonymous with “preferred, desired, accepted, tolerated and subjectively optimal,” and target risk varies, as does the set-point temperature on a thermostat.

More precisely, the target level of accident risk is determined by four categories of motivating (i.e., subjective utility) factors:

1. The expected **advantages** of comparatively **risky** behaviour alternatives: for instance, gaining time by speeding, making a risky manoeuvre to fight boredom.
2. The expected **costs** of comparatively **risky** behaviour alternatives: for instance, automobile repair expenses, insurance surcharges for being at fault in an accident.

3. The expected **benefits** of comparatively **safe** behaviour alternatives: for instance, an insurance discount for accident-free driving.
4. The expected **costs** of comparatively **safe** behaviour alternatives: for instance, using an uncomfortable seatbelt, being called a wimp by one's peers.

The higher the values in categories 1 and 4, the higher the target level of risk. The target level of risk will be lower as the values in categories 2 and 3 rise. Some of the motivating factors in all four categories are economic in nature; others are of a cultural, social or psychological kind. They are usually so thoroughly internalized that most people, most of the time, are not consciously aware of them.

It is obvious that a person does not arrive at a target level of risk by careful conscious *weighing of the exact probabilities and value (positive or negative) of various outcomes*, which are essentially unknown for any specific traffic situation, and even if they were known it would take time and calculation equipment that is not available to the decision-maker behind the steering wheel. So, instead the driver relies on a different decision-making mode that is intuitive and affective in nature: *the target level of risk is what "feels right."* That this deciding on "what feels right" is not necessarily inferior to an elaborate analytical process has been demonstrated in recent research.^{1,2} Similarly, in laboratory experiments on risk homeostasis, in which it was virtually impossible for the participants to act on precise knowledge, they quickly learned to optimize risk (see Chapter 9)), which also turned out to generalize to other tasks with answers that were unknown to the participants.

Thus, the target level of risk should not be viewed as something that people arrive at by explicitly calculating probabilities of various possible outcomes and their respective positive or negative values. A person who lowers the thermostat before going to sleep, or when leaving home for the weekend, chooses a setting intuitively rather than on the basis of precise calculations of expected cost and benefits. This is equally true when that person resets the target temperature on the thermostat the next morning or after returning from the weekend trip.

The expression "target level of risk" should not be understood to imply that people strive for a certain level of risk for its own sake. Target risk does not mean risk

¹Usher, M., Russo, Z., Weyers, M., Brauner, R. and Zakay, D. (2011). The impact of the mode of thought in complex decisions: *Intuitive decisions are better*. *Frontiers in Psychology*, 2, 37.

²Dijksterhuis A., Bos M.W., Nordgren L.F. and van Baaren, R.B. (2006). On making the right choice: the deliberation without attention effect. *Science* 311, 1005-1007.

for the sake of risk¹, just as the target temperature you set on your thermostat is not necessarily the one you would choose if energy costs were less important, or you needed more warmth. Similarly, fever may well be useful in the body's fight against disease, but that does not mean that a fever is what you really want.

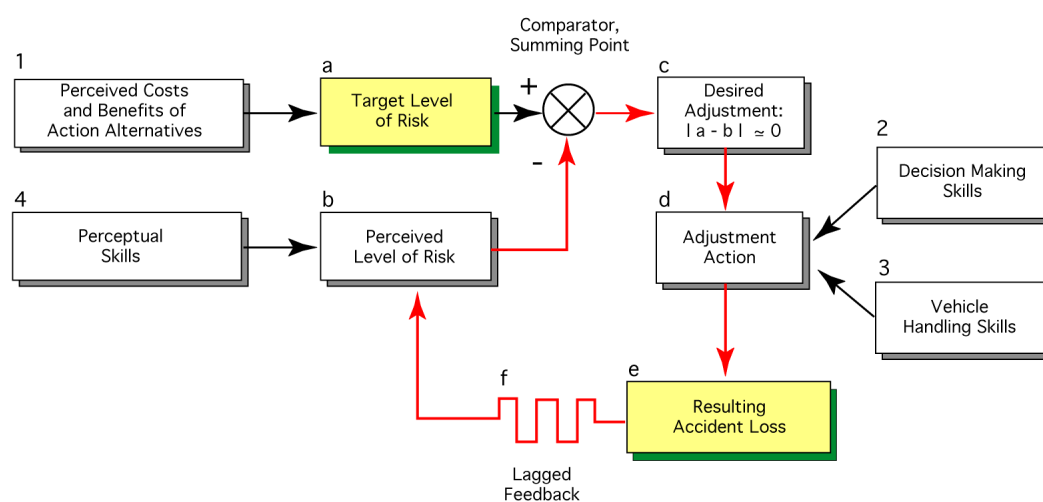


Figure 4.1: Homeostatic model relating the accident rate per head of population in a jurisdiction to the level of caution in road-user behaviour and *vice versa*, with the average target level of risk as the controlling variable.² Note the analogy between this figure and Figure 2.1 in Section 2.1 above.

It is obvious that economic motives play an important role among the factors that influence anybody's target level of risk. If moving oneself or goods from A to B is a way of making money, driving fast gains profit as well as time, but it also means greater accident risk, higher fuel costs and more vehicle wear and tear. Accident risk may also be accepted for the purpose of satisfying other than economic desires, such as curiosity, adventure, seeking variety, and fighting boredom. Note that being curious implies being uncertain about outcome and thus that people may actually seek

¹As some critics of risk homeostasis theory seem to infer; e.g., Hedlund, J. (2000). Risky business, safety regulations, risk compensation, and individual behavior. *Injury Prevention*, 6, 82-89.

²Wilde, G.J.S. (1982). The theory of risk homeostasis: implications for safety and health. *Risk Analysis*, 2, 209-225.

uncertainty. Almost one-half of all travel is due to weekend, holiday and leisure trips.¹ As Goethe said: “One does not travel only to arrive,” or, according to more recent observations:

*“Trip time is part of destination activity in some ways—[and] may be the source of various satisfactions: self-discovery, reflection, daydreams, reaching outside work and family context—we could list numerous examples which would clearly show that the minimization of distance covered or time spent is not what is sought—but] pleasure in driving, speed, physical effort, a special relationship with the environment.”*²

A person’s target level of traffic accident risk is defined as *that level* of subjective accident risk at which the difference between benefits and costs (including the perceived danger of accident) is believed to maximize. There may be cases in which risk is *deliberately pursued*, but most risks that people incur are rather more *passively accepted* as the inevitable consequence of their deliberate choice of action. Anybody who takes to the road knows that they an accident might happen, either because of their own behaviour, or because of the behaviour of other road users that cannot be predicted, let alone controlled.

Passive acceptance of risk is typical of travel by public means. Anybody deciding to board an aircraft, train, or bus as a passenger takes that risky decision before the act of boarding. That person has virtually no control over what will happen next. Thus, the subjective level of risk may be elected in the sense of being preferred or desired, but in other cases it may be better described as accepted or tolerated.

¹Bouladon, G. (1979). Costs and benefits of motor vehicles. In *Urban transport and the environment: background reports*. Organization for Economic Cooperation and Development, in cooperation with the European Conference of Ministers of Transport, Paris, pp. 277-319.

²Matalon, B. (1978). Do we move for other reasons than going places? *Proceedings, Research Conference on Mobility in Urban Life*, Arc-en-Senans, Sept. 28-30.

Why people should opt for a level of accident risk that is greater than zero can be explained by referring to Figure 4.2. As you move from left to right along the horizontal axis of exposure to accident risk (for instance, by increasing your speed or your amount of driving), both expected gains and expected losses increase. Greater speed means shorter travel time towards your destination, as well as more thrill and

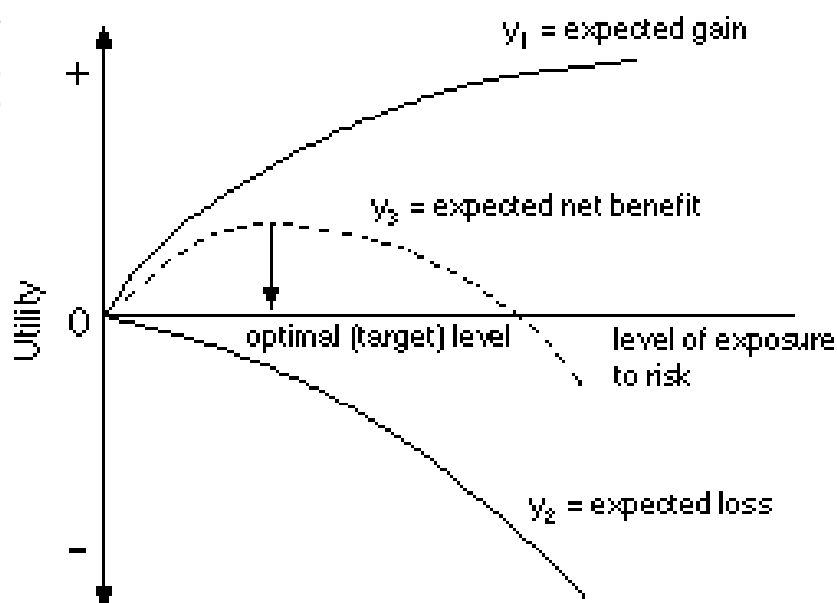


Figure 4.2: Theoretical representation of road users as net benefit maximizers and thus as risk optimizers. They choose an amount and manner of mobility such that the associated level of subjective risk corresponds with the point at which the expected net benefit is maximal. Note that the curve y_3 has been drawn so that each y_3 value equals the corresponding value y_1 minus the corresponding value y_2 absolute.¹of transport.

excitement. Greater speed also means more wear and tear on your car, higher gasoline consumption, a chance of a traffic ticket, and more severe consequences if an accident were to happen.

For each speed and level of subjective accident risk, the expected net benefit equals the expected gain minus the expected loss. In Figure 4.2, the curves describing expected gain and expected loss have been drawn such that the expected net benefit curve rises from left to right, then reaches a top which is followed by a decline. At zero speed or zero subjective risk, there is no mobility and the net benefit of mobility is nil.

¹Wilde, G.J.S. (1988). Risk homeostasis theory and traffic accidents: propositions, deductions and discussion of dissension in recent reactions. *Ergonomics*, 31, 441-468.

Risk taking is not to be glorified, but it should not be condemned either. Look at turtles: they don't get anywhere if they don't stick their necks out.

When speed is extremely high, the expected loss is greater than the expected gain and the expected net benefit falls below zero.

The extremes are thus to be avoided: people should neither minimize nor maximize the danger of accident. What they should do instead is attempt to maximize the expected net benefit from road travel and choose a speed and other actions accordingly. They should, therefore, try to select a level of risk that is above zero and that provides a maximal net benefit from the behaviours chosen. Risk homeostasis theory maintains that that is exactly what people are trying to do. Since zero risk is obviously not a meaningful goal, because there is no behaviour with total certainty of outcome, people target their risk level above zero.

"The policy of being too cautious is the greatest risk of all" said Jawaharlal Nehru, the first president of independent India. This is how the idea of the danger of accepting no more than zero risk has been expressed in a jocular anonymous rhyme:

"Opportunities missed"

*There was a very cautious man,
who never laughed or cried.
He never risked, he never lost,
he never won, nor tried.*

*And when he one day passed away,
his insurance was denied.
For since he never really lived,
they claimed he never died.*

Some of the variations in target risk between individuals are relatively *long-lasting*, for instance, those due to cultural values, the state of the economy, the socio-economic status of the person, incentives for accident-free driving, occupation, peer-group attitudes, level of education, gender, age, and possibly personality traits. *Shorter-term* variations occur within the same individual and are due to the specific purpose of the trip and the urgency of arriving on time, current pre-occupations with stressing life events, mood, fatigue, being under the influence of alcohol, etc. Finally, some variations in target risk are *momentary* and may be incurred by the same person within the course of a trip. The target level rises after being held up in traffic and drops when making unexpectedly good progress, allowing the driver to relax. It has been shown that the longer drivers have to wait at a stop sign before entering a major street, the more they become willing to accept gaps in traffic that are shorter than

those they rejected at first.¹ A sudden change in conditions, such as a rain shower, may increase the desire of pedestrians and bicyclists to reach their destination as quickly as possible if there is no shelter, thus increasing their target accident risk.

Variations in the target level of risk within the same person should not be viewed as a deficiency, let alone as a breakdown or absence of homeostatic control. As has been emphasized above, homeostasis does not mean invariance of the end result, but refers to a process that aims at insuring that the end result matches the set-point variable. When we have a fever, our body temperature is still homeostatically maintained. "The body's thermostat is simply set at a higher level."² The target temperature level is higher when people have a fever, just as the target blood pressure level is higher during heavy physical work than when people are resting.

In 1929, Walter Cannon,³ an American physiologist, proposed the term "homeostasis" as a label for the dynamic process that had been discovered some 70 years earlier by the French physician Claude Bernard.⁴ He showed considerable wisdom in calling it *homeo*-stasis, not *iso*-stasis. "Homeo" means "like, matching, agreeing" while "iso" means "same, equal, identical," as in isobar, isotope and isotherm. An isotherm is not a homeotherm, and isosceles is not homeosceles. Encyclopedias explain the difference between isostatic and homeostatic. Isostatic has to do with a state of sameness, homeostatic with a mechanism that keeps the output at a desired level. Homeostasis, therefore, should *not* be viewed as a process that keeps the output the same, at an invariably fixed level. As was stressed by researchers at Harvard University another 70 years later:

Bernard's and Cannon's teachings that the integrity of higher forms of life relies on maintenance of a constant internal milieu have been central to modern physiological theory. Unfortunately, the teaching of [the concept of homeostasis] to successive generations of medical students has led to an overly simple perception being embedded in the collective medical consciousness. Cannon never suggested that every physiological variable is tightly regulated within limits, nor did he indicate that even the most well-regulated variables were maintained at an absolute constant level.

It is interesting to note that Cannon (1929), in the article in which he first outlined his concept of homeostasis, specifically pointed out that even the most tightly regulated variables may oscillate. He accordingly defined homeostasis as the process which regulates a physiological variable within certain limits, but that

¹Ebbesen, E.B. and Haney, M. (1973). Flirting with death: variables affecting risk taking at intersections. *Journal of Applied Social Psychology*, 3, 303-324.

²Langley, L.L. (1965). *Homeostasis*. New York: Reinhold.

³Cannon, W.B. (1929). Organization for physiological homeostasis. *Psychological Review*, 9, 399-431.

⁴Bernard, C. (1859). *Leçons sur les propriétés physiologiques et les altérations pathologiques des liquides de l'organisme*. Paris: J.B. Ballière.

*the variable may oscillate between those limits, and the limits themselves may change in response to some special demand.*¹

The “overly simple perception,” alas, is not limited to people in the medical profession. Some researchers and practitioners in the field of safety and public health seem to suffer from the same affliction.

You may have noticed that I belabour the point that the target level of risk is not fixed once and forever—nor is the accident rate per capita. But I think there are good grounds for reiterating this point. The fact is that some published critiques of risk homeostasis theory have mistakenly interpreted it as stating that the target level of risk, and thus the accident loss, is immutably fixed.^{2,3} This misinterpretation explains why one critic made the rather amusing, but no less erroneous, quip by referring to the theory as “the law of the conservation of misery.” Risk homeostasis does not imply a law of “the conservation of accidents,”⁴ just as homeostasis of body temperature or blood pressure does not imply invariant body temperature or invariant blood pressure.

Homeostasis is a process, not an outcome, let alone an invariant outcome. Expressions such as “partial homeostasis,” “exact homeostasis,”⁵ “incomplete homeostasis” and similar ones that have cropped up in well over 20 years of “the great risk homeostasis debate” make very little sense. The use of such expressions betrays two basic misunderstandings of the nature of homeostasis. For one thing, these expressions are mistaken because they refer to outcome, not to process. For another, they misinterpret the outcome as something that should be fixed and invariant. Some people have referred to risk homeostasis theory saying that it implies constancy of risk.^{6,7,8} They’ve even mislabeled it “the constant risk hypothesis.”⁹ We will see, in Chapter 11, that the main hope for developing interventions that are capable of reducing the accident loss per person is precisely located in the very pliability of the target level of risk.

4.2 *The perceived level of risk*

As indicated by Box **b** in Figure 4.1, individual road users experience or anticipate, at any moment of time, a certain amount of danger, and they compare this

¹Moore-Ede, M.C., Sulzman, F.M. and Fuller, C.A. (1982). *The clocks that time us: physiology of the circadian timing system*. Cambridge, Mass.: Harvard University Press.

²Evans, L. (1986). Risk homeostasis theory and traffic accident data. *Human Factors*, 27, 555-576.

³McKenna, F.P. (1987). Behavioural compensation and safety. *Safety Science*, 9, 107-121.

⁴Michon, J.A. (1979). *Personal communication*. Department of Psychology, University of Groningen NL.

⁵Janssen, W.H. and Tenkink, R. (1988). Risk homeostasis and its critics: time for an agreement. *Ergonomics*, 31, 429-433.

⁶Oppe, S. (1988). The concept of risk: a decision theoretic approach. *Ergonomics*, 31, 435-440.

⁷Rumar, K. (1988). Collective risk but individual safety. *Ergonomics*, 31, 507-518.

⁸Evans, L. (1985). Human behavior feedback and traffic safety. *Human Factors*, 27, 555-576.

⁹Veling, I.H. (1984). A laboratory test of the constant risk hypothesis. *Acta Psychologica*, 55, 281-294.

with their target level of risk. Here again, subjective accident risk is not to be viewed as the result of an individual's explicit multiplication of probability and severity estimates, but as a more global notion representing the degree of danger felt by the individual. Moreover, the monitoring of risk need not be focal in the person's conscious awareness, just as human beings are usually unaware of their body temperature, hunger or thirst, heart rate, level of psycho-physiological arousal, or ambient light conditions when reading, and so forth. However, they do become consciously aware of these conditions if somebody asks about them or when there are marked or sudden changes. Most of the time, most road users only have pre-attentive, near-conscious awareness of risk.¹ More often than not, risk is only on the back-burners of their minds.

The level of traffic accident risk that is perceived by the individual person at any moment of time derives from three sources: the person's past experience with traffic, the person's assessment of the accident potential of the immediate situation, and the degree of confidence the person has in possessing the necessary decision-making and vehicle-handling skill to cope with the situation.

The person's past experience embraces a vast variety of earlier events: personal fear-arousing occurrences, traffic conflicts, near-accidents, close calls, narrow escapes, witnessing other people's accidents, conversations with others about accidents, exposure to accident reports and occasional statistics in the mass media. These experiences leave the driver with a general impression of the degree of riskiness of the road. As these occurrences are commonplace and correlated with the accident statistics as gathered by police forces and governments, there is no need to assume that, for homeostasis to occur, people have more than a very dim knowledge of the official statistics.

The immediate situation includes the physical features of the road environment (weather, geometry, signs and signals), the driver's own speed and direction, and the paths and speeds of other road users. People read the risk implications of these features.

Finally, the perceived level of risk will be relatively low if the person is confident about having the necessary coping skills, and higher in the case of persons who doubt their abilities.

4.3 Ongoing adjustment action

As indicated by the *comparator* (also called "summing point") symbol in Figure 4.1, road users continuously monitor the perceived amount of accident risk, compare this with their target level, and attempt to reduce any difference, be it positive or negative, between the two. More precisely, they attempt to reduce the discrepancy to a

¹Ben-David, G., Lewin, I., Haliva, Y. and Tel-Nir, L. (1972). The influence of personal communications on the driving behaviour of private motorists in Israel. *Accident Analysis and Prevention*, 4, 269-301.

level that is below the just-noticeable-difference or JND. These comparisons would normally be expected to be made at an intuitive and moderately conscious level and they are followed by a very large array of possible decisions. Whenever the difference between the perceived and target level of risk is below the JND, the person will not alter his or her behaviour. But when it exceeds the JND, the individual will take corrective action. That is the stable “decision rule” that endures in conditions of forever varying levels of accepted and perceived risk.

Some of these corrective actions have immediate effects only, while the effects of others are of a longer-term nature. The decisions having short-term effects upon safety include changing one’s pathway, speed, following distance, or trajectory; signalling to other road users; buckling or unbuckling the seatbelt; turning the vehicle lights on or off; increasing or decreasing one’s mental effort in the driving task; concentration on particulars and general vigilance. The choice of vehicle or transportation mode—e.g., private car versus the bus or train—or of deciding to make a particular trip or not, are examples of longer-term decisions. The choice that is made is the one the person believes will best serve the maximization of her or his overall benefit.

4.4 *The resulting accident toll*

Any action that is performed (Box **d**) after the choice has been made carries an objective likelihood of accident risk, be it greater or smaller. The sum total of all the performed actions, along with the objective risk of each of them, across all road users in a jurisdiction and over an extended period of time (such as one year), determines the traffic accident loss in that jurisdiction in that year (Box **e**, Figure 4.1).

Subsequently, this loss, along with the everyday experiences of accident risk that are associated with it (fear-provoking events, near-accidents, conversations about accidents, exposure to mass-media accident reports, and so forth), influence the level of risk as perceived by the surviving road users in the jurisdiction, that is, those who have not had a fatal accident (Box **b**). Thus, as long as the target level of risk (Box **a**) remains unaltered, accident loss at one point in time (Box **e**) and the degree of subsequent caution (Box **c**) displayed in road-user behaviour are related to each other in a mutually compensatory process that unfolds over time.

The first implication of this reasoning is that, at any point in time where the past accident rate is lower than the level of risk that people are willing to accept, road users will subsequently adopt a riskier manner and/or amount of mobility. The second implication is that they will do the opposite when the past record, and the personal experience associated with it, exceeds the preferred or target level of accident risk.

The first of these implications of risk homeostasis theory provides an explanation for what happened in Sweden and Iceland when those countries changed from left-hand to right-hand traffic at an early morning hour in the late 1960s. To the great surprise of many—including experts, laymen and politicians in Sweden and Iceland—the traffic accident rate per head of population dropped immediately and considerably

after the change-over, but it subsequently returned to pre-existing trends, within two years in Sweden and, in Iceland, after about ten weeks.¹

According to risk homeostasis theory, these findings may be explained as follows. Because of the change-over's major impact and fear-arousing interference with existing skills and habits, road users in these countries at first overestimated the level of accident risk that it would create. The thought of having to get up the following morning and drive on the opposite side of the road made drivers very apprehensive. Some road safety experts expected disastrous consequences.

Thus, the perceived level of risk surged to an unusual level that far exceeded the target level of risk. As a result, Swedish road users took unusually cautious adjustment actions, which in turn caused an unusual dip in the accident rate. During the 12-month period after the change-over date there was a 17% reduction in the number of traffic fatalities as compared to the preceding 12 months. After some time, however, the Swedes discovered, through their individual experiences and reports in the news media, that the new situation was not as dangerous as they had thought. The perceived level of risk went down, coming closer and closer again to the target level of risk. Consequently, the perceived need for prudent adjustment declined, cautious actions became less prevalent, and the accident rate returned to normal.

The various phases in this process can readily be visualized by reference to Figure 4.3. This figure is merely a simplification of the flow diagram in Figure 4.1 in Section 4.1 with all elements outside the closed loop are removed (i.e., boxes 1,2,3,and 4), and the time dimension is collapsed (from a spiral to a circle).

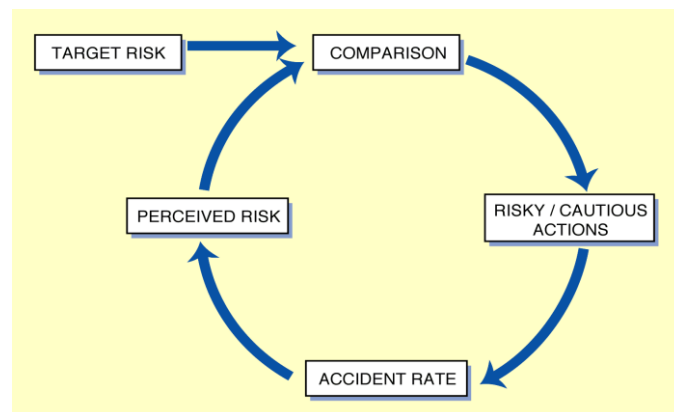


Figure 4.3, showing the “circular causality” that links changes in perceived risk to changes in behaviour, while unexpected changes in the accident rate lead to changes in perceived risk, and thus to subsequent behaviour.

The difference between Sweden and Iceland in the time it took for the per capita accident rate to return to normal may be explained by reference to Symbol **f** in Figure 4.1 in Section 4.1. The time lag, assuming that all other influencing factors are equal,

¹Wilde, G.J.S. (1982). The theory of risk homeostasis: implications for safety and health. *Risk Analysis*, 2, 209-225.

would be expected to be longer to the extent that the population is larger. As compared to Iceland, Sweden had approximately forty times more inhabitants at the time of the change-over to right-hand traffic.

Jocular minds in the area of road safety have suggested that we should have such change-overs on a regular basis, say, every two or three years, in all countries. According to one of their jokes, the government of a particularly dumb country—or a particularly dumb government of any country (please fill in your favourite target)—planned to do exactly that. But, realizing that this would meet with considerable public opposition, this government decided to introduce the change-over in a gradual manner: in the first few weeks it would apply to trucks and buses only.

In Canada, four provinces changed from left-hand to right-hand driving in the early 1920s. No quantitative studies of the effect on the accident rates seem to be available, but 1923 surely was a horrible year for oxen in Nova Scotia. As these dimwitted animals were unable to learn to adapt to the new rule of the road, a fresh supply of oxen had to be trained to move on the right. Displaced oxen were slaughtered in large numbers and for a long time the year was known as “the year of cheap beef.”¹

4.5 *Skills that influence road-user behaviour*

There are three types of skill that have an effect on the level of risk perceived and the action performed: perceptual skills, decision-making skills and vehicle-handling skills. Perceptual skill (Box 4) determines the extent to which the person's subjectively perceived risk (Box b) corresponds to the objective risk. Perceptual skill includes the ability to correctly assess one's level of decision-making and vehicle-handling skill. This is important, because it implies that persons with limited decision-making or vehicle-handling skills are at no greater accident risk, provided they realize their limitations and act accordingly. As Leonardo da Vinci said: “He who fears dangers will not perish by them.”² And, if the more skilful tend to overestimate their level of skill to a greater extent than the less skilful, it also implies that people with superior decision-making and vehicle-handling skills may be at a greater risk of accident than those who are inferior in these skills (see Chapter 6). Similarly, individuals with superior levels of all three types of skill are more likely to get involved in accidents than people with lower levels of skill if their target levels of risk are higher.

Decision-making skill (Box 2) refers to the operator's ability to decide what she or he should do in order to produce the desired adjustment (Box c) so that the difference between the target and the perceived level of risk is minimized, that is, $[a-b]$ equals

¹Automobiles, The Early days in Nova Scotia, no date.
<<http://ns1758.ca/auto/automobiles.html#roadrule1923>>.

²Richter, I.A. (1952). *Selections from the Notebooks of Leonardo da Vinci*. London: Oxford University Press, p 278.

about zero. It then depends upon the person's vehicle-handling skill (Box 3) as to how effectively he or she can carry out that decision.

The level of performance in any task can be improved by two contrasting methods: fitting the operator to the task, and/or fitting the task to the operator. The first can be achieved by providing good training procedures, by repeated practice on the task, and by providing people with knowledge of their level of performance. The second can be achieved by creating a workstation and a physical work environment that enable the operator to perform the task at a more efficient level. Thus, the level of skilful driving performance can be improved by proper driver education on the one hand, and, on the other, by an ergonomically designed human-made environment, including controls and displays in vehicle design, and road geometry, signs, and signals in the traffic environment that reduce human error.

Many of these interventions, however, are unlikely to have a lasting effect upon the traffic accident loss, and only those that affect the target level of risk in the population can definitely achieve this. Why should this be so?

If I have been clear in what I have written so far, you already will have guessed the answer and realize that it is a simple one: *the road users' task, as they see it and as it is performed by them, is not to minimize accident risk, but to maintain it at a level that is in keeping with their target level of risk, that is, their optimal level of risk.* They attempt to maintain their target level of risk in order to maximize the overall benefit they can reap from their mode and manner of mobility. They act in accordance with what is reflected in popular sayings such as "nothing ventured, nothing gained," "no pain, no gain," "no guts, no glory," "nul culot, nul héro," and "la fortune sourit aux audacieux." The desire to maximize overall benefit offers strong motivation toward improvement of one's skills. The better one's skills, the more one is able to choose actions that agree with one's target level of risk. Sometimes a challenge is sought to enhance skill and performance. A calm sea does not hone a sailor's skill and you cannot discover a new world unless you are willing to lose sight of your own safe port. Accidents will happen in the process.

As skills serve not to minimize risk, but to optimize it, the three types of skill are all located outside the closed loop in Figure 4.1, just as their thermostatic counterparts are in Figure 2.1. Thus, raising the level of these skills (Boxes 2, 3 and 4) for people in the same nation should not be expected to influence that nation's accident loss per head of population, although, for the individuals in that nation, individual differences in skill may matter a great deal to the likelihood of their personal survival.

4.6 Individual differences in skill

Individuals differ not only in the accident risk they are willing to accept (Box a), but also in their ability to perceive accident risk and in their decision-making and executive skills in the face of risk (Boxes 4, 2 and 3). In other words, people differ in both *willingness* and *ability*. Because of their incorrect perceptions of the objective accident risk, some people are risk-underestimators, while others are risk-overestimators. The risk-underestimators take more risk than corresponds with their

target level, while risk-overestimators take less risk than they would if they were better informed.

Consider an imaginary education programme that produces population-wide improvements in risk perception, and the effects this would have. There would be a decrease in risk for the underestimators and an increase for the overestimators.

The unquestionable benefit of such education towards more correct risk perception is that individual road users would become more sophisticated “risk managers.” Each of us would be enabled to adjust our behaviour more closely to our target level of risk. Thus, some would acquire a better chance to survive because they no longer underestimate objective risk, while others would become more likely to be killed because they no longer overestimate objective risk.

Would the nation-wide accident loss be reduced by our imaginary education programme? It depends. It would be reduced if the average perceived level of risk in the population is currently lower than the objective level of risk—in other words, if cases of risk-underestimation currently outnumber cases of the risk-overestimation. Such a situation would be similar to the effect of faulty thermometers that consistently indicate temperatures that are lower than the true temperature, so that actual room temperatures are higher than desired.

So, a crucial question arises: do people generally underestimate objective accident risk? The studies reported in Sections 3.1 and 3.3 have shown that drivers agree reasonably well with one another in their judgements of *comparative* accident risk when operating their vehicles in different road sections. Moreover, their pooled or collective perception of subjective risk corresponds remarkably well with the objective accident risk per vehicle-kilometre in each section as calculated from accident records.

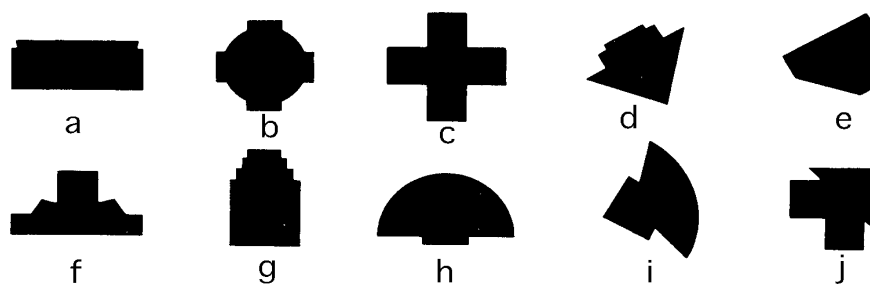


Figure 4.4: The individual's task is to rank the above geometric shapes according to their surface area.¹

This is in agreement with findings regarding comparative judgement in domains other than risk.^{1,2} Figure 4.4 offers an example. People are asked by an experimenter

¹After A.T. Poffenberger (1932), cited by P. Hofstätter (1986). *Gruppendynamik*. Hamburg: Rowohlt.

to rank the ten geometrical shapes according to their surface area. As you can see, this is no easy task. The extent of correlation between an individual's ranking and the true ranking is usually quite weak, sometimes even in the order of zero. Now suppose the experimenter combines the rank orders given across individuals and then calculates the correlation between the pooled judgements and the truth. What is found is that the pooled judgements correspond better with the truth as the number of individuals increases. For instance, the average correlation between individual judgements and the correct rank order may be in the order of $r = 0.36$; pooled across seven individuals the correlation may grow to $r = 0.79$ and across twenty it may reach $r = 0.92$. It can be calculated that 138 individuals would suffice to obtain a correlation of $r = 0.99$. That is a very small number in comparison with the millions of road users. The message is that individually we may be far from perfect judges, but together we know surprisingly much.³

Thus, there is reason for believing that drivers collectively make quite accurate assessments of *relative* risk, but that does not eliminate the possibility that, as a group, they either over- or underestimate the *objective* level of risk of particular manoeuvres in particular road situations, or of road traffic in general.

The notion "objective level of risk" is more easily mentioned than measured. What is meant by this term is the amount of accident risk (probability times severity) associated with a particular behaviour by a particular driver on a particular road in the presence of other particular road users. It includes the risk implications of the driver's skill, his momentary perceptions, his mental alertness, the speed of his vehicle, the braking ability of the car, the likely actions of the other road users, and so forth.

Needless to say, at this level of specification it is impossible to quantitatively ascertain the objective level of risk. The notion makes sense in theory only. The notion of relative risk is less demanding; all that is needed is to establish whether a given manoeuvre by a given driver under given circumstances is more risky or less risky than some other manoeuvre under the same conditions, or the same manoeuvre under other conditions.

If you ask a sample of drivers how they rate their own quality as a driver, you will typically find that more than half of them say that they are better than the average driver.^{4,5} This arithmetical absurdity has also been observed in numerous fields other than driving and is due to the fact that overconfidence is more frequent than underconfidence. People are more likely to have expectations that are unrealistically

¹Gordon, K. (1924). Group judgments in the field of lifted weights. *Journal of Experimental Psychology*, 7, 398-400.

²Peterson, C.R. and Beach, L.R. (1976). Man as an intuitive statistician. *Psychological Bulletin*, 68, 29-46.

³Hofstätter, P. (1986). *Gruppendynamik*. Hamburg: Rowohlt.

⁴Svenson, O. (1981). Are we all less risky and more skilful than our fellow drivers? *Acta Psychologica*, 47, 143-148.

⁵DeJoy, D.M. (1989). The optimistic bias and traffic accident risk perception. *Accident Analysis and Prevention*, 21, 333-340.

optimistic than unrealistically pessimistic.^{1,2,3} It is thus possible that people more often than not underestimate the traffic accident risk they expose themselves to.

There are, however, two factors that should dampen any enthusiasm for our imaginary nation-wide programme to improve risk perception as a means towards per capita accident reduction. One of these has already been mentioned—the programme would lead to an increase in the accident risk of those individuals who used to overestimate it. The other is that individuals who overestimate their perceptions of mastery and of being in control are marked by greater happiness, persistence at tasks, and mental health, and they are ultimately more effective in their performance than those who don't. A degree of unrealistic optimism is characteristic of normal human thought. Not exaggerating one's mastery or chances of success is associated with low self-esteem and mental depression.^{4,5}

Self-aggrandizement, or unrealistic optimism about one's own performance, is a good thing, provided it is not excessive. A healthy dose of self-overestimation is wholesome, not only for the individual in question, but also for others, because it appears to promote the ability to care for others and to help them, to facilitate social bonding, and thus ultimately foster a more benevolent and happier society. Similarly, it has been found that optimism, realistic *and* unrealistic, may be protective of physical health.⁶

Who would, in the face of this, want to reduce average people's self-perceptions to what is mathematically correct? It would also be a very difficult task, in part because the objective risk is quite often not known on the collective level, let alone for particular individuals. In the domain of traffic and occupational accidents, fatalities are relatively faithfully recorded; the accident costs in the form of physical injury and material damage are not reliably monitored. Fortunately, however, improvement in risk perception is not necessary if one wishes to reduce the accident loss per head of population, as will be seen in Chapter 11.

4.7 *Homeostasis is generated by the actions of individuals*

The periodicity in the fluctuations of the level of the output variable—the controlled variable—that is inherent in any homeostatic mechanism may or may not be visible in population accident statistics (see Figure 2.2). On the individual level, an

¹Wright, G. (1984). *Behavioural Decision Theory*. Harmondsworth, Middlesex: Penguin.

²Weinstein, N.D. (1980). Unrealistic optimism about future life events. *Journal of Personality and Social Psychology*, 39, 806-912.

³Horvath, P. and Zuckerman, M. (1993). Sensation seeking, risk appraisal, and risky behavior. *Personality and Individual Differences*, 14, 41-52.

⁴Taylor, S.E. and Brown, J.D. (1988). Illusion and well-being: a social psychological perspective on mental health. *Psychological Bulletin*, 103, 193-210.

⁵Dowse, G. and McClure, J. (1996). Depression, the future and the past: Predictions correspond to recall of personally relevant events. *Australian Journal of Psychology*, 48, 93-97.

⁶Taylor, S.E., Kemeny, M.E., Reed, G.M., Bower, J.E. and Gruenewald, T. (2000) Psychological resources, positive illusions and health. *American Psychologist*, 55, 99-109.

increase in caution is likely to occur after a close call or after one hears of somebody else's accident. Similarly, a reduction in caution is likely to occur when all goes well for an extended period of time.

Such fluctuations in an individual's level of cautiousness following a lucky or unlucky experience can easily be demonstrated in the laboratory, as will be seen in Chapter 10. On the aggregate level, dips in accident rates are expected to occur if road users collectively perceive a sudden increase in accident potential, as was the case when Sweden (in 1967) and Iceland (in 1968) changed from left-hand traffic to right-hand traffic.¹ Likewise, there are indications that major aviation accidents are followed by periods in which fewer people decide to fly.² Usually, however, fluctuations in caution and imprudence in different individuals would be out of phase with one another, and the temporal fluctuations of the accident rate of the collective would thus be flattened out.

Another dampening factor is the human ability to anticipate change in "intrinsic risk." Suppose, for example, that a highway is upgraded from two lanes to four. This signifies a reduction in intrinsic risk, and if drivers were to maintain the same behaviour (speeds, levels of alertness, etc.), the accident rate per hour of driving on that highway would decrease. But people may be able to anticipate the change in intrinsic risk and to modify their behaviour accordingly. This is "feed-forward adaptation,"³ as distinct from adjustment following *feedback*. Thus, behavioural compensation may occur in response to the introduction of non-motivational accident counter-measures (those that do not affect the willingness to take risk) *before* a change in accident rate has an opportunity to occur. In fact, the anticipatory compensation prevents just that.

Homeostasis is supposed to take place through the actions of *individual* human beings, not on the level of the human collective in some mysterious or metaphysical manner. Although the accident loss per capita characterizes a collective and is often remarkably stable from year to year, this does not imply some decision-making process on a supra-individual level. The accident loss is the sum total of the separate consequences of individual actions.

According to the theory, individual road users try to keep their accident risk per time unit of exposure in equilibrium with their prevailing target level of risk. As the target level of risk is greater than zero, the individual runs an inevitable risk of accident. If the accident happens and it is fatal, the individual can no longer make any subsequent adjustment actions, but the individuals in the population of survivors can. Each accident that happens adds an increment to the perceived level of accident risk.

Suppose now that, on average across individuals, the target level of risk corresponds in reality with one fatal accident per two million hours of exposure to

¹Wilde, G.J.S. (1982). The theory of risk homeostasis: implications for safety and health. *Risk Analysis*, 2, 209-225.

²Wilde, G.J.S. (1984). On the choice of the denominator for the calculation of accident rates. In S. Yagar (Ed.), *Transport risk assessment*. Waterloo, Ontario: University of Waterloo Press, pp.139-154.

³Wilde, G.J.S. (1982). The theory of risk homeostasis: implications for health and safety. *Risk Analysis*, 2, 209-225.

road traffic. Suppose, too, that the individuals spend, on average, 400 hours per year in road traffic.¹ Consequently, there would be one fatality per 2 million divided by 400 equals 5000 person-years of life. In the course of one calendar year, therefore, about 1 million divided by 5000, which is about 200 individuals, would be expected to be killed on the roads in a jurisdiction of one million inhabitants.

The surviving members of the population become aware, in a general and quantitatively diffuse way, by virtue of their everyday experiences on the roads and conversations with others, as well as through accident reports in the media. These experiences influence the level of accident risk perceived by road users who have had no fatal accident, and thus influence their subsequent behaviour. A ship stranded on the beach is a beacon for those at sea. The deaths of some are a warning to others to be more careful. People typically learn, not only from their own mistakes, but also from mistakes made by others: one person's fault is somebody else's lesson. People typically learn from their own successes and also from the successes of others. This is how the accident loss in a population can be maintained at a more or less stable level over time.

If one looks up at a flock of birds turning in flight, or down from a tall tower at the traffic movements below, the collective action sometimes appears as if it were guided by an "invisible hand." The illusion is created by the smooth coordination of individual decisions, the individuals (birds or drivers) each finely tuning their actions to the actions of other individuals. Continuity over time is similarly achieved.

4.8 *Conceptual underpinnings and wider extensions*

Although the theory of risk homeostasis was originally conceived in an effort to explain various features of accident statistics and other observations in the domain of transportation risk, it can readily be extended to the area of occupational safety and public health² insofar as it depends on lifestyle. It would be surprising if the mechanism that seems to explain road user behaviour would not hold for industrial workers, or people in general in whatever activity they may be involved. The basic nature of the human being does not change as a function of the situation. The amount of risk accepted may be different from one activity or situation to another, but the basic closed-loop process between loss and caution, and between caution and loss, would still be expected to hold. Risk homeostasis may thus apply not only to road use, but also to industrial safety, sports, making love, smoking, drinking, doing home

¹Zahavi, Y. and Ryan, J.M. (1980). Stability of travel components over time. *Transportation Research Record*, 750, 19-26.

²Menahem, G. (2000). [A target level of risk model of respiratory pathologies and smoking behaviour](#). *Applied Economics*, 31, 709-722 Also see. Menahem, G. (1998). Maladies, recours aux soins et attitudes à l'égard du risque. *Bulletin d'information en économie de la santé*, No. 9, April.

repairs, climbing ladders, physical exercise, investing money, gambling, and who knows how many other activities including controlling acts of terrorism.¹

It should be emphasized that this theory attempts to explain the accident *rate* per head of population, not the occurrence of specific individual accidents, nor their immediate and material causes, such as errors of perception, decision or execution. The occurrence of these errors is viewed as the consequence of the extent to which people fact that they expose allow themselves or others to make such errors, and of the themselves to dangerous conditions, including malfunctioning equipment. The specific errors leading to *specific* accidents may be interesting, but they have no bearing on the *rate* of accidents. The error rate is viewed as a direct consequence of the accepted level of risk. The identification of specific errors may help avoid specific types of accidents in the future, but this does not mean that the future accident rate will be favourably affected. The elimination of specific errors does not imply a commensurate reduction in the overall rate of errors, nor a commensurate reduction in the accident rate. We may recall the delta illusion that was mentioned in the Introduction: successive damming of the channels in the delta will reduce or even eliminate the flow of water through these channels, but the total amount of water running to the sea is not reduced.

Most people who settle or live in flood-prone or quake-prone areas do so knowingly and accept the risk in return for the fertility of the land. People know that driving or flying carries a risk of accident. The theory does not deal with the rare and presumably totally unforeseeable events that go under the poetic name of “acts of God.” People’s risk acceptance is viewed as the underlying cause, the “root cause”, the “upstream cause”—the “*causa causans*”—of the accident rate per head of population.

From what has been said so far about risk homeostasis theory, it is clear that the human being is seen as a strategist, a planner, who attempts to optimize, not minimize, the level of risk-taking for the purpose of maximizing the benefits—economic, biological, and psychological—that may be derived from life. Taking risks greater than zero is rational.

The human being is not perceived as a robot with a conditioning history, a robot that needs some additional conditioning for the accidents to go away. Such a view would suggest that what is needed to reduce the accident rate is more road user training, including driver training.

The human being is not perceived as a haphazard bundle of poorly controlled emotions that can erupt at any time, and needs the disciplining force of a paternalistic authority to be kept in check. This view would inspire accident countermeasures that take the form of legislation against specific unsafe acts, and the enforcement of such legislation.

The human being is not perceived as a less than perfect automaton with a few loose nuts and bolts that will function more safely if its environment is made more

¹Tetzlaff, J. (2000). Risk management in a dangerous world: practical approaches. *DePaul Business Law Journal*, 12, 1-31.

forgiving. According to that view, accidents can be reduced by better engineering and more sophisticated ergonomics of the hardware of roads and vehicles.

Instead, the human being is being viewed as a being that, if *motivated* by accident countermeasures to act more safely, will do so, and the accident rate per head of population will go down.

Yet, on repeated occasions, the theory has been charged with casting a pessimistic perspective on the potential for traffic accident prevention.^{1,2} Hence the reference to it as “Wilde’s law of the conservation of accidents,”³ or “the principle of the preservation of the accident rate.”⁴ Nothing could be farther from what I intended. What the theory does is to stress the resilience, ingenuity, adaptability and resourcefulness of human beings under changing environmental conditions, including those of their own collective making. It would be saddening indeed if people showed no inclination to search for behaviour alternatives when confronted with changing technological conditions that provide them with new opportunities to behave in productive ways, without altering their degree of willingness to take risks of their own choice. There would be cause for pessimism about the human condition if the accident rate per time unit of exposure or per capita went down as a result of interventions that do not affect the amount of risk people are willing to take.

Suppose a “Mr. X” has decided on the value of his life, and thus, on the extent to which he is willing to risk it. He tries to obtain a maximum quality and quantity of mobility in return for this sacrifice he is willing to make. Now provide this person with a seatbelt, wider lanes, better brakes or whatever intervention that can make driving intrinsically safer—that is, safer provided no change in behaviour occurred. Mr. X has the choice of responding to this intervention with or without changing his behaviour. If he does change his behaviour, he can obtain an even higher quality and quantity of mobility. If he does not change it, he no longer obtains the maximum benefit in return for what he is willing to sacrifice. That’s dumb, not rational, and if people typically reacted in this fashion, there would be serious cause for a pessimistic view of their ability to utilize new opportunities.

For safety interventions to be effective in reducing the accident rate per head of population, these interventions have to reduce people’s willingness to risk their lives. Chapter 11 describes methods for this purpose and the results obtained with these methods. It will be seen that the art of effective safety management is the art of reducing the target level of risk. The fact that the target level of risk is modifiable is sufficient reason for debunking the myth that the theory of risk homeostasis is pessimistic and that accident rates cannot be reduced.

¹Huguenin, R.D. (1982). Zur Problematik von Risikohomöostasetheorien in der Verkehrspsychologie. *Zeitschrift für Verkehrssicherheit*, 28, 180-187.

²McKenna, F.P. (1985). Do safety measures really work? An examination of risk homeostasis theory. *Ergonomics*, 28, 489-498.

³Underwood, G., Jiang, C. and Howarth, C.I. (1993). Modelling of safety measure effects and risk compensation. *Accident Analysis and Prevention*, 25, 277-288.

⁴Michon, J.A. (1979). *Personal Communication*. Department of Psychology, University of Groningen, the Netherlands.

Instead of motivating people towards greater safety, one could, as some have suggested, attempt to interfere with the “natural unfolding” of the homeostatic dynamic (presuming that this dynamic explains what is going on). Roads might be designed such that curves appear to be more dangerous than they are. Driver training might teach students that certain manoeuvres are more dangerous than they are. One might introduce “safety features” in cars, such as collapsible steering columns, padded dashboards and reinforced doors. Some authors suggest such invisible interventions may preclude the operation of risk adjustment on the part of road users,¹ but consider the following. Suppose one were to install in one road section only a new type of pavement surface such that it seems to provide more friction with the tires than it actually does.

We would indeed expect a reduction in the accident rate (both per km driven and per hour of driving) to occur in that road section, because the (invisible) improvement would lead drivers to move more conservatively than they otherwise would. As long as the new pavement is installed in only one or a few road sections, the drop in the overall accident rate in the jurisdiction would probably be too small to be detectable to the driver population (and maybe even in the jurisdiction-wide accident statistics). So, no behavioural adaptation would be expected to occur.

If, however, a large part of all roads in the jurisdiction were covered with the new pavement, the reduction in accidents would become more likely to be detected. Consequently, drivers would be expected to change their driving behaviour and the jurisdiction-wide accident rate would return to “normal”. (just as it did in Sweden after the change-over, described in Section 4.4). In sum, the safety benefit of the new pavement would be very small and/or short-lived. Whether engineering interventions are visible or not, “risk homeostasis hovers over all these safety devices like the sword of Damocles”²

Another example of surreptitious safety “intervention” might take the form of interfering with the feedback loop from accidents to accident risk perception (see Figure 4.1) by mass media propaganda that tells people that the roads are more dangerous than they are.

Apart from being distasteful to a society that values full disclosure of the facts and ready access to information (called “glasnost” in Moscow and Irkutsk), any such attempts to instill a false sense of insecurity are unlikely to be effective in the long run. People will eventually find out. One can fool some of the people some of the time, but not all of the people all the time, as one president of the USA has said. Moreover, when a policy of deception is pursued, the authorities will eventually lose credibility and respect when people find out, and this may have various kinds of repercussions that are counterproductive to a healthy functioning of society. The civil engineer who presented the keynote address at a conference in Australia stated: “As

¹ Hedlund, J. (2000). Risky business, safety regulations, risk compensation, and individual behavior. *Injury Prevention*, 6, 82-89.

² Schulze, H., Christ, R., Heijer, T., Mäkinen, T. and Nilsson, L. In Vehicle Safety devices. GADGET Work-package report. BAST, Bergisch-Gladbach, 1999.

designers we are responsible to ensure that hazards are neither disguised, nor exaggerated.”¹ Secrecy and deception will come home to roost.

¹Hoban, P.(2001). "Zero Road Toll - A dream or a Realistic Vision," keynote address, 24th Australasian Transport Research Forum, Hobart, Tasmania, April 17-20.

*L'homme, ivre d'une ombre qui passe,
porte toujours le châtiment
d'avoir voulu changer de place.*
Charles Baudelaire, *Les hiboux*¹

5 Deductions and data

In the preceding pages we have attempted to give a detailed description of homeostasis theory. In this and the next several chapters, we will deal with the question of empirical support for this interpretation of people's behaviour in the face of health and safety risks. But before any data are presented, it may be useful to specify what factual findings we should expect to see if we suppose the theory is valid.

If we overlook short-term fluctuations in the accident rate and other variables that influence it, we can deduce a major consequence of risk homeostasis: the annual accident loss is the consequence of the hourly risk people are willing to take times the time they spend on the road times the number of people in the population.

In other words, when we count up the total numbers of accidents across the entire road network in a jurisdiction, across the entire population, and over an extended period of time (such as one year), *the total traffic accident loss (A) = the target risk (R) multiplied by the average number of hours (h) spent in traffic multiplied by the number of members in the population (N)*. This is the basic equation shown in Table 5.1.

The data necessary for direct testing of this equation are, unfortunately, lacking at present. While the number of people in the population (N) can be assessed with considerable reliability, and some estimates of the amount of time spent in traffic (h) are in existence, the value of the target level of risk (R) remains resistant to quantification, as has been discussed in Section 4.6. We will, therefore, have to resort to validating the main idea by testing the derivatives, the other two equations in the table.

As far as the total loss due to traffic accidents (A) is concerned, reasonably trustworthy accident data exist for fatalities only, although even these have been questioned.² Road accidents with property damage only, and even those with physical injury, are usually not reported in a reliable manner.^{3,4} When focusing on fatal accidents, some of the available data may be inspected for their agreement with deductions that can be derived from the above equation when the terms are juggled around. This is precisely how the other two equations below were derived and you

¹Baudelaire, C. (1930). *Les fleurs du mal*. Paris: L. Conard.

²Metzner, G. and Brinkmann, B. (1993). Inaccuracies in the official accident statistics of fatal traffic accidents: Comparative studies in West Germany during two time periods. *Journal of Traffic Medicine*, 21, 165-169.

³Hakkert, A.S. and Hauer, E. (1988). The extent and implications of incomplete and inaccurate road accident reporting. In J.A. Rothengatter and R.A. de Bruin, *Road user behaviour: Theory and research*. Assen, the Netherlands: van Gorcum.

⁴Hutchinson, T.P. (1987). *Road accident statistics*. Adelaide, Australia: Rumsby Scientific Publishing.

will have no difficulty in verifying that both are merely alternative versions of the one above.

The first of these deductions is *cross-sectional* in nature (see Equation 2 in the table). It says that the average moving speed in different road sections is inversely proportional to the accident rate per passing vehicle in those road sections. In Sections 3.1 and 3.3 we found evidence that the lower the accident rate per km driven in a given road section, the faster people will drive in that road section. The present deduction, however, is more demanding: the product of the accident rate per km driven and the average driving speed should be independent of the road section in which the driving is done.

This deduction involves a comparison, within the same time frame, of average moving speeds (in km/h) between various road sections with different accident rate records per vehicle-kilometre [$A/(n \times \text{km})$]. The term km/h stands for average vehicle speed in each road section, while $A/(n \times \text{km})$ is the accident loss divided by the number of vehicles that pass a road section of a length measured in km. If findings agree with these deductions, they offer support for the notion that the accident rate is stable per time unit of exposure and independent of where the driving is done. Note that the comparison of speeds *between sections* is different from the study of speed differences *between individual drivers* at a particular location and how these are related to accident involvement.¹

The *longitudinal* deduction from the basic equation in Table 5.1 is different in that it involves comparisons between *different time periods* within the same jurisdiction over a sequence of years which are marked by different spatial accident rates. This deduction states that one should be able to observe an inverse proportional relationship between, on the one hand, the accident loss per unit distance of mobility (A/km) and, on the other, the amount of mobility per head of population (km/N), which may vary from one year to another. In other words, as the accident rate per km drops from year to year, the kilometrage per head of population should show commensurate increments. Moreover, the accident loss per inhabitant (A/N) should remain unchanged for the simple reason that it is the product of the two: $(A/\text{km}) \times (\text{km}/N) = A/N$.

¹Munden, M. (1967). *The relation between a driver's speed and his accident rate*. Road Research Laboratory, United Kingdom, Report No. LR88.

Table 5.1: Risk homeostasis: some simple equations

Basic equation: (Equation 1),	$A = R \times h \times N$
Cross-sectional deduction: (Equation 2),	$km/h = R \div [A/(n \times km)]$
Longitudinal deduction: (Equation 3),	$km/N = (R \times h) \div (A/km)$
where:	
A = accident loss in traffic	
h = hours spent in traffic per person	
km/h = moving speed	
km/N = total distance driven per head of population	
N = number of people in the population	
n = number of vehicles passing through a road section	
R = target level of risk.	

A word of warning! Please note that the cross-sectional deduction holds only to the extent that the value of the target risk level (R) is invariant across the different drivers who pass through different road sections. This may or may not be true, since it's conceivable that drivers with different target levels of risk choose different routes and are more likely to be seen in some road sections than in others. For the longitudinal deduction to bear out fully, it's necessary that the target level of risk (R) and the amount of time spent on the roads (h) remain constant over the years. This is not quite true, as we will see below, in Section 5.4, which discusses the effects of economic factors on the traffic accident rate. Finally, the amount of the accident loss (A) would have to be assessed in a constant fashion when testing either one of the deductions, and this condition is not likely to be approximated, unless one considers fatalities only.

5.1 *Cross-sectional and longitudinal accident data*

Regarding the cross-sectional deduction we have seen in Section 3.1—that when the same individuals are observed in different road sections, average driving speed is higher in those road sections where the accident rate per vehicle-mile is lower—a British study found a correlation coefficient $r = -0.67$ in a sample of 20 drivers, and a later Canadian study found correlations $r = -0.73$ and $r = -0.74$ in a sample of eleven drivers, each of whom drove the route twice (see Section 3.3).

Another researcher did not observe the same drivers in each road section, but followed a somewhat different method of data collection. Accident rates for 40 different road sections in and around Detroit, Michigan, were gathered from police records over a two-year period. Accident severity was not considered, only accident numbers. For each road section, the number of passing vehicles was counted over a period of 48 hours, and the average driving speeds were determined over 84 hours, using a method that may have been more convenient than accurate.

From the data plotted in Figure 5.1, a correlation $r = -0.57$ may be calculated between the frequency of accidents per unit distance driven in various road sections, and average moving speed in these road sections. If the three outlying data points are disregarded, the correlation increases to $r = -0.66$.

As can be seen in this figure, the author related the accident rate (A) per million vehicle miles of each of the road sections to total travel time per road section (T), in an exponential function instead of a simple linear one (as the deduction from risk homeostasis would predict; see Equation 2 in Table 5.1). Additional calculations show, however, that the non-linear component, reflected in the curved solid line, is not statistically significant. It would seem that the data are in reasonable agreement with what the theory would expect: where the spatial accident rate is half as high, people drive twice as fast. This expectation is presented by the dotted line in Figure 5.1. *In other words, the accident rate per time unit of exposure remains essentially constant from road section to road section.*

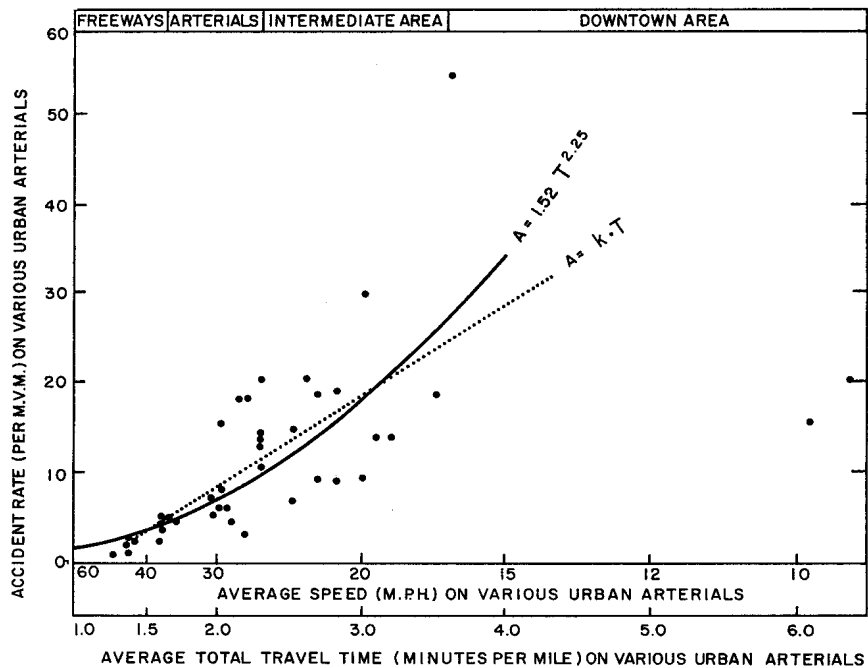


Figure 5.1: Accident rates per million vehicle miles (m.v.m.) related to average total travel time per mile in various road sections of different road design (graph adapted).¹ One mile equals 1.61 km.

¹May, A.D. (1959). A friction concept of traffic flow. *Proceedings, 30th Annual Meeting of the Highway Research Board*. Washington, DC, pp.493-510.

For inspection of data relevant to the longitudinal deduction, we turn to Figure 5.2. This was selected because it is the longest time-series I could find in the available literature sources.¹ Here again, there may be some problems with the data. The total mileage driven per year is estimated from the total amount of taxable gasoline sold and may contain errors. Nevertheless, Figure 5.2 gives rise to some interesting observations.

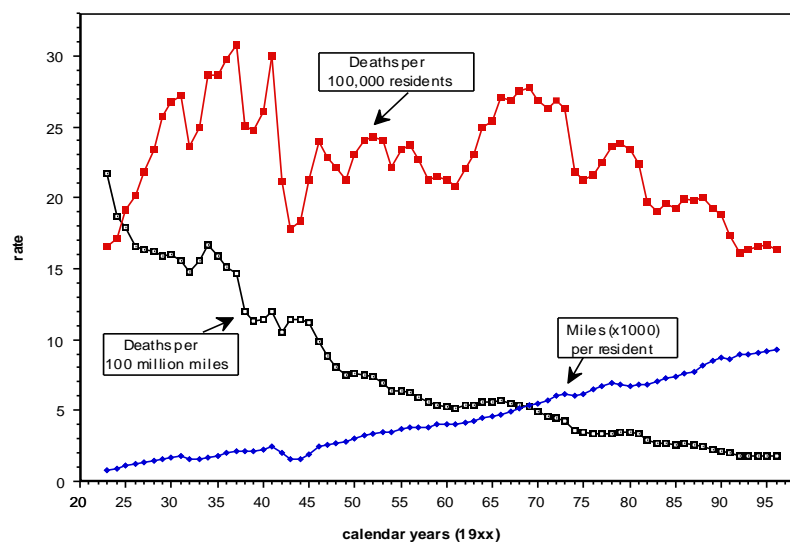


Figure 5.2: The traffic death rate per distance travelled, the traffic death rate per capita, and the road distance travelled per capita in the USA, 1923-1996.²

The *spatial* accident rate, which is expressed here

5.2 The accident rate “per km driven” as distinct from “per head of population”

We have seen from Figure 5.2 that in a period in which the death rate per unit distance of mobility dropped considerably, no systematic reduction in the traffic death rate per head of population occurred from year to year. This raises the question as to which criterion will best measure the effectiveness of a traffic safety measure: fatalities per km driven or fatalities per capita.

The reduction (by a factor of twelve or so) between 1923 and 1996 in the death rate per unit distance driven between 1923 and 1996 may have been caused by

¹Wilde, G.J.S. (1991). Economics and Accidents: A commentary. *Journal of Applied Behavior Analysis*, 24, 81-84.

²Graphed from data published by the National Safety Council (various years). Accident Facts. Chicago, Illinois.

interventions such as the building of more forgiving roads, the construction of more controllable and crashworthy cars, by advances in the medical treatment of accident victims, and other factors. At any rate, major progress has been made.

In contrast, the degree of traffic safety per citizen per year has not been so favourably affected. From the perspective of risk homeostasis theory, this is not surprising, because the theory expects people to change their behaviour in the face of accident countermeasures that do not alter the target level of risk, and to change their behaviour in a manner such that the temporal accident risk remains essentially the same. Accordingly, they simply “consume” the technological innovations for the purpose of enhancing their performance and maximizing their net benefit. And if their target level of accident risk is not reduced, there is no reason to expect the accident rate per citizen to go down.

As we have seen with respect to the cross-sectional deduction in Section 5.1, in those locations where the accident rate per vehicle-kilometre is low, drivers move faster and the accident rate per hour behind the wheel remains essentially unaltered. Driving at twice the speed allows people to cover a given distance in half the time, and by spending the same amount of time on the road they can double the amount of mobility. So, if more road sections that offer a low spatial accident rate are being built, people will react by adding to their mobility accordingly.

The fact that the curve describing mileage per capita shows no sign of tapering off in recent years suggests that the human desire for greater mobility is insatiable—provided faster travel is made available. In 1923, Americans travelled on average 760 miles (about 1,225 km) in motor vehicles. By 1996, this figure has risen to 9,261 miles (14,901 km), twelve times as much. Note that these mobility rates are calculated per resident, not per licensed driver. They include everybody in the nation, regardless of age or whether they have a driver’s licence. Note also that the mobility per automobile increased by the same factor as the death rate per unit of mobility had dropped!

So, when shall we call a safety measure effective? If we take the accident rate per km driven as the criterion, technological interventions can clearly be effective. They are productive from an engineering point of view, and any country’s ministry of transport will be only too happy to point this out. Interventions of this kind are also productive for your own personal benefit, because they allow you to move faster per unit distance of mobility and thus to enjoy a greater distance of mobility against the same risk of death per hour on the road.

But from the point of view of public health, the story is quite different, since there is no reduction in the number of people killed on the roads. That country’s ministry of health will not be equally pleased. Neither should you, because your likelihood of becoming a traffic fatality is not diminished, and it may even have increased! In fact, there have been periods in which the death rate per unit distance of mobility dropped while the traffic death rate per inhabitant showed an increase. In the years following the Second World War and including 1972, the year before the oil crisis, Ontario experienced an era of relatively steady economic growth. Data on the fatality rate per

km driven are available as of 1955, hence the choice of the time period covered in Figure 5.3.

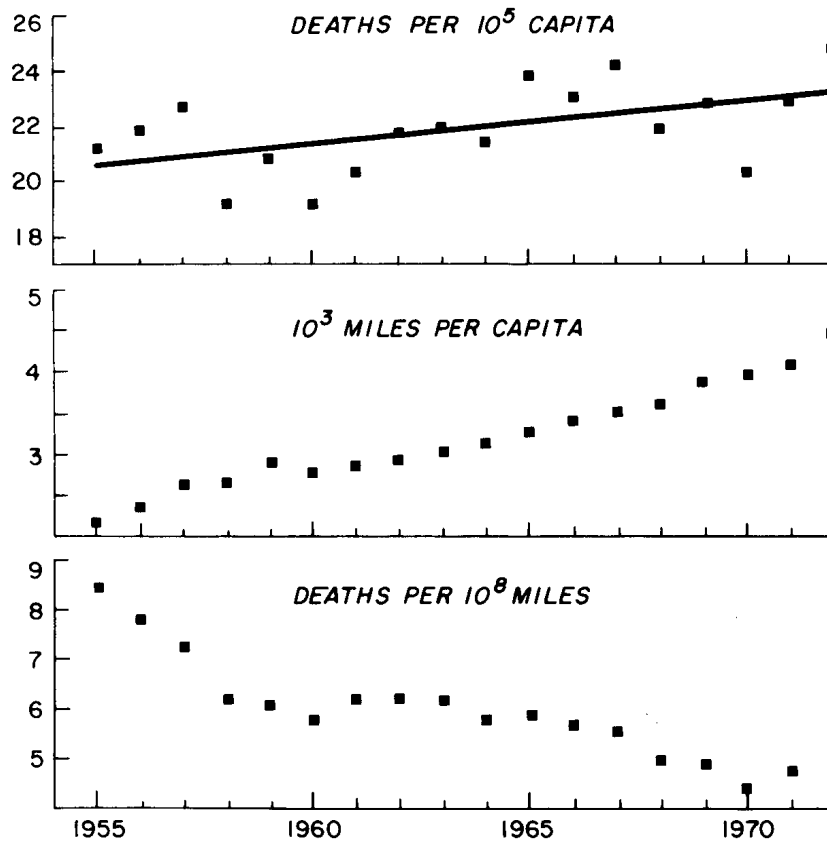


Figure 5.3: Traffic deaths per distance driven and per capita, and distance driven per capita in a period of economic growth; Ontario 1955-1972.¹

¹Wilde, G.J.S. (1984). On the choice of denominator for the calculation of accident rates. In S. Yagar (Ed.), *Transport risk assessment*. Waterloo, Ontario: University of Waterloo Press, pp. 139-154.

As Figure 5.3 shows, the death rate per unit distance of mobility dropped, the motor-vehicle mobility per citizen rose, but so did the traffic death rate per capita, on average by 0.8% per year. This was also a period of major road construction, especially of four-lane freeways which allowed fast and attractive travel by car from city to city. As a result, people were lured out of the train, into their cars and onto the roads. In 1955, travel by train for Canada amounted to 296 km per head of population.¹ In 1972 it was 151 km, while trains were about 30 times safer per passenger-kilometre than road travel.² It's no wonder that the road traffic death rate per inhabitant rose. People spent more time driving the roads and less riding the train.

This takes us to a remarkable inference: one and the same accident countermeasure may improve safety per km driven and contribute to an increase in the accident rate per head of population! As other researchers have put it: "Making an activity safer may increase mortality."³ The apparent paradox in this statement is due to the fact that making an activity such as driving safer per km of mobility may attract more people to it so that more people will die in that activity. Thus, the provision of more crashworthy cars and forgiving roads may lead to a reduction in the death rate per km driven, to no change in the death rate per hour of exposure to traffic, and to a higher death rate per head of population.

Consider another scenario, one in the area of lifestyle-dependent health. Imagine that somebody invents a cigarette that reduces the death rate per cigarette smoked to one-half that of present-day cigarettes. Is that progress? Should the marketing of these cigarettes be hailed as a boon for public health? The answer is that it all depends. If there is no change in people's desire to be healthy, smokers might react by smoking twice as much. Their death rate would not be altered. But this is not the only potential repercussion: the very availability of the "safer" cigarette may lead fewer people to stop the smoking habit, and may seduce more non-smokers to yield to the temptation, because smoking has become less dangerous. As a result, the smoking-related death rate per capita would increase.

That smokers maintain their nicotine intake regardless of the nicotine content of the cigarettes they smoke has been known for over thirty years.⁴ In 1992 an editorial in the *American Journal of Public Health* noted again that cigarettes with lower nicotine content are smoked more frequently, puffed more often and inhaled more deeply. The authors posited "the very real prospect that the existence of low tar and low nicotine cigarettes has actually caused more smoking than would have occurred in their absence and thereby raised the morbidity and mortality associated with

¹Statistics Canada, Catalogue No. 52-207, Table 9.

²McDougall, J.L. (1966). *The relative safety of railway and highway operations*. Department of Economics, Queen's University, Kingston, Ontario.

³Vaupel, J.W. and Yashin, A.I. (1985). Heterogeneity's ruses: some surprising effects of selection on population dynamics. *The American Statistician*, 39, 176-185.

⁴Schachter, S. (1977). Studies of the interaction of psychological and pharmacological determinants of smoking: I. Nicotine regulation in heavy and light smokers. *Journal of Experimental Psychology General*, 106, 5-12.

smoking.”¹ In 1997 Australian researchers observed that work-place smoking bans causes smokers during their “smoke breaks” outside buildings to take more puffs per cigarette.²

Speaking of the workplace... with respect to the danger of back injuries associated with lifting heavy objects, it has been found that the use of abdominal belts—also known as back belts or weightlifters’ belts—is being perceived by workers as the safest lifting technique.³ Workers who used these belts increased the self-selected weight to be lifted by as much as about one-fifth.⁴ And managers expected them to do so.⁵ Thus, it may well be that the use of these belts reduces the rate of back injury per kilogram lifted, but not necessarily the rate of weightlifting-related injuries per worker. As soon as you give it some thought, that becomes obvious, doesn’t it?

Once again, when shall we call a safety measure effective? The answer depends on the criterion of choice. The drop in **accident** loss per unit distance of mobility may be viewed as a triumph by the ministry of transport, while the attendant rise in the traffic accident loss per capita may give rise to grave concern in the ministry of health. The latter might argue that “yes, the operation was successful, but the patient died.” In other words, it would seem that engineering interventions for the purpose of greater safety can put more kilometres into people’s years, and thus allow people to drive more kilometres per death, but fail to add years to people’s lives.

Therefore, instead of thinking of these interventions as if they were “safety measures,” it may be more appropriate to refer to them as “mobility-promotion measures.”⁶ And similarly, the black belts just mentioned may be turn out to be “weight-lifting promotion” measures, without reducing the chances of pain and injury in the people who do the lifting of weights.

Whatever denominator one chooses for the calculation of the accident rate, it is obvious that a clear distinction should be made between the accident rate per unit distance of mobility, and the accident rate per hour of road use or per inhabitant. “[...] different measures paint different pictures concerning changes over time and the current state of motor-vehicle safety.”⁷ If the denominator of the accident rate is not clearly spelled out, the discussions about traffic safety and about theories of accident causation and the effectiveness of diverse accident countermeasures will remain

¹Warner, K.E. and Slade, J. (1992). Low tar, high toll. *American Journal of Public Health*, 82, 17-18.

²Chapman, S., Haddad, S. and Sindhusake, D. (1997). Do work-place smoking bans cause smokers to smoke “harder”? Results from a naturalistic observational study. *Addiction*, 92, 607-610.

³Rabinowitz, D., Bridger, R.S. and Lambert, M.I. (1998). Lifting technique and abdominal belt usage: A biomechanical, physiological and subjective investigation. *Safety Science*, 28, 155-164.

⁴McCoy, M.A., Congleton, J.J., Johnson, W.L. and Jiang, B.C. (1988). The role of lifting belts in manual lifting. *International Journal of Industrial Ergonomics*, 2, 259-266.

⁵Bridger, R.S. and Freidberg, S.S. (1999). Managers’ estimates of safe loads for manual handling: evidence for risk compensation? *Safety Science*, 32, 103-112.

⁶Wilde, G.J.S. (1998). Can traffic calming devices be expected to reduce the accident rate per head of population or per unit distance driven? Paper presented at Traffic Safety Summit ‘98, Kananaskis, AB, Canada, Oct. 4-7, www.ama.ab.ca/trafsafe/traf_safe_summit/presnt34.pdf.

⁷Sivak, M. (1996). Motor-vehicle safety in Europe and the USA: A public-health perspective. *Journal of Safety Research*, 27, 225-231.)

muddled forever, as they have been in the past and often continue to be.^{1,2} Some authors even went as far as to make indiscriminate use of changes in the rate of accidents per km and accidents per person as measures of intervention effect, as if they were equivalent yardsticks!³ Results of such poorly articulated work have been frequently quoted and sometimes been viewed as evidence against risk homeostasis theory. Confusion breeds confusion.

The same holds for discussions about the effectiveness of various measures for the promotion of health. A cigarette that is safer per one hundred million cigarettes smoked is not equivalent to a reduced smoking-related death rate in the nation. Confusion breeds confusion.

5.3 *A historical note on what happened between 1870 and 1910*

Automobiles appeared on the roads at the end of the 19th century. The first fatal motor vehicle accidents in England and Wales occurred in 1900.⁴ In that year, four individuals were killed due to this means of road transport. In 1910 this number amounted to 362. So, motor-vehicle fatalities rose sharply, but what is interesting is that the overall number of traffic fatalities showed no such development in this period, as can be seen from Figure 5.4.

Around the turn of the 19th century, motor-vehicle fatalities, and those associated with bicycles, including those wonderful velocipedes, became more frequent from year to year, while those associated with horses and horse-drawn vehicles—the latter not shown in the graph—dropped, and the total number of traffic fatalities showed no clear upward trend. Without a change in their total number, fatal accidents appeared to have undergone a metamorphosis: the horse was replaced by the engine as the source of power, and the carriage was replaced by the car as the vehicle of death. There was risk redistribution, but no risk reduction. Mobility increased, but no change in the overall traffic death rate is apparent in these early data. An Australian researcher, who also noted the high death rate associated with horses and buggies before the arrival of the automobile, studied traffic death trends in New South Wales from the first to the last decade of the 1900s. His patterns of findings are very similar to the British ones just described and “[...] the conclusion is drawn that there is no evidence that could cause us to question the existence of risk compensating behaviour in New South Wales road users.”⁵

¹Zlatoper, T.J. (1989). Models explaining motor vehicle death rates in the United States. *Accident Analysis and Prevention*, 21, 125-154.

²Grayson, G.B. (1996). *Behavioural adaptation: A review of the literature*. Report 254. Crowthorne, U.K.: Transport Research Laboratory.

³Evans, L. (1985). Human behavior feedback and traffic safety. *Human Factors*, 27, 555-576.

⁴Plowden, W. (1971). *Motor car and politics 1896-1970*. London: The Bodley Head.

⁵Knott, J.W. (1994). Road traffic accidents in New South Wales, 1881-1991. *Australian Economic History Review*, 34, 80-116, p. 80.

In Chapter 12 we shall see that, in a similar fashion, the overall violent death rate per capita has not changed appreciably between 1900 and 1975 in the majority of countries.

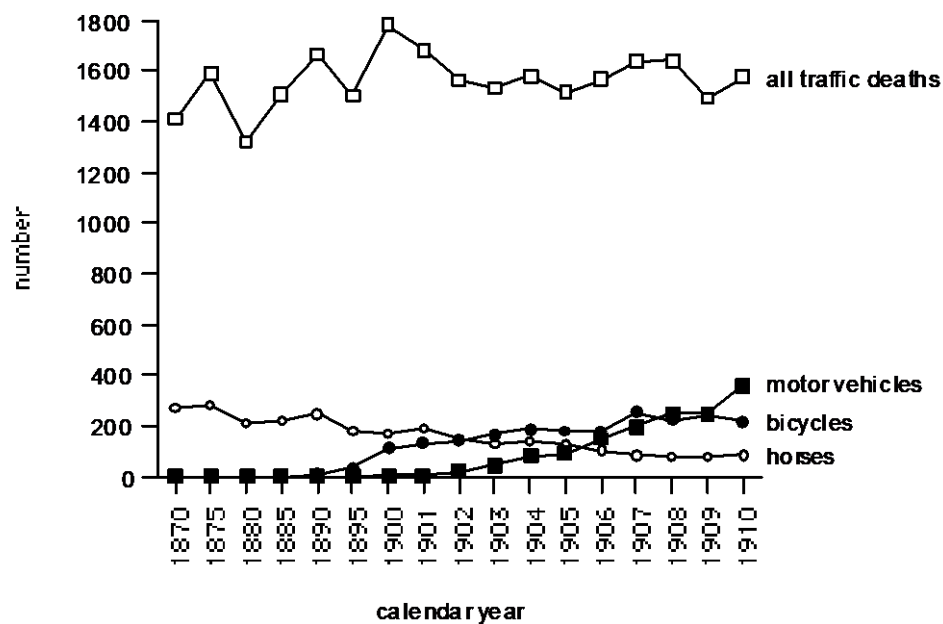


Figure 5.4: Road deaths related to various means of transport in England and Wales from 1870 to 1910.¹

5.4 *Traffic accidents and the state of the economy*

In Section 5.1 and Figure 5.2 we noted marked variations in the annual road fatality rates per head of population in the USA between 1923 and 1989. Such variations have occurred in other countries and they often lasted over a considerable number of years. Consider the peak between the early 1960s and the early 1970s in Figure 5.2. According to the theory advanced in this report, such longer-term fluctuations must be due to changes in the target level of risk, and are not caused by technological, legal, educational or other accident countermeasures that fail to affect that target level of risk. So, the question arises as to what factors could possibly explain these longer-term fluctuations.

As was discussed in Section 4.1, the target level of risk is assumed to depend on four classes of utility factors:

¹*Care on the Road* (1986), February, p. 10.

1. The benefits expected from risky behaviour alternatives.
2. The costs expected from cautious behaviour alternatives.
3. The benefits expected from cautious behaviour alternatives.
4. The costs expected from risky behaviour alternatives.

The first two categories have an enhancing effect upon the target level of risk, while it is reduced by the latter two. What factors could have caused the fluctuations in the target level of risk across the population as a whole and over several years? It is suggested here that the answer is of an economic nature.

When the economy is in a recession, the benefits expected from risky behaviour are reduced, because time is worth less money. There is less to be gained from driving many km and from driving fast. There is less to be gained from driving through a red or amber light or from cutting corners in other ways. At the same time, the costs expected from risky behaviour are increased, because the costs of accidents, gasoline, insurance surcharges for having an accident, of car repairs, of vehicle wear and tear, etc., rise relative to real income. In terms of Figure 4.2 in Section 4.1, expected gain (the top curve) moves downward and the expected loss (the bottom curve) drops more sharply, with the result that the optimal level of exposure to risk (the point marked by the arrow) moves toward the left, indicating a lower level of target risk.

This is precisely why some of the complex formulae that have been developed by economists for the purpose of longitudinal prediction of accident loss have included price and income fluctuations over time, among several other variables. But the interpretation of these prediction equations has often been obscure.^{1,2} In part, this was due to lack of independence between the variables that were entered into the prediction formulae. It was also due to heterogeneous criteria that were being predicted, for instance, deaths per km driven in some studies and deaths per capita in others. That these two criteria are *not* interchangeable as yardsticks of safety has been shown in Section 5.2. In fact, decreases in the accident loss per km driven may occur in the same time period in which the loss per head of population remains unaltered or even increases. Different criteria of safety may be as different as apples and oranges, and confusion between them turns comparative studies into lemons.

The difficulties of interpretation have been reduced by the simpler equations put forward in recent times. In a study of American trends in the annual numbers of people killed in traffic between 1960 and 1983, a set of no more than three variables produced a remarkably accurate prediction. The variables were: the annual numbers of people unemployed, the number of workers employed, and the number of people not in the labour force. When USA citizens between ages 15 and 19—whose financial

¹Zlatoper, T.J. (1989). Models explaining motor vehicle death rates in the United States. *Accident Analysis and Prevention*, 21, 125-154.

²Wilde, G.J.S. (1994). Risk homeostasis theory and its promise for improved safety. In R.M. Trimpop and G.J.S. Wilde (Eds.), *Challenges to accident prevention: the issue of risk compensation processes*. Groningen, the Netherlands: Styx Publications.

prosperity is particularly sensitive to economic fluctuations, since they're the last to be hired and the first to be fired—were considered separately, the relationship between the economic juncture and the traffic death rate was found to be even more pronounced than in the population as a whole. The young don't have the financial reserves to buffer the impact. In statistical terms: the coefficient of determination was $R^2 = 0.89$ for the citizenry as a whole and $R^2 = 0.98$ for people between 15 and 19.¹ The coefficient of determination, by the way, simply equals the square of the correlation coefficient (r).

It should be noted that, due to the growth of the American population by about 1% per year, the interpretation of the marked correlation between the predicting variables still presented a problem. Increases in the size of the population alone, when everything else remains the same, would be expected to lead to an increase in the number of people killed. Population increases alone would not, however, be expected to lead to an increase in the traffic fatality rate per 100,000 inhabitants.

This is also true for a study of British data² that used a slight modification of the earlier procedure and arrived at a somewhat lower coefficient of determination: $R^2 = 0.88$. Another researcher avoided the lack-of-independence problem by expressing the unemployment rate as a percentage of the work force.³ Marked correlations were found (simple r 's in the order of 0.7) between monthly unemployment statistics for younger and older males and females in British Columbia and the traffic casualty rate per one million kilometres driven during 84 consecutive months from 1978 through 1984. The study concluded that "some portion of [the decrease in frequency and severity of road accidents] can be attributed to increases in unemployment which appear to remove young male drivers from the driving population." It should be noted that this investigation focused on the rate of accidents per unit distance driven, *not* per head of population, although the latter would seem to be the criterion of greatest interest from a public health and safety perspective. A marked and positive relationship between the state of the economy and the per capita road accident rate has also been noticed in the Sultanate of Oman,⁴ and a recent longitudinal study of the relationship between economic and traffic mortality fluctuations in 32 OECD countries observed that "[...] an increase of on average 1% in economic growth is

¹Partyka, S.C. (1984). Simple models of fatality trends using employment and population data. *Accident Analysis and Prevention*, 16, 211-222.

²Adams, J.G.U. (1985). *Risk and Freedom: the record of road safety regulation*. London: Transport Publishing Projects.

³Mercer, G.W. (1987). Influences on passenger vehicle casualty accident frequency and severity: unemployment, driver gender, driver age, drinking driving and restraint device use. *Accident Analysis and Prevention*, 19, 231-236.

⁴Al-Reesi, H., Ganguly, S.S., Al-Adawi, S., Laflamme, I., Hasselberg, M. and Al-Maniri, A. (2013). Economic growth, motorization, and road traffic injuries in the Sultanate of Oman. *Traffic Injury Prevention*, 14, 322-328.

associated with a 1.1% increase in road mortality, and vice versa."¹ A similar statistic was found for motorcyclists' deaths in the USA: an increase of 10% in real income per capita was associated with a 10.\$ increase in the motorcycle fatality rate.²

5.4.1 *Additional analyses of unemployment rates*

In order to provide further and more easily interpretable information on the relationship between economic ups and downs and per capita traffic fatality rate, simple product-moment correlations were calculated between the annual variations in the unemployment rate as a percentage of the workforce and the traffic death rate per 100,000 people. The lack-of-independence problem was thus eliminated and the calculations focused upon the accident rate per head of population. Eight different countries were included in the analyses. The unemployment data used in the calculations are those published by the International Labour Office.³ The numbers of traffic fatalities and population sizes were derived from the relevant annual statistical yearbooks published by the countries involved. These came from the National Safety Council in the USA⁴ and from Statistics Canada.⁵

¹Chen G. (2014) Association between economic fluctuations and road mortality. *European Journal of Public Health*. First published on line:
<<http://eurpub.oxfordjournals.org/content/early/2014/02/24/eurpub.cku014>>

²French, M.T. and Gumus, G.(2014). Macroeconomic fluctuations and motorcycle fatalities in the U.S. *Social Science and Medicine*, 104, 187-193.

³International Labour Office (various years). *Yearbook of labour statistics*. Geneva, Switzerland.

⁴National Safety Council (various years). *Accident facts*. Chicago, IL.

⁵Statistics Canada (various years). *Causes of death, vital statistics*. Ottawa.

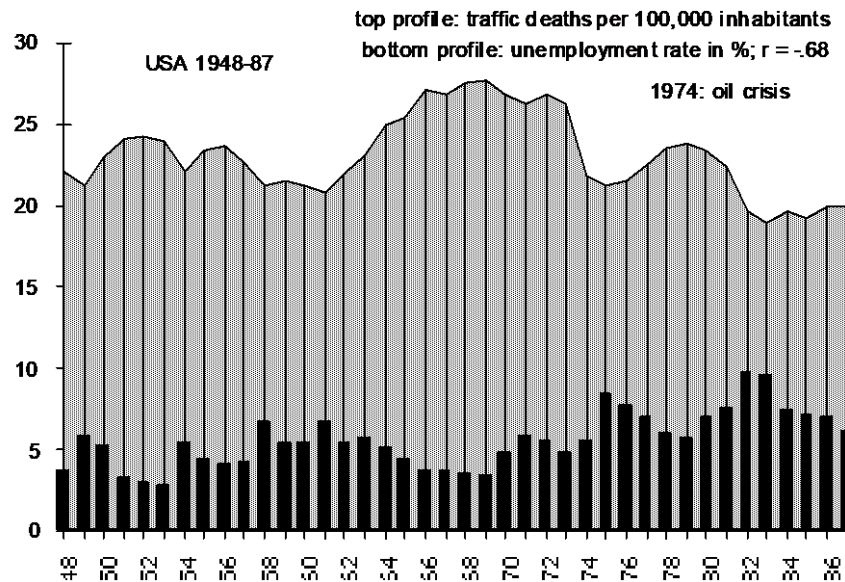


Figure 5.5: Annual variations in the unemployment rate and the traffic death rate per capita in the USA, 1948-1987.

The year-to-year variations in the USA and the Netherlands have been graphed in Figures 5.5 and 5.6. Observations cover the 30-year period from 1948 to 1987 in the USA. If you inspect this figure closely you will see that increases in unemployment from one year to another are associated with drops in the traffic death rate per head of population. Decreases in the unemployment rate from one year to the next occur together with increases in the death rate. This is true for virtually all comparisons from one year to the next. The peaks and high ranges in the death rate occur in the same time periods as troughs and valleys in the unemployment rate, and vice versa. The two profiles come very close to being each other's mirror image. This is less true for the Netherlands, but there the correlation is stronger: $r = -0.88$ as compared to -0.68 in the USA.

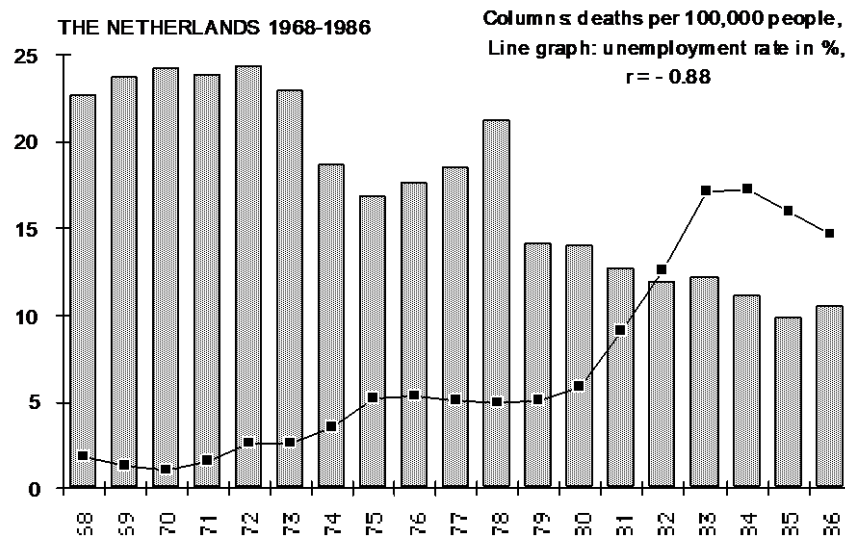


Figure 5.6: Annual variations in the unemployment rate and the traffic death rate per capita in the Netherlands, 1968-1986.

For all eight countries considered in Table 5.2, the correlations are sizable, yet there are reasons to suggest that they suffer from attenuation due to unreliability and that true correlations may be higher still. The unemployment rate is usually estimated from samples, household surveys, or otherwise limited data bases. That estimate is thus subject to error. The same holds for the numbers of people killed as a consequence of a road accidents.^{1,2} The number of people residing in a country is not exactly known either. Time lags in the variations between the one variable and the other would also have an attenuating effect upon the correlation coefficients as calculated. On the other hand, the coefficients would be inflated if the measurement errors in both variables were correlated.

To complicate matters further, over the years, there have been changes in various countries in the proportion of young people in the population, with the young being involved more often in accidents *and* more likely to be laid off in bad economic times. There have also been changes in the definition of what constitutes “being unemployed,” as well as changes in legislation and in agreements that offer employees greater or lesser protection from being laid off. The implication is that

¹Metzner, G. and Brinkmann, B. (1993). Inaccuracies in the official accident statistics of fatal traffic accidents: comparative studies in West Germany during two time periods. *Journal of Traffic Medicine*, 21, 165-169.

²Hutchinson, T.P. (1987). *Road accident statistics*. Adelaide, Australia: Rumsby Scientific Publishing.

changes in the economic juncture may be less directly reflected in the unemployment rate of some countries than in others, and less in some time periods than in others.

Table 5.2: Product-moment correlations between annual unemployment rates and per capita traffic death rates in eight different countries.

United States 1948-1987	-0.68
Sweden 1962-1987	-0.69
Finland 1965-1983	-0.86
Canada 1960-1986	-0.86
United Kingdom 1960-1985	-0.88
The Netherlands 1968-1986	-0.88
West Germany 1960-1983	-0.83
Switzerland 1968-1994	-0.91 ¹

The longer a recession lasts, the more likely the ratio of part-time jobs to full-time jobs will increase and that young people will spend more years in education instead of trying to find a job. Older unemployed people in the workforce may become discouraged and stop looking for work. These factors reduce the unemployment figures for those who are actively looking for work. The recorded unemployment rate is thus reduced, even in the absence of economic recovery, in fact, precisely because of it. Moreover, in some countries, migrant labour is sent home when unemployment rises, thus changing the are actively looking for work. The recorded unemployment rate is thus reduced, even in the absence of economic recovery, in fact, precisely because of it. Moreover, in some countries, migrant labour is sent home when

¹The relationship was even stronger ($r=0.96$) when calculated from ARIMA analysis with the index of industrial production as a measure of economic prosperity. Wilde, G.J.S. and Simonet, S.L. Economic fluctuations and the traffic accident rate in Switzerland: A longitudinal perspective. Bureau suisse de prévention des accidents, Berne CH, 1996 (27 pages).
<<http://www.bfu.ch/German/forschung/Forschungsergebnisse/pdfForschungsergebnisse/Pilotstudien/R9615.pdf>>.

unemployment rises, thus changing the number of residents and the population distribution in terms of age and socio-economic status, both of which affect accident likelihood.^{1,2}

5.4.2 *New questions arising*

The findings presented so far indicate that ups and downs in the economic juncture have a major effect upon the per capita traffic fatality rate, unless one can meaningfully argue that the accident rate determines the unemployment rate, or that both variables are controlled by a third factor. These findings also open an entire portfolio of new questions for further research. To mention a few: which indicator of economic fluctuations is the most closely related to the accident rate? Is it the unemployment rate or some other index, such as stock exchange trading, consumer spending, or possibly the consumption of electricity? Is the traffic fatality rate within specific population subgroups (age, gender, socio-economic status) more sensitive to the economic juncture than is true for others? Does the economic juncture also affect the industrial or occupational accident rate? This is in fact suggested by German data³ and a study of almost a century of Italian workplace accidents, which came to the conclusion that “[...] the factors influencing human safety conditions in industrial activities do not depend on technological development.”⁴ Do the economic fluctuations influence still other categories of accidents such as those occurring at home or during leisure-time activities and sports, and do these fluctuations differentially affect the fatality rate in diverse road-user categories such as drivers, occupants, bicyclists, and pedestrians?

Furthermore, when the road fatalities vanish during bad economic times, where do they go? Are they replaced by other forms of violent death, such as suicides and homicides?

Is the reduction in the traffic death rate offset by an increase in other forms of lifestyle-dependent death, for instance, in mortality associated with smoking, drinking, exercising too little or too much, or other health-relevant habits?

Does the reduction in the traffic fatality rate per capita during bad economic times signify a net decrease in mortality when *all* causes of death are considered, or do causes of death that are usually not attributed to lifestyle become commensurately more prominent?

¹Harano, R.M., Peck, R.C. and McBride, R.S. (1975). The prediction of accident liability through biographical data and psychometric tests. *Journal of Safety Research*, 7, 16-52.

²Chebat, J.C and Chandon, J.L. (1986). Predicting attitudes toward road safety from present and future orientations: An economic approach. *Journal of Economic Psychology*, 7, 477-499.

³Bartels, K. (1976). *Über die Wirksamkeit von Arbeitssicherheitsprämien*. Dortmund, Germany: Bundesanstalt für Arbeitsschutz und Unfallforschung, p. 15.

⁴Fabiano, B., Parentini, I., Ferraiolo, A. and Pastorino, R. (1995). A century of accidents in the Italian industry: Relationship with the production cycle. *Safety Science*, 21, 65-74.

Table 5.3: Product-moment correlations between the unemployment rate in different economic sectors and the national per capita traffic death rate in the USA, 1948-1987.¹

private wage and salary workers in finance, insurance and real estate	-0.47
government workers in non-agricultural industries	-0.58
private wage and salary workers in wholesale and retail	-0.67
private wage and salary workers in construction	-0.67
total work force, 16 years and over	-0.68
wage and salary workers in agricultural industries	-0.68
private wage and salary workers in manufacturing	-0.70
private wage and salary workers in services	-0.70
private wage and salary workers in mining	-0.73
total wage and salary workers	-0.75
private wage and salary workers in transportation and public utilities	-0.80
private wage and salary workers in private households	-0.85

**Note: "private worker" means not employed by government; household survey data.*

Among the additional questions raised above, two issues were empirically explored for the purpose of this chapter. First, is the unemployment rate in some particular sector of the economy more closely related to the aggregate per capita traffic death rate than is true for other sectors? As can be seen from Table 5.2, this would seem to be true for the USA. The data were obtained from the US Department of Labor and from the National Safety Council. Depending upon the economic (i.e., employment) sector considered, correlations between unemployment and the overall traffic death rate over the same period were found to vary by as much as between $r = -0.47$ and $r = -0.85$, but the reasons for these differences remain to be investigated.

The second question on which some data were analysed concerns the process through which an economic recession leads to a reduction in traffic fatalities per capita. Do people drive less or do they drive more safely, or both? Again, data were derived from the National Safety Council and the US Department of Labor. The mileage per capita was calculated by dividing the death rate per capita by the death rate per mile (note that $\text{km/A} = (\text{A/N}) \div \text{A/km}$; see Table 5.1). As is suggested by Figure 5.7, both effects occur.

¹Wilde, G.J.S. (1994). Risk homeostasis theory and its promise for improved safety. In R.M. Trimpop and G.J.S. Wilde (Eds.), *Challenges to accident prevention: The issue of risk compensation behaviour*. Groningen, the Netherlands: Styx Publications.

Reductions in mileage driven or reductions in the rate of growth in mileage driven seemed to occur in years that showed a major increase in the unemployment rate, e.g. 1954, 1958, 1974 (the year of the oil crisis), 1980 and 1982. Sudden reductions in the death rate per mile driven can also be seen in years in which unemployment surges: 1949, 1954, 1958, 1961, 1974 and 1982. Increases in employment seem to be associated with more road mobility per head of population *and* with more road deaths per mile driven. So, during bad economic times people reduce the distance they drive, and when they drive, they drive in a more cautious manner.

How can the remarkable patterns presented in this section be explained? It would seem absurd to suggest that the traffic death rate is responsible for the unemployment rate. Not enough employed people die on the roads to provide substantial job opportunities for those out of work. Two other possibilities remain: either the fluctuations in the unemployment rate cause the variations in the death rate, or the fluctuations in both are due to some third factor or set of factors. I think that the first of these offers the most likely explanation. For reasons mentioned at the start of this section, when the economy is depressed, so is the level of risk people are willing to take on the road. When the economy is booming, there is also more to be gained from more and faster driving. In such a period, the value of current time is increased.¹

¹Wilde, G.J.S. and Kunkel, E. (1984). Die begriffliche und empirische Problematik der Risiko-kompensation. *Zeitschrift für Verkehrssicherheit*, 30, 52-61.

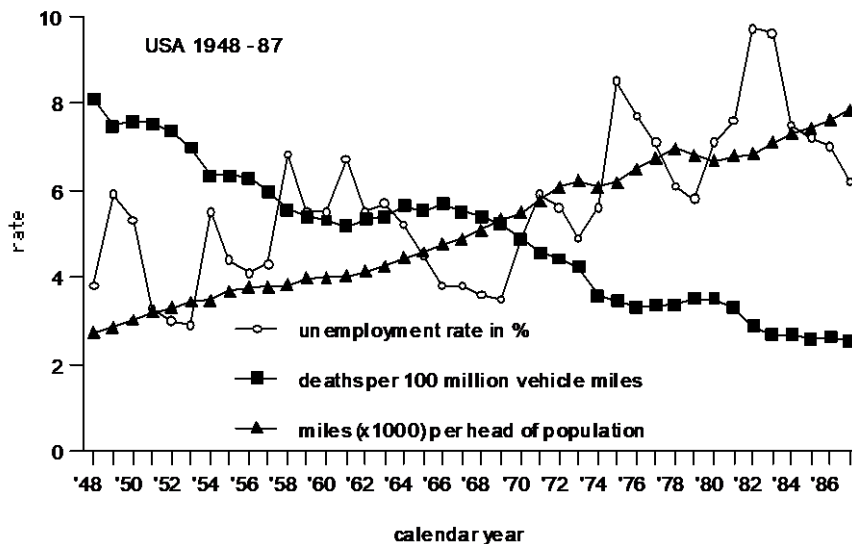


Figure 5.7: Annual unemployment rate, traffic death rate per mile driven and mileage driven per capita, USA, 1948-1987.¹

It would, of course, be bizarre, to propose that the economy deliberately be kept in a depressed state for the purpose of enhancing traffic safety, but the observation that the accident rate is influenced by economic factors can be put to positive use in countermeasure design. This will be the topic for Chapter 11. Recessions are bad for people, and a reduction in the per capita traffic fatality rate is a minor consolation. At any rate, it shows that “nothing is so bad that it isn’t good for something.”

5.5 Is there no counterevidence?

The short answer is: “Not really, at least not so far.” The long answer follows.

As has been indicated at the end of Section 3.4 and elsewhere,² there has been considerable opposition to the ideas comprised by Risk Homeostasis Theory (RHT). Some reactions have been rather emotional, but here we will try to deal, not with their form, but with their substance, and it will be shown below that in substance these reactions equally inappropriate.

First, some critics have pointed out that, over the years, there have been major reductions in the traffic accident rate per distance travelled. As you can see from Figures 5.1, 5.2 and 5.3, this is indeed an observation of fact. Facts, however, can

¹Wilde, G.J.S. (1991). Issues that remain: commentary on Session 3. *Proceedings, Enforcement and rewarding: Strategies and effects. International road safety symposium*. Organization for Economic Cooperation and Development and the European Conference of Ministers of Transport, pp. 157-163.

²Wilde, G.J.S. (1982). Critical issues in risk homeostasis theory. *Risk Analysis*, 2, 249-259.

only contradict a theory to the extent they are in conflict with what a theory predicts. RHT does not say that the accident rate per kilometre driven cannot be reduced - witness Chapters 4 and 5. If it did, the theory would be as unrealistic as this criticism is irrelevant.^{1,2}

In spite of the fact that all that had been published in 1994, as well as eight years earlier,³ as recently as 2002, thus several years after the above materials were published (but not necessarily read, so it would seem), two critics argue that “The most compelling argument against risk homeostasis is the observation that occupant death rates in passenger cars per distance travelled fell by nearly two thirds in the United States from 1964 to 1990.” Any reader attentive to what I wrote will notice that this argument does not attack the theory, but a misrepresentation of it. The theory does not contend, as these critics allege, that the crash rate per unit distance travelled cannot be reduced. In fact, what risk homeostasis theory does say is that such reductions are accompanied by increases in distance travelled. Consequently, a reduction in the crash rate per unit distance driven does not result in a similar reduction in the crash rate per hour of road use or per head of population per annum. No debate about risk homeostasis can make sense when critics or proponents fail to distinguish between crash rate per km driven, per hour of exposure, or per capita. The distinction is between: How dangerous is it to drive a kilometre and how many people are dead at the end of the day?

RHT deals with accident rates per time unit of road-user exposure, including the risk per head of population per calendar year (see the beginning of this chapter and Section 5.2). Confusion and/or lack of distinction between the accident rate per distance driven and the accident rate per head of population continue to cloud the discussion about risk homeostasis.⁴ If the fundamental nature of the distinction is not recognized, any discussion about accident prevention in general, and risk homeostasis in particular, becomes pretty well meaningless.⁵

Second, other critics attack RHT because they fail to distinguish between the cross-sectional and longitudinal predictions that follow from RHT, as specified in Table 5.1 at the beginning of this chapter. Here are the facts: the traffic accident toll in the USA, expressed as the number of fatalities divided by the estimates of aggregate distance driven in motorized travel, diminished by a factor of approximately 2.5 over the years from 1943 to 1972 (see Figure 5.2). If the time spent on the road and the

¹Wagenaar, W.A. (1992). Risk taking and accident causation. In Yates, J.F. (Ed.), *Risk-taking behavior*. New York: Wiley, pp. 257-281.

²Grayson, G.B. (1996). *Behavioural adaptation: A review of the literature*. Report 254. Crowthorne, U.K.: Transport Research Laboratory.

³Wilde, G.J.S. The Risk Compensation Theory of Accident Prevention. *Proceedings, Twelfth Annual Convention of the Austrian Traumatological Society, Salzburg, Austria, October 7-9, 1976*

⁴Wilde, G.J.S., Robertson, L.S. and Pless, I.B. (2002) For and against: Does risk homeostasis theory have implications for road safety *British Medical Journal*, 324,1149-1152.

⁵Hedlund, J. (2000). Risky business, safety regulations, risk compensation, and individual behavior. *Injury Prevention*, 6, 82-89.

target level did not change in this period, and if one may overlook the comparatively small kilometrage in non-motorized road travel, then the *average speed of mobility* must have increased by this same factor 2.5 if RHT is correct. The critics in question^{1,2} follow the same train of thought, but their reasoning derails beyond this point. They say that the *average speed of motor vehicles* should have increased by this factor and, as this is not the case, RHT must be wrong. However, the correct inference from RHT—which is also drawn by others³—is that the *average speed of road mobility of the population* should have increased by that factor when *aggregated across all modes*: on foot, by bicycle, automobile, etc. Somebody who buys her or his first car also generally purchases a greater speed of mobility.

Consider now that, in the period concerned, the number of motor vehicles per US inhabitant has risen from 0.23 to 0.58, the number of driver's licences from 0.34 to 0.56, while the network of high-speed roads has been greatly expanded and cars have been made more powerful. Consider also that the estimate of the total motor vehicle mobility divided by the number of inhabitants increased approximately fourfold, i.e., from some 1500 to 6000 miles on average per head of population. Although it may not be possible to determine from these data by how much the average speed per citizen (aggregated across all modes) in road traffic has increased, there would seem to be no evidence in clear conflict with the RHT estimate of a factor of about 2.5.

Third, the well-established fact that accidents are usually, though not always, more frequent when it is raining has been called “a good demonstration of the failure of risk homeostasis.”⁴ Indeed, RHT would have some explaining to do if it were true that the total accident loss (the sum of frequency of accidents times their average severity) per road user in rain is greater than in fair weather, but no such fact has been established.⁵ It turns out, accidents in rain, although more numerous per kilometre of driving,⁶ are less severe on average than those on dry pavement. For instance, over a seven-year period in Ontario, the ratio of recorded fatal to personal-injury accidents under dry conditions was found to be about 40% higher than under wet pavement conditions. This ratio was about the same or higher still when dry road conditions were compared with pavements covered with loose snow, slush, packed snow and ice.

¹Shannon, H.S. (1986). Road accident data: interpreting the British experience with particular reference to risk homeostasis theory. *Ergonomics*, 29, 1005-1015.

²Evans, L. (1986). Risk homeostasis theory and traffic accident data. *Risk Analysis*, 6, 81-94.

³Hoyos, C.G. (1984). Stellungnahme zu einer Diskussion über die Theorie der Riskokompensation. *Zeitschrift für Verkehrssicherheit*, 30, 61-62.

⁴McKenna, F.P. (1987). Behavioural compensation and safety. *Journal of Occupational Accidents*, 9, 107-121.

⁵Wilde, G.J.S. (1989). Accident countermeasures and behavioural compensation: the position of risk homeostasis theory. *Journal of Occupational Accidents*, 10, 267-292.

⁶Brodsky, H. and Hakkert, A.S. (1988). Risk of a road accident in rainy weather. *Accident Analysis and Prevention*, 20, 161-176.

Moreover, the fatal plus personal-injury accidents constitute a smaller fraction of all recorded accidents when they happen in rain.¹

A report published by a group of international experts mentions that in the city of Oslo, 15% of all accidents happened on snow and ice-covered roads, though they carried only 5-10% of all traffic, but the relative number of fatal accidents was found to be lower; there was more material damage and less personal injury.² Further, several studies report a reduction in both motorized and pedestrian traffic under rainy conditions.^{3,4} Similarly, in Britain, thick fog has been found to reduce traffic volumes to about 70% of normal on weekdays and to about 50% on weekends.⁵ On an expressway in France, heavy rain was found to cause drivers to increase the time gap between the car ahead and themselves, and to reduce average speed by as much as 36 km/h.⁶ In addition, it was found by the author that on an expressway in Toronto, Canada, "Overall, drivers' respond to rainfall conditions by reducing both speed and speed deviations, and increasing headway. Taken in combination, drivers are taking positive steps in order to either maintain or improve safety levels."⁷ In a Norwegian study, similar findings have been observed in curves as a function of weather conditions and road surface friction.⁸

It would seem reasonable to conclude from this that people react to inclement weather in at least two ways: they reduce the amount of travelling under these conditions and they behave in traffic in a manner such that, although more accidents happen per km driven, the average severity of the accidents is considerably less than when the weather is fine.

Suppose, nevertheless, that it had been established that the accident loss per time unit of road-user exposure is greater in rainy weather. Would that necessarily gainsay RHT? Rain and wet roads reduce both motorized and pedestrian travel and this reduction is self-selective: some people decide to stay off the roads while others decide to travel. It has been observed that under rainy conditions, there is an increase

¹Adams, J.G.U. (1985). Smeed's law, seat belts and the emperor's new clothes. In L. Evans and R.C. Schwing (Eds.), *Human behaviour and traffic accidents*. New York: Plenum.

²OECD (1976). *Adverse weather, reduced visibility and road safety: driving in reduced visibility due to adverse weather*. Paris: Organization for Economic Cooperation and Development.

³Rutherford, G.S. and Schofer, J.L. (1976). *Analysis of pedestrian travel characteristics*. Paper presented at the 55th Annual Pedestrian Research Board, Washington, DC, January 19-23.

⁴Palutikof, J.P. (1991). Road accidents and the weather. In A.H. Perry and L.J. Symons (Eds.), *Highway meteorology*. London: E. and F.N. Spon.

⁵Musk, L.F. (1991). The fog hazard. In A.H. Perry and L.J. Symons (Eds.), *Highway meteorology*. London: E. and F.N. Spon.

⁶Seddiki, E. (1993). Impact de la pluie sur le trafic autoroutier. *Recherche - Transports - Sécurité*, No. 41, 13-24.

⁷Unrau, D.D. (2004). Driver response to rainfall on the Gardiner Expressway. Unpublished Master's thesis, University of Western Ontario, Waterloo, 2004.

⁸Kvernland, J.K. (2013). Føreres fartsvalg under ulike friksjonsforhold. < <http://www.diva-portal.org/smash/get/diva2:646875/FULLTEXT01.pdf>>.

in the proportion of male highway drivers to the total number of those who are still on the road.¹ These individuals may have a higher habitual level of risk tolerance. Additionally, their risk acceptance may also be raised temporarily. Using the roads under adverse conditions is experienced as unpleasant, and this is why many refrain from it. People may attempt to reduce the duration of their trip and thus accept more accident risk than they normally would. Although drivers slow down in the rain (sometimes by little² and sometimes by much^{3,4}) and pedestrians tend to move faster, the adaptation in speed may be less than would occur without the momentary increase in risk acceptance. Alternatively, it may be true that those who brave adverse weather are unrepresentative of the road-user population as a whole, in that they underestimate the danger of an accident under these conditions more than is true for the population in general.

Whatever the merit of these interpretations, it is difficult to see clear evidence against RHT in the observation that there are more accidents in the rain.

Several other observations have been mentioned by various authors as counter-evidence to RHT. Examples are: the effects of speed limits; the effects of special road markings on drivers' speed and accidents at junctions; the effects of new occupational health legislation upon accidents in industry; the fact that there have been reductions in the occupational accident rate over several decades; the alleged safety benefit of radial versus cross-ply tires and studded tires in particular; the supposition that the obligation to wear crash helmets is beneficial to the safety of motorcyclists; and the idea that the manufacture of more crashworthy cars increases the safety of the driver. All of these objections seem relatively easy to refute,^{5,6} and so is the argument that the drastic reduction in the per capita traffic accident rate that has occurred in Japan constitutes evidence against RHT (see Section 8.4).

Simulated driving^{7,8,1,2,3} and air-traffic control⁴ environments have been used by various experimenters that were conducted to test the validity of RHT under well-

¹Wilde, G.J.S. and Ackersviller, M.J. (1982). The effect of posting observed driver behaviour upon subsequent driver response: The case of moving speed. Report prepared for Transport Canada, Traffic Safety, July.

²National Cooperative Highway Research Program, Highway Research Board, (1968). *Effects of illumination and operating characteristics of freeways*. Report No. 60, Washington, DC, p. 42.

³Hawket, D.C.L. (1978). Speeds and headways of vehicles on rural roads. *Traffic Engineering and Control*, 19, 71.

⁴Wilde, G.J.S. (1977). *Shoulder belt use related to sex, age, moving speed and weather conditions*. Transport Canada, Road Safety, Report No. TP1093/CR7709, Ottawa.

⁵Wilde, G.J.S. (1982). Critical issues in risk homeostasis theory. *Risk Analysis*, 2, 249-258.

⁶Wilde, G.J. S. (1988). Risk homeostasis theory and traffic accidents: Propositions, deductions and discussion of dissension in recent reactions. *Ergonomics*, 31, 441-468.

⁷Tränkle, U. and Gelau, C. (1992). Maximization of subjective expected utility or risk control? Experimental tests of risk homeostasis theory. *Ergonomics*, 35, 7-23

⁸Jackson, J.S.H. and Blackman, R. (1994). A driving simulator test of Wilde's risk homeostasis theory. *Journal of Applied Psychology*, 79, 950-958.

controlled conditions. None of these have come to the conclusion that RHT is not valid. A doctoral dissertation defended at the University of Amsterdam contains as many as seven experiments involving the prospect of real gains and real losses for the participants. The author concluded that all predictions derived from the theory under scrutiny were empirically confirmed.⁵ From one of the experiments, which compared the efficacy of incentives and punishment in reducing accidents per time unit of exposure to risk, it was concluded that “[...] the incentive scheme reduced the numbers of accidents whereas the punishment scheme resulted in an increase in accidents, even though the probability of being caught speeding was the ten-fold of that in real traffic. The driver’s adverse behavior under a punishment scheme may be seen to be the result of trying to take other risks than ones one (likely to be) punished for. One may therefore argue that the legislative and executive powers should invest at least as much in incentives as in disincentives.” We will return to this topic in Chapter 11.

Mention should be made, however, of one study⁶ that found no evidence in support of RHT. The fact that, instead of actual behaviour as in the experiments above, ratings and behavioural intentions were solicited from the subjects may have undermined the validity of the study as the authors themselves admit. It is remarkable that this otherwise ingenious and carefully conducted study should not mention our own earlier experiments on risk in the laboratory, nor does it mention other validity-limiting factors of studies of “risk taking under safe conditions.” For an account of these and an overview of our own experiments, see Chapter 9.

¹Hoyes, T.W., Dorn, L., Desmond, P.A. and Taylor, R.G. (1996). Risk homeostasis theory, utility and accident loss in a simulated driving task. *Safety Science*, 22, 49-62.

²Glendon, A.I. Hoyes, T.W., Haigney, D.E. and Taylor, R.G. (1996). A review of risk homeostasis theory in simulated environments. *Safety Science*, 22, 15-25.

³Hoyes, T.W., Stanton, N.A. and Taylor, R.G. (1996). Risk homeostasis theory: A study of intrinsic compensation. *Safety Science*, 22, 77-86.

⁴Desmond, P.A., Hoyes, T.W. and Taylor, R.G. (1994). Applying risk homeostasis theory to a simulated air-traffic control task. In Robertson, S.A. (Ed.), *Contemporary ergonomics 1994*. London: Taylor and Francis, pp. 305-310)

⁵Schmidt, W.F. *Incentives for traffic safety*. Doctoral thesis, Amsterdam: University of Amsterdam, November 1998.

⁶Stetzer, A. and Hofmann, D.A. (1996). Risk compensation: Implications for safety interventions. *Organizational Behavior and Human Decision Processes*, 66, 73-88.

*And you all know security
Is mortals' chiefest enemy.*
William Shakespeare, *Macbeth*.¹

6 Intervention by education

If the theory advanced in this report is to be acceptable on the basis of facts, two conditions must be fulfilled. First, it should be found that accident countermeasures that don't reduce the target level of risk don't reduce the accident loss per head of population, regardless of whether they reduce the accident rate per unit distance of mobility. Second, accident countermeasures that do reduce the target level of risk should lead to observable reductions in per capita accident loss.

In this chapter, and in the two that follow it, empirical findings that mainly concern the first condition will be discussed. The second stipulation will be dealt with in Chapter 11. The traditional policy toward improvement of road safety—although the denominator of safety has rarely been clearly identified—goes under the common label of the “*Triple E*” approach: *E*ngineering, *E*ducation and *E*nforcement. Note that in this approach there is no specific reference to the concept of motivation—the concept that, according to risk homeostasis theory (RHT), is the most relevant to safety of all.

6.1 Education

There is nothing in this theory that categorically denies the safety benefits that could potentially be obtained through education or even training. By “education” we mean the effort to enlighten, to civilize and thus to impart more mature views, beliefs, and values. “Training” refers to the instilling of practical perceptual, decisional, and motor skills. The notion that people could be educated to lower their acceptance of accident risk is not incompatible with the postulates of RHT. In fact, a reduction in accidents and violations achieved in a preliminary study of a form of psychotherapy applied to repeated offenders might be explained in terms of RHT.²

As a further case in point, the work of Austrian researcher Lieselotte Schmidt³ is explicitly aimed at a reduction of the target level of risk, not by means of material inducements (such as monetary rewards, merchandise, or extra holidays),⁴ but through the enhancement of moral judgement, safety-consciousness, awareness of personal responsibility, and consideration for other people, as well as for the ecological environment. Another decidedly unmaterialistic approach is being pursued by Helena

¹Shakespeare, W. *Macbeth*, Act III, Scene 5.

²Prothero, J.C. (1978). Evaluation of an experimental treatment for problem drivers. *Human Factors*, 20, 489-493.

³Schmidt, L. (1988). Implications of new risk models for the analysis of traffic safety as well as for other traffic-related problems. In J.A. Rothengatter and R.A. de Bruin (Eds.), *Road user behaviour: Theory and research*. Wolfeboro, New Hampshire: Van Gorcum. Also see www.ictct.org/dlObject.php?document_nr=395&/Schmidt.pdf.

⁴Wilde, G.J.S. (1985). The use of incentives for the promotion of accident-free driving. *Journal of Studies on Alcohol*, Supplement No. 10, 161-167.

Intervention by education

Drottenborg in Sweden. Her research deals with the relationship between aesthetics and road safety, raising questions such as whether speed choice is influenced by the experience of beauty of the road environment.¹

There can be no question that the perspectives developed by Liselotte Schmidt and Helena Drottenborg are much more palatable to the cultured mind, at both the emitting and receiving end of the education process, than “materialistic bribery into safe conduct” and rewarding people for virtues they are morally obliged to display of their own accord. But there remains the practical question as to how effective this approach can be in a human condition in which stimuli generally tend to score a greater effect as they hit the subject closer to the wallet.

In a more optimistic vein, however, it is interesting to note that behaviours conducive to economic success, or reflecting it, often become “the proper thing to do.” A deep tan and a slender body may be fashionable in one society while corpulence and an alabaster skin are fashionable in another. Wearing a white shirt, having long and polished fingernails, or walking on high heels may elicit social admiration while few of the admirers consciously realize that the attractiveness derives from economic aspiration or success.

In northern Europe or Canada (“the Scandinavia of the Americas”), to be tanned in winter-time is a signal of being prosperous enough to spend a vacation on the ski slopes or in the south; in warmer climes, to be tanned marks a person as someone who is demeaned by having to make a living labouring the land. It will be interesting to see how the increased threat of skin cancer is going to affect people’s admiration for a “beautiful” tan, because it may come to signal lack of care about oneself rather than an indicator of success. An alabaster skin may acquire greater physical attractiveness: “She had so transparent a skin that I almost could have felt her pulse with my eyes, I believe.”² Already gone is the image of a female smoker as “a sophisticated lady,” smoking now being viewed as self-destructive. For many the turn-on has turned into a turn-off.

The extension of material rewards to people who have no accidents may eventually lead to a situation in which cautious conduct will be seen as “the proper thing to do.” To play it safe will less often be viewed as sissy and more often as sensible. Thus, the value-oriented educational approach taken by Liselotte Schmidt and the material-incentive approach advocated by this author may ultimately lead to similar end results. Which of the approaches is the more (cost-) effective is a matter for empirical investigation.

¹Drottenborg, H. (1999). *Aesthetics and safety in traffic environments*. Department of Technology and Society, Traffic Planning. Lund, Sweden: Lund Institute of Technology.

²Lichtenberg, G.C. (1742-1799). *Aphorisms and letters*. Translated and edited by F. Mautner and H. Hatfield (1969). London: Jonathan Cape, p.80.

6.2 Training

It is not incompatible with RHT to propose that *training* could be used as a means for safety promotion, although its effects will necessarily be limited and the past record is not encouraging.¹ Consider a group of people who incur greater actual accident risk than corresponds with their target level of risk because they underestimate the danger of the situations or manoeuvres in which they engage. Correction of their error in risk perception would, according to RHT, be expected to lead to a reduced accident risk *for the group in question*.

This, however, is only one of the consequences. Suppose that, as a result of training the risk-underestimators, the accident rate in the population *as a whole* drops to a level that is noticeably lower than before. People would then experience a reduced need for caution, and the per capita accident rate would not change in the long run.

There is another consequence. It should not be overlooked that there are other people who overestimate the danger of particular conditions or manoeuvres, and correction of risk perception on the part of the risk-overestimators would be expected to lead to an increase in their accident likelihood. “He who fears dangers will not perish by them,” according to Leonardo da Vinci. People with a strong fear of flying are unlikely to become the victims of airplane crashes. Those who are afraid of heights will not climb a tall ladder and thus run no risk of falling from it. Agoraphobics rarely become pedestrian casualties. A successfully treated agoraphobic runs a greater likelihood of becoming a pedestrian casualty than when terrorized by this phobia. “Just as courage imperils life, fear protects it,”² but Leonardo would probably agree that excessive fear also hampers survival: in order to maximize potential benefit, people must optimize the amount of risk they take. As optimal risk is greater than zero risk, the occurrence of accidents is an inevitable consequence of the struggle for success. The challenge is to optimize accident risk, not to minimize it. Nothing ventured, nothing gained.

So, when people whose overestimation of risk has been successfully corrected take to the roads again, their accident frequency should rise. If the aggregate accident rate rises enough to be noticeable to people in general, then people in general will become more cautious and the aggregate accident rate will be expected to return to the old equilibrium between target risk and experienced risk.

It would seem, then, that little lasting benefit for safety may be expected from training. In the jargon of control theory, this is because the skill factors are outside “the closed loop” (see Figures 2.1 and 4.1). Perceptual, decisional, and motor control skills can only produce fluctuations in the system output—as graphed in Figure 2.2—but no lasting and stable change.

¹Brown, I.D., Groeger, J.A. and Biehl, B. Is driver training contributing enough towards road safety? In J.A. Rothengatter and R.A. de Bruin (Eds.), *Road users and traffic safety*. Wolfeboro, New Hampshire: Van Gorcum, pp.135-156.

²Richter, I.A. (1952). *Selections from the Notebooks of Leonardo da Vinci*. London: Oxford University Press, p. 278.

Intervention by education

Nonetheless, driver training is often viewed as an accident antidote. Some countries even demand formal driver training by law—as a prerequisite for taking a driver's test. That the wisdom of this is questionable is illustrated by the 1983 Québec law that made driver training courses mandatory for anybody wishing to obtain a driver's licence. Prior to that date, this was required only of 16- and 17-year-olds.

The effect of the change in legislation was investigated by researchers at the Université de Montréal, who concluded that the new requirement had no appreciable effect on the frequency or severity of accidents amongst newly licensed drivers who were 18 or older. That was one major finding, but there was another. The risk of accident actually *increased* for 16- and 17-year-olds. This was attributed to the fact that the new legislation resulted in an increase in the number of young people obtaining a licence before age 18. The economic incentive for waiting until that age—and avoiding the added cost of taking training at a registered driving school—was no longer in existence.¹

Other countries leave it to prospective drivers to decide how they wish to be trained: formal driver training offered by high schools, by private driving schools, or informal instruction from one's parents or an older sibling. Changes in Norwegian law in 1994-1995 that allowed learner drivers to receive less training by driving schools and more informal training showed no difference in accidents risk after licensure.²

Some insurance companies offer premium discounts to novice drivers who have participated in driver training in high school. This may be viewed as a reflection of the belief that formal training is beneficial to safety, or it may simply be a commercial tactic to enlarge the market and sell more insurance. Belief in the efficacy of driver training would seem to be the reason for governments and/or school boards to subsidize driver training in high school. An alternative reason might be to enhance the mobility of youth.

So, there are two opposing views, the prevailing one maintaining that driver training is productive towards safety, and the view held by RHT that it is not. Further empirical facts should be interesting. A British study compared the accident experience of drivers who had been trained in one of the following ways: (a) driving school only, (b) with friend or relative only, and (c) combined tuition.³ Accident experience was expressed in terms of the average number of km driven per accident occurrence, so the higher the rate, the safer. In the first group (a) the average was 19,392 km; with friend or relative (b) it was 22,801 and for combined training (c) 14,536 km. In other words, the safest performance was found in group (b)—amongst those novice drivers who had not obtained any professional instruction.

¹Potvin, L., Champagne, F. and Laberge-Nadeau, C. (1988). Mandatory driver training and road safety: The Quebec experience. *American Journal of Public Health*, 78, 1206-1209.

²Sagberg, F. (1997). *An evaluation of changes in car driver training and licensing in Norway*. Report 371/197. Oslo: Institute of Transport Economics.

³Skelly, G.B. (1968). *Aspects of driving experience in the first year as a qualified driver*. Report LR149, Road Research Laboratory, Crowthorne, England.

Intervention by education

In Ontario, self-reported and officially recorded accidents were compared between (a) some 800 motorcyclists who had graduated from the Motorcycle Training Programme conducted by the Ontario Safety League, and (b) some 1100 motorcyclists who had informal training only. There was no significant difference in accident experience between the two groups.¹

Although both of these studies fail to support the notion that formal training makes people more accident-free, it may be countered that we are dealing with self-selected samples. People chose one form of training or another, and it is conceivable that this choice was made on the basis of personal characteristics that are associated with accident involvement. A Swedish study found that children whose parents had given them traffic safety training had *more* accidents than untrained children, apparently because they were allowed more freedom to spend time and use their bicycles in real traffic.²

Therefore, we turn to a real-life experiment which was conducted in Georgia, the Georgia with Atlanta as the capital, not Tbilisi. In DeKalb County in this state, trainee drivers were not allowed to choose, but were arbitrarily assigned to one of three training conditions. The first was called the Safe Performance Curriculum [*sic*]. This had been developed by the National Highway Traffic Safety Administration and was considered the most advanced and thorough driver-training programme available in the USA. It involved about 32 hours of classroom instruction, 16 hours of training on a simulator, 16 hours of instruction on a driving range, 3 hours of practising emergency manoeuvres, and over 3 hours of driving on public roads, including 20 minutes of night-time driving.

The second was a minimal training programme for providing the skills that are necessary to pass the driver's test. Since this included no more than a total of about 20 hours' instruction in the classroom, on the driving range and on the simulator combined, and only one hour of actual driving by the student, this course contained considerably fewer hours of instruction than the typical high school training course.

A third group of students received no formal training and were expected to be taught by their parents (although some may have taken training in private driver training schools). The three groups were matched in terms of gender, age, grade point average and parents' socio-economic status.

Each of the groups in this four-year study consisted of about 5500 students. Learner-drivers who had graduated from the special training programme obtained their driver's licences sooner and had significantly *more* crashes than those who had received minimal training or no high school driver training at all. There was no significant difference in the crash involvement of the latter two groups.

It is obvious that the results of this large-scale field experiment do not support the notion that improved driver education helps prevent accidents. In passing, we may

¹Jonah, B.A., Dawson, N.E. and Bragg, B.W.E. (1982). Are formally trained motorcyclists safer? *Accident Analysis and Prevention*, 14, 247-255.

²Edman, B. (1997). *Trafiktränade barn löper större olycksrisk*. VTI aktuellt, 20, nr. 4, p. 9.

Intervention by education

note that the same holds for post-licensure defensive driving courses.¹ This is in agreement with what one would expect on the basis of RHT. But why was the safety record of the graduates of the supposedly superior training course actually *worse*? According to some analysts of the data, a “possible explanation is that, compared to students receiving the [intensified course] or even more typical high school driver education courses, students in the [minimal] course may have finished the course with less confidence in their driving skills because of their limited behind-the-wheel instruction; this may have resulted in a slower rate of licensure and more caution during their initial periods of solo driving.”²

This would seem a plausible interpretation, because on a separate test of driving skill, the group with the intensive training performed better than the group with minimal training, and the latter did better than the group without any high school driver training. So skill could not have made the difference. Most likely, the difference was due to overconfidence, or underestimation of risk due to overestimation of one’s own ability, in this case, inspired by having had the privilege of receiving “superior” instruction. That interpretation has also been advanced by others.³

There can be no question that we are dealing here with a rather consistent phenomenon. Some jurisdictions with a graduated licensing procedure in place offer novice drivers a reduction in time necessary to earn a full licence, on the condition that they take a driver education course. This has led to considerably higher accident involvement, by as much as 27 and 45%, among learner drivers who accepted the offer and took the course than among those who did not!⁴ In order to remedy this problem, suggestions for improvement of the driver education courses have been put forward.⁵

Alternatively, as it is so difficult to accept the notion that training could make people worse, one could reason as follows. Suppose that beginner drivers as a group more often overestimate accident risk than underestimate it. All else being equal, they will thus incur fewer accidents than agrees with their target level. Now assume that one of the effects of training is to correct this overestimation of risk. As a result, additional training should lead to an increase in accident rate precisely because the graduates have become more competent—more competent risk takers, that is (see Figure 4.2). Better driving skill—risk perception included—does not necessarily

¹Lund, A.K. and Williams, A.F. (1985). A review of the literature evaluating the defensive driving course. *Accident Analysis and Prevention*, 17, 449-460.

²Lund, A.K., Williams, A.F. and Zador, P. (1986). High school driver education: Further evaluation of the DeKalb County study. *Accident Analysis and Prevention*, 18, 349-357.

³Brown, I.D., Groeger, J.A. and Biehl, B. (1987). Is driver training contributing enough towards road safety? In J.A. Rothengatter and R.A. de Bruin (Eds.), *Road users and traffic safety*. Wolfboro, New Hampshire: Van Gorcum, pp.135-156.

⁴Mayhew, D.R. (2007). Driver education and graduated licensing in North America: Past, present, and future. *Journal of Safety Research*, 38, 229-237.

⁵MacNeil, S.(2007). Driver Education, Training and Licensing. Chapter 11 in Dewar, R.E. and Olson, P.L., *Human Factors in Traffic Safety. Second Edition*. Tucson, Arizona: Lawyers and Judges Publishing Company, pp. 231-266.

Intervention by education

mean fewer accidents. It would seem that the most promising prospect for reducing the accident likelihood in novice drivers lies in measures that effectively lower the level of accident risk they are willing to accept.^{1,2,3} These measures will be discussed in Chapter 11.

Other studies too, show that better driving skill is not associated with greater safety. The number of different types of faults made by drivers during the licensing test in Britain was unrelated to their subsequent accident record, but it should be noted that their faults were not serious enough to make the candidates fail the test.⁴ A sample of over 22,000 drivers in Illinois showed the same lack of relationship between mistakes made on the written licensing test and subsequent frequency and type of moving violations over a four-year period.⁵ Similarly, being at fault in an accident was not more common in drivers with less than average knowledge of the written driving test.

In June 1993 a course of driving on slippery roads was made mandatory for truck drivers in some parts of Norway, but not in other regions. The latter served as a comparison area in the study that sought to evaluate the effect of the new legislation. The investigators concluded that the new regulation failed to result in a reduced accident rate; if anything, accident risk increased as a consequence of the course. This was attributed to the course making a contribution to driving ability, but an even greater contribution to truck driver confidence, the net effect being higher frequency of accidents.⁶

Focussing upon passenger-car drivers instead, a Swedish investigation of the effect of real-life experimental efforts at improving driver education arrived at similar results. And a similar explanation was given: the training added to skill, but even more to confidence.^{7,1} A very similar conclusion was drawn from yet another study of

¹Lonero, P.L., Clinton, K., Brock, J., Wilde, G., Laurie, I. and Black, D. (1995). *Novice driver education: Model curriculum outline*. Washington, D.C.: AAA Foundation for Traffic Safety.

²Lonero, P.L., Clinton, K., Wilde, G.J.S., Roach, K., McKnight, A.J., MacLean, H., Guastello, S.J., and Lamble, R.W. (1995). In search of safer roads: *What works in changing road user behaviour*. Report SRO-95 102. Toronto: Safety Research Office, Safety Policy Branch, Ministry of Transportation, (ISBN 0-778-4354-0).

³Wilde, G.J.S. (1997). Two challenges to driver education: Improvement of risk perception and reduction of risk acceptance. In U. Schulz (Ed.), *Wahrnehmungs-, Entscheidungs- und Handlungsprozesse beim Führen eines Kraftfahrzeugs: Zum Gedenken an Ulrich Tränkle*. Münster, Germany: LIT Verlag, pp. 15-40.

⁴Sheppard, D., Henry, J.P. and Mackie, A.M. (1973). *Faults in the driving test and their relationship with subsequent accidents*. Technical Note TN 782. Transport and Road Research Laboratory, Crowthorne, England.

⁵Conley, J.A. and Smiley, R. (1976). Driver licensing as a predictor of subsequent violations. *Human Factors*, 18, 565-574.

⁶Christensen, P. and Glad, A. (1996). *Mandatory course of driving on slippery roads for drivers of heavy vehicles. Effect on the accident risk*. Oslo: Institute of Transport Economics, Report 334/1996 (in Norwegian).

⁷Gregersen, N.P. and Bjurulf, P. (1996). *Young novice drivers: Towards a model of their accident involvement*. Linköping, Sweden: Swedish National Road and Transport Research Institute, Report 257.

Intervention by education

the effects of skid training on skill and confidence in novice drivers of passenger cars in Norway, Sweden, Denmark and Finland.² On the other side of the Atlantic, the 1986 US Motor Vehicle Safety Act that came into effect in California in 1992 and demanded higher standards for testing and licensing of commercial drivers did not have a significant effect on the rate of fatal accidents or fatal plus injury accidents of heavy vehicles in California³.

A study of the accident record of racing drivers in the USA found these drivers to be involved in crashes considerably more often than drivers on average, matched for age and gender. We are referring here, of course, to the accidents of licensed racing drivers while driving public roads, not racetracks.⁴ They were found less safe per km driven, as well as per person-year.

In our view, the increased accident frequency of the racing drivers is not due to their superior driving skill—since accident frequency in RHT is regarded as ultimately independent of skill—but can more likely be attributed to a greater-than-average acceptance of risk, which induced them to pick up the activity of car racing to begin with. At their level of skill, driving like the average driver may be intolerably boring. Imagine you can master the piano like a Beethoven and all you are allowed to play is “Twinkle, twinkle, little star”! It is not surprising that the racing drivers incurred many more traffic fines than drivers in general, especially for speeding. As has been said by an Australian driver educator: “Strong motivation makes up for weak skills better than strong skills make up for weak motivation. Without strong motivation to reduce risk, advanced skills training can lead to more crashes, not fewer.”⁵

6.3 Lulled into an illusion of safety

Maybe the above-mentioned explanation for the lower safety of the students who had taken the Safe Performance Curriculum—namely, overconfidence—is the correct one. It definitely has a very familiar ring to it, and not just due to lines from Shakespeare such as the one quoted at the head of this chapter. In the English of Shakespeare’s day, “security” meant “a sense of safety,” the word finding its root in *sine cure*, being carefree. This is a desirable state of affairs, provided that the sense of safety is warranted.

¹Gregersen, N.P. (1996). *Young drivers’ overestimation of their own skill: An experiment on the relation between training strategy and skill*. Linköping, Sweden: Swedish National Road and Transport Research Institute, Report 258.

²Katila, A., Keskinen, A. and Hatakka, M. (1996). Conflicting goals of skid training. *Accident Analysis and Prevention*, 28, 785-789.

³Hagge, R.A. and Romanowicz, P.A. (1996). Evaluation of California’s commercial drivers license program. *Accident Analysis and Prevention*, 28, 547-599.

⁴Williams, A.F. and O’Neill, B. (1974). On-the-road driving records of licensed race drivers. *Accident Analysis and Prevention*, 6, 263-270.

⁵Jerrim, A. (1996). Trainers must meet behavior challenge. *Driver/Education: An Independent Information Service*, 6, 8-9. xxx

Intervention by education

That it often is not, and that the sense of safety may be greater than actual safety, has not only been observed for traffic, but also for the home medicine cabinet, the use of condoms, and for other equipment designed to contain danger. It is this situation that can be fatal.

Suppose that yield signs at intersections are replaced by stop signs, that traffic lights are installed at crossings where relatively little traffic passes, that curved roads are straightened out, that slippery road sections are replaced by high-friction road surfaces, that unmarked pedestrian crosswalks are equipped with zebra stripes, and the like. According to risk homeostasis theory, such modifications of the road environment should not improve the accident rate per person, nor should they make it any worse.

Nonetheless, there have been cases in which such changes have been reported to lead to *increases* in accident rates at the locations concerned. According to some of the proposed explanations: "A straight, monotonous road lulls the driver," while marked crosswalks give pedestrians "a false sense of security that the motorist can, and will, stop in all cases."¹ That study was conducted in California.

More recently, a report on the topic of marked crosswalks in Sweden contains the following information: after the introduction of new regulations that demanded that drivers yield to pedestrians at marked (zebra) crosswalks. Pedestrians waited only one-third as long as they had done before. The annual number of pedestrians injured was 40% higher [than before the new regulation] and the number of severely injured was 25% higher, but the number of fatalities did not increase. It is noteworthy too, that there was also an increase in accidents incurred by vehicles that had observed the regulation to give way being hit by another vehicle. "The most common cause was the vehicle observing the regulation being hit from behind."²

These findings bring earlier studies to mind. The first is a much older study, also conducted in California, which showed an increased incidence of pedestrian collisions in marked crosswalks, compared to unmarked crosswalks, at 400 uncontrolled intersections in the city of San Diego.³ The other studies, which are mentioned in Section 7.3. show likewise that intersection **traffic control devices, like yield signs, stop signs, or even traffic lights, fail to reduce** the rate and severity of accidents between automobiles, because of more rear-end and side-swipe collisions.

A much more recent study analyzed the almost 10,000 pedestrian/automobile collisions that occurred over 10 years at almost two thousand different intersections in the Toronto, Canada, which occurred either before or after adding pedestrian countdown signals at signalized intersections. In contrast to some earlier small-scale

¹Mahalel, D. and Szternfeld, Z. (1986). Safety improvements and driver perception. *Accident Analysis and Prevention*, 18, 37-42.

²Thulin, H. (2007). *Uppföljning av regeln om väjningsplikt för fordonsförare mot fotgängare på obebakt övergångsställe*. (The effect on pedestrian safety of the regulation that drivers give way to pedestrians at marked crossings; in Swedish with English abstract). Linköping, Sweden, VTI Report R597.

³Hermes, B. (1972). Pedestrian Crosswalk Study: Crashes in Painted and Unpainted Crosswalks," Transportation Research Board, Record No. 406. Washington, DC.

Intervention by education

pilot studies, no significant difference was found in the rate of the collisions at these locations in the before/after comparison, and there was no evidence to suggest differential effects by age, injury severity and the location of the signals under study.¹

Changes in accident rates are only compatible with RHT (unless, of course, they are caused by events or interventions that reduce people's accepted level of risk) provided they are local, rather than general throughout the entire road network, and if they are modest and/or short-lived. In other words: only if the difference in accident rate is less than the "just noticeable difference" (see Sections 2.2 and 4.3).

Besides pedestrians, other victims of the "lulling effect" have been reported, e.g., children under the age of five. In 1972, the Food and Drug Administration in the USA ordered manufacturers of painkillers and other selected drugs to equip their bottles with "child-proof" lids. Such covers are difficult to open for children (and sometimes for adults as well) and often go under the name of "safety caps," a misleading name, as we will see. Their introduction was followed by a substantial increase in the per capita rate of fatal accidental poisonings in children. It was concluded that the impact of the regulation was counterproductive, "leading to 3,500 additional (fatal plus non-fatal) poisonings of children under age 5 annually from analgesics."² These findings were explained as the result of parents becoming less careful in the handling and storing of the "safer" bottles. "It is clear that individual actions are an important component of the accident-generating process. Failure to take such behavior into account will result in regulations that may not have the intended impact." Indeed, safety is in people, or else it is nowhere.

It should be added here that a later study on the issue of childproof packaging came to rather different conclusions. Its author argues that the packaging has had a beneficial effect. The somewhat puzzling contradictions between the two studies that were done with respect to the same legislation in the same country may be due to the fact that the first study largely concentrated on accidental poisonings associated with aspirin and the more recent study dealt with prescription drugs. There are also differences between the time periods studied and even in the date used to indicate when the new legislation came into effect! At any rate, the more recent study also notices that "the reduction in the child mortality rate from the unintended ingestion of oral prescription drugs is less than might be expected [and that] further reductions in the child poisoning rate are possible if consumers, including older consumers, use

¹Camden, A, Buliung, R, Rothman, L, Macarthur, C., and Howard, A. (2012). The impact of pedestrian countdown signals on pedestrian-motor vehicle collisions: a quasi-experimental study. *Injury Prevention*, Feb 25. [Epub ahead of print]. Worse still, a subsequent analysis of the same data led to the conclusion that the pedestrian death rate actually *increased* as a result of the countdown signals: Richmond SA, Willan AR, Rothman L, Camden A, Buliung R, Macarthur C, Howard A. (2013). The impact of pedestrian countdown signals on pedestrian-motor vehicle collisions: a reanalysis of data from a quasi-experimental study. [Epub ahead of print]. Final conclusions must await refinements in the research methodology.

²Viscusi, W.K. (1984). The lulling effect: The impact of child-resistant packaging on aspirin and analgesic ingestions. *American Economic Review*, 74, 324-327. *Injury Prevention*,

Intervention by education

child-resistant packaging and use it correctly.”¹ So, even here, responsibility for prevention of mishaps is assigned to people and not the equipment per se.

If parents can be blamed for the lack of effectiveness of safety caps, does a government that passes such near-sighted safety legislation go guilt-free? Does an educational agency that instills a feeling of overconfidence in learner drivers go guilt-free? Does a traffic-engineering department that gives pedestrians a false sense of safety remain blameless; or a government that requires driver education at a registered driving school before one is allowed to take the licensing test? Is it responsible to call a seatbelt a “safety belt,” to propagate through the media such slogans as “seatbelts save lives,” “speed kills,” “to be sober is to be safe,” “use condoms for safe sex,” or others of the same ilk?

In any event, it is interesting to note that accident countermeasures sometimes may increase danger, rather than diminish it. If stop signs are installed at junctions in residential areas and at all railway crossings that have no other protection, if flashing lights appear at numerous intersections, if warning labels are attached to the majority of consumer products, these measures will eventually lose their salience and their credibility. They amount to “crying wolf” when no such beast is in the area. And in the rare event there is one, the warning will no longer be heeded and there may be a victim.

6.4 Warning signs

That over-use of warnings may be dangerous has been argued by others as well.² A warning that is not perceived as needed will not be heeded—even when it is needed. “A warning can only diminish danger as long as there is danger.” This is the paradox of warning. It sounds puzzling, but what it means is that warning signs can only make people behave more cautiously if they agree that their behaviour would probably have been more risky if they had not seen the warning sign. Similarly, “a warning can increase danger when it overstates danger,” meaning that a person’s behaviour may become less cautious if that person has learned that the danger is usually less great than stated in the warning. The somewhat puzzling element in these statements is due to the word “danger” having been used with two different meanings. The first meaning is a “lack of caution in the face of an external threat, increasing the likelihood of accident,” while the second use of the word refers to some “external threat.”

In some cases, a warning sign will have no effect on the frequency or size of the external threat. A stop sign placed on the roadway at a railway crossing will not normally affect the number or speed of approaching trains. Consider, however, a

¹Rodgers, G.B. (1996). The safety effects of child-resistant packaging for oral prescription drugs. *Journal of the American Medical Association*, 275, 1661-1665.

²Papastravrou, J.D. and Lehto, M.R. (1996). Improving the effectiveness of warnings by increasing the appropriateness of their information content: Some hypotheses about human compliance. *Safety Science*, 21, 175-189.

Intervention by education

street crossing in a residential neighbourhood without any special “protection.” The basic rule applies: traffic coming from the right has the right-of-way (or from the left, in some parts of the world). The city engineering department installs a yield sign on one of the two streets. Suppose you are approaching the junction while driving on the street with the yield sign. The chances of colliding with a car at a ninety-degree angle are now increased if you merrily proceed through the crossing without appropriate checking, because cross-traffic always has the right-of-way, regardless of whether it comes from the right or the left, and is less likely to be watching out for you.

For the cross-traffic the situation is different. The threat of angular collision while proceeding through the intersection without appropriate checking is diminished due to the apparent protection by the yield sign. So, the new situation does not call for the same level of caution; your cross-traffic, assuming that it notices the presence of the new yield sign, can afford to reduce their attention or move faster and still proceed at the same subjective risk as before the installation of the yield sign. As a result, if anybody driving your street drives past the yield sign into the crossing while cross-traffic is present, a collision is more likely to happen. Not surprisingly, then, the installation of yield signs has not been found to reduce accidents at intersections.¹ A yield sign is useless from a safety point of view, at least in the longer run, while it may have the merit of improving traffic flow.

And so we come to the conclusion that warning signs have little or no lasting effect upon safety, regardless of whether their installation alters the external threat. Maybe they are more effective in serving a rather different purpose, namely, that of reducing the legal liability of a city’s engineering department, or of a product manufacturer, if an accident happens. In the case of litigation, they can point out: “Yes, at that intersection, accidents are possible, but we told you so.” *Seeking protection from legal liability and seeking to protect the public from accidents should not be confused.* Clearly, the two purposes demand rather different action. The authors, whose study came to the conclusion that ice warning signs failed to have an effect on the frequency and severity of road accidents in Washington State in the US, commented that the authorities in various US states “[...] have compensated for the difficulties in predicting ice as a roadway hazard by resorting to over-signing, and/or sign placement on all bridges, regional boundaries; or other standard roadway features). Both of these policies seem to be intended to protect state transportation agencies from liability as much as they are intended to improve highway safety. Too many signs or ice-warning signs posted at potentially inappropriate locations (i.e., locations where ice hazard is rarely present) can desensitize drivers thereby negating any safety enhancement the signs may have.”²

A Finnish study, on the other hand, used warning signs, encouraging drivers to reduce their speeds and increase their following distances, which were activated *under appropriate conditions only*, that is under bad weather conditions. Significant effects

¹Roer, P.O. (1961). Pedestrian crossovers. *Traffic Engineering*, 13, 21-22.

²Carson, J. and Mannering, F. (2001). The effect of ice warning signs on ice-accident frequencies and severities. *Accident Analysis and Prevention*, 33, 99-109.

Intervention by education

on driver behaviour were observed, but unfortunately the effect on accidents was not included in the study.¹

In the next chapter we will discuss some technological countermeasures that, despite great expectations on the part of those who developed them, did not seem to have a measurable effect on safety, not even in the short term. First, however, we will deal with the question of the effects of mass media communications on health and safety habits.

6.5 *Mass media messages for safety and health*

A cursory look at the present state of affairs suggests that society has become more and more reliant on the mass media as channels for influencing attitudes and behaviours, and less reliant on more traditional word-of-mouth and face-to-face communication. Television, radio, newspapers, periodicals, posters, and other message carriers are being used in efforts to distribute knowledge, to educate, to teach skills, to shape attitudes, and to propagate or discourage various habits.

In contrast to engineering advances in mass communications technology, social-science information on how people respond to mass-messages has been slow to develop. There is, as yet, no firm and detailed body of knowledge telling us what beneficial or detrimental effects, if any, may be expected from a given mass media communication. Although the citizenry is continually exposed to print and broadcast messages, the consequences are mostly unknown.

It is true that large numbers of commercial advertising messages are tested for their effects on consumers, but the resulting knowledge may not be of much use to society as a whole because this knowledge remains largely confidential. At the same time, many public service messages for the promotion of health and safety remain untested and their effects are unknown. Some of the safety and health publicity may have no effect, or may even lead to attitude or behaviour change contrary to that desired. Without programme evaluation, this can never be determined.

6.5.1 *Yardsticks of effectiveness*

In order to determine the effect of mass media messages, a great variety of yardsticks have been used.^{2,3,4} These include:

¹Rämä, P. (2001). Effects of weather-controlled variable message signing on driver behaviour. Espoo, Finland: VTI Publications 447.

²OECD (1979). *Road safety campaigns: Design and evaluation*. Paris: Organisation for Economic Co-operation and Development.

³OECD (1978). Chairman's report and report of sub-group III: *Mass media communications for pedestrian safety*. Crowthorne GB: Transport and Road Research Laboratory.

⁴Wilde, G.J.S. (1993). Effects of mass media communications on health and safety habits: An overview of issues and evidence. *Addiction*, 88, 983-996.

Intervention by education

- a. attractiveness ratings by a subject sample,
- b. effectiveness ratings by a subject sample,
- c. effectiveness ratings by experts,
- d. the number of people exposed to the message,
- e. the extent of message recall by the public,
- f. change in knowledge as a result of exposure,
- g. change in attitudes or behavioural intentions expressed by the recipients,
- h. change in self-reported behaviour,
- i. change in behaviour, such as drinking or smoking, observed under laboratory conditions,
- j. change in unobtrusively observed behaviour under real-life conditions,
- k. change in the *ultimate target*, that is, improvement against some definition of “health” or “quality of life,” such as a reduction in the per capita accident rate or a reduction in what is considered to be “lifestyle-dependent” mortality.

It is obvious that these criteria vary greatly in their *relevance* to the ultimate criterion of health or safety. Moreover, there may be disagreement between different individuals and between different societal factions as to what constitutes the ultimate criterion.

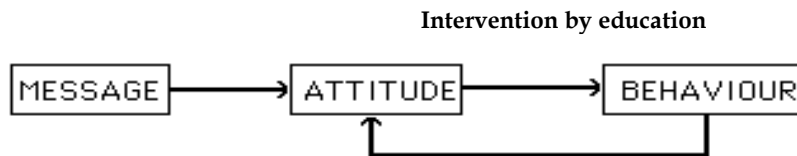
Because of the limited pertinence of intermediate criteria such as those listed above (with the exception of **k**), these are all of a remote, intermediate, surrogate, or proxy nature. Data from empirical studies on the effects of mass-media messages should be evaluated with this in mind.

There are various factors that are responsible for the reduced pertinence of the intermediate yardsticks in common use. The relationship between attitude and manifest behaviour is often weak. One factor responsible for this may be the particular measurement procedure used. Another is that behaviour is also being affected by influences other than attitude, such as the person’s perceptions of the norms held by others and the social pressure thus produced.¹

Attitude change may lead to behaviour change, and *vice versa* as well. Studies show that if one is made to commit oneself to some behaviour because of a small inducement, one’s attitude towards that behaviour may change. Some authors, therefore, describe attitude change as an *iterative* process: a communication brings about a minor change in attitude towards an advertised product or recommended practice that is enough to make the recipient willing to try it out.² The experience that follows with the product or practice causes the person to modify or solidify the original attitude, and this leads to additional experience with its effects on attitude, and so on:

¹Fishbein, M. and Ajzen, I. (1975). *Belief, attitude, intention and behavior*. Reading, Mass.: Addison-Wesley.

²Kapferer, J.N. (1978). *Les chemins de la persuasion*. Paris: Gauthier-Villars.



Like the relationship between attitude and behaviour, the relationship between *knowledge* and manifest behaviour is also weak in many behaviour domains. For example, cigarette smokers and heavy drinkers are no less aware of the dangers of their habit than abstainers or moderate users^{1,2} But the awareness does not necessarily mean a change in behaviour.

Other yardsticks of effect seem even more questionable. Ratings of message effectiveness made by experts don't necessarily predict the behaviour change the messages produce, even when the effectiveness ratings are pooled across a panel of safety experts.³ This is why, when it comes to evaluating the persuasive effect of messages, there is no truly dependable alternative to empirical testing of the behavioural effects on the recipients.

Finally, it is important to stress that a behavioural effect does not necessarily imply a change in the ultimate criterion *k*. This is because lifestyle-related disease, injury, or mortality does not exclusively depend upon specific behaviours. Smoking is not the only habit leading to premature lifestyle-dependent death. Seatbelt use or sobriety does not guarantee immunity to fatal accidents, since the same consequences may follow from other acts. Therefore, an increase in the frequency of decisions to quit smoking, to put on the seatbelt, or to refrain from drinking before driving, can only be expected to bring about a commensurate reduction in morbidity and mortality rates if *all other relevant factors* remain the same. Stated another way, this condition stipulates that people who decide to comply with the recommended safety or health behaviours do *not*, at the same time, adopt other behaviours that are associated with an increase in the likelihood of morbidity or mortality. One of the main contentions of the current text is that this condition may not hold true and that people *do* change other behaviours in addition to those targeted by interventions.

An increase in seatbelt wearing does not imply fewer fatal or injury accidents. Quitting cigarette smoking does not imply an increase in the quitters' lifespan. A reduction in the amount of drinking and driving does not imply a reduction in the overall number or severity of accidents. With respect to AIDS, it has been suggested that the increased use of condoms, as propagated by mass communication messages and other means, can only be expected to slow the spread of the disease to the extent that the objective reduction in the danger of contamination exceeds the subjective

¹Kapferer, J.N. (1978). *Les chemins de la persuasion*. Paris: Gauthier-Villars.

²Beltramini, R.F. (1988). Perceived believability of warning label information presented in cigarette advertising. *Journal of Advertising*, 17, 26-32.

³Piccolino, E.B. (1968). *Depicted threat, realism and specificity: Variables governing safety poster effectiveness*. Doctoral dissertation, Illinois Institute of Technology, Chicago; Dissertation Abstracts International, 28B, 4330.

Intervention by education

reduction.¹ In other words, if mass communications would cause people to feel that “safes” are safer than they are, their sexual behaviour may change to the effect that they will be more endangered. A doctoral psychology student at my university (not one of my students) investigated the effect of televised AIDS messages produced by the Ontario Ministry of Health upon the intent to use condoms and the intent to avoid casual sexual partners. Several weeks after viewing the messages, the individuals who reported that they were more inclined to use condoms also reliably indicated that they were less inclined to avoid casual sexual partners. Not surprisingly, these results were explainable in terms of risk homeostasis theory.²

Regardless of whether or not this is the correct interpretation, we seem to be dealing here with a case in which the danger of a lulling effect is far from imaginary. It seems that many public health authorities feel that condom use is about the only feasible preventive measure against the threat of AIDS and, therefore, propagate it as “safe sex.” Is this responsible behaviour?

While the choice of yardstick is one factor that may cause uncertainty regarding message effect, another is the manner in which an attempt is made to establish the connection between message characteristics and “effect” variables. To illustrate the interpretation ambiguities which are associated with studies that are merely *correlational* in nature, suppose a researcher finds in a sample of respondents a positive association between the frequency of watching advertisements and the frequency and/or amount of drinking. There are, in principle, three possible interpretations:

1. exposure to alcohol advertisements stimulates drinking;
2. being a drinker increases interest in alcohol advertisements, and thus exposure;
3. both drinking and exposure to advertisements are due to a third factor that explains both, for instance, belonging to a particular social stratum, being unemployed or scoring high on some personality trait.

The direction of causality is generally obvious in investigations that take the form of a controlled experiment. It is for this reason that evidence from experiments conducted by the Addiction Research Foundation in Toronto is considerably more compelling. These experiments involved exposing audiences to alcohol advertisements or scenes on television, and monitoring their drinking. None of the experiments showed convincing evidence that exposure to alcohol advertisements increased the amount of drinking by the subjects.³ However, the contrived nature of

¹Adams, J.G.U. (1988). Why more condoms may not contain the spread of AIDS. London: *The Independent*, Jan. 8.

²Ng, W.-J. (October, 1992). *The impact of public service announcements on AIDS risk perception and preventive health behaviours*. Ph.D. thesis, Department of Psychology, Queen’s University, Kingston, Ontario.

³Smart, R.G. (1988). Does alcohol advertising affect overall consumption? A review of empirical studies. *Journal of Studies on Alcohol*, 49, 310-323.

Intervention by education

these experiments should be acknowledged and the nagging question remains as to what extent the findings may be generalized to real life.

The body of literature on the effect of mass media communications in the area of health and safety clearly shows that these messages can have a significant effect upon people's knowledge, attitudes and behaviours. What the literature also shows is that some messages have a much greater effect than others, and the characteristics of the more effective communications have been identified.^{1,2}

6.5.2 Message components

The effect of the message depends on the recipient's opinion of the identified source of the message. The effect will be greater if the communicator is perceived as credible, knowledgeable, and trustworthy, and free from selfish interest in the attitude or behaviour that is being advocated. The effect will be greater if the source is perceived as similar to the receiver. Similarity breeds attraction. Similarity here refers to characteristics such as age, sex, linguistic style, social class, personality traits, and group membership, etc. "Presumably the receiver, to the extent that he perceives the source to be like himself in diverse characteristics, assumes that they also share common needs and goals. The receiver might therefore conclude that what the source is urging is good for 'our kind of people', and thus change his attitude accordingly."³ The "psychological distance" between the source and the recipient may also be reduced by having part of the message express views that are also held by the audience.

An obvious condition for persuasion to occur is that the position promoted by the message is different from the one already held by the recipient. Less obvious is *how much* change should be advocated for a message to have maximal effect. Counter to some intuitive expectations, research has shown that it is not true that the greater the change being advocated, the greater the change that will occur. Instead, what has been found is that advocated change should not exceed the "latitude of acceptability."

If, however, the advocated change does exceed the latitude of acceptability, no actual change will occur or, worse still, the message may produce a boomerang effect. The recipients do change their position, but in a direction opposite to what is being advocated in the message.

An interesting boomerang effect occurred as the result of a 60-minute televised safety programme regarding drinking and driving. A sample of 600 families in four US cities were interviewed on their perceptions of accident causation before and after the airing of the programme. Counter to expectation and intent, the programme

¹Wilde, G.J.S. (1993). Effects of mass media communications on health and safety habits: An overview of issues and evidence. *Addiction*, 88, 983-996.

²Elliot, B.J. (1991). Effective mass communication campaigns: A source book of guidelines. Canberra, Australia: Federal Office of Road Safety, Department of Transport and Communications.

³McGuire, W.J. quoted by Sandell, R. (1977). *Linguistic style and persuasion*. London: Academic Press.

Intervention by education

appeared to decrease the anxiety level about travelling on holiday weekends. This was judged to be due to the fact that the programme focused on one source of danger only, namely, drinks. There was a 20% upward shift in the number of interviewees who felt that the increased risk did not apply to them, since the programme's narrow approach allowed viewers to attribute the likelihood of accidents to heavy drinking, not their own behaviour.¹ The boomerang returns in Section 11.2 below.

The behavioural importance of the concept of latitude of acceptability is neatly illustrated in an experiment conducted by the Austrian Road Safety Council. On a section of a six-lane highway just outside Vienna, an effort was made to reduce drivers' speed, which averaged well over 100 km/h before the experiment. In one period, a traffic sign (also a form of mass communication) was installed that indicated a speed limit of 80 km/h. The 100 km/h sign had a *greater* speed-reducing effect than the 80 km/h sign!²

The use of a paternalistic or lecturing approach in the presentation of the message is generally to be avoided because most people, when attending to radio or television, are usually not in the mood to be taught, but to be entertained. For greater effectiveness, messages should nonetheless be marked by *concrete instructiveness*. General slogans such as "Safety first," "Live a healthy life," "Safety is no accident," or "Alcohol kills slowly" (that's OK, who's in a rush?), cannot be expected to have much effect. What action is one supposed to take? The message should clearly spell out what specific behaviour is being advocated. Something like "Had a few drinks? Get a ride!" might be preferable.

Messages tend to be more effective if designed such that they are perceived as *personally relevant* by the recipient. They should not blame "the other guy" as the main culprit of the problem, as in the boomerang case above. Messages should enhance the processes of modelling and imitation, and the target behaviour should be displayed in the message. In order to make the audience react, the message should create a motivational state in the recipient. *Motivating appeals* pertain to conditions that individuals either try to achieve (romance, belongingness, prestige, self-actualization) or try to avoid (horror, pain, death, grief, or ridicule).

Research on the differential effectiveness of various motivation-oriented appeals promoting the same behaviour has not been very extensive and the findings are not very clear, with two major exceptions: the use of humour has not been shown to be effective in the promotion of safe behaviour; and the use of fear is beset with major difficulties.

Strong fear appeals are aversive and lead to what is called "defensive avoidance": the recipients turn their attention away from the message, either at the very instant of exposure or by refusing to think about the message later. Particularly horrific images were used in an intensive mass media program in the state Victoria in Australia. Originally it was claimed that these messages were highly effective, even cost-

¹Naisbitt, J. (1961). The great holiday massacre: A study of impact. *Traffic Safety*, 58, 12-15, 36, 48-49.

²Bhalla, S. K. and Biehl, B. (1972). Influence of speed limits on driver behaviour in Austria. *Kleine Fachbuchreihe*, Band 11. Vienna, Austria: Kuratorium für Verkehrssicherheit, pp. 53-60.

Intervention by education

effective, but these claims were subsequently refuted and the drop in casualties attributed to economic trends.¹ Mild or intermediate fear appeals can be useful, provided that the audience has an immediate opportunity to take the advocated action so that the induced state of anxiety will effectively be reduced.

Two factors are of major importance in the choice of channel or channels for communication. The choice should take account of the exposure rate in the audience as a whole or in population subgroups that one wishes to reach. When the purpose of the message is to bring about a direct effect in the form of a behaviour change, the principle of *immediacy* applies. Messages are more likely to have such an effect to the extent that they reach the audience at a moment, and in a situation, in which the advocated behaviour can actually be displayed by the recipients. This can put television at a disadvantage in advertising for road safety. Television is a low-immediacy channel for messages recommending seatbelt use or driving with headlights on when it's raining. It's a high-immediacy channel for alcohol advertisements, as is countertop advertising for cigarettes in stores.

Exposure to the message is usually under the control of people themselves and will reflect their attitudes and behavioural dispositions. As the saying goes: "Volvo owners read Volvo advertisements." This does not mean that the more Volvo advertisements are printed or aired, the more Volvos will be purchased. Nor does it mean that if more of these advertisements, and those of competing manufacturers, are distributed, more cars of all makes will be sold. What it does mean is that people who have purchased a Volvo are more likely to read Volvo advertisements than the advertisements for other car makes.

The interpretation put forward by social psychologists for the fact that people selectively expose themselves to advertisements that agree with choices already made is that they seek after-the-choice justification for their decision. Voters expose themselves more to political messages that agree with their own views. Cigarette smokers pay more attention to cigarette advertisements than do non-smokers.²

This is why the mere observation of a positive correlation between exposure to a given type of message and a particular behaviour does not allow the conclusion that the exposure in question causes that behaviour or enhances its frequency. Yet, such claims are made, and they are made frequently.³

There appears to be general consensus among mass communication researchers that mass media messages, if effective at all, usually have a direct effect only on a relatively small number of recipients. These people may then pass on their behaviour change to other individuals in face-to-face interaction. The opinion leaders—the early adopters—in this two-step or multi-step flow of mass communication can be found in all layers of the population. Opinion leadership is not a general characteristic of

¹White, M., Walker, J., Glonek, G. and Burns, N. (2000) Re-investigation of the effectiveness of the Victorian Transport Accident Commission's road safety campaigns. .Safety Strategy, Transport SA, Walkerville SA, Australia.

²Kapferer, J.N. (1978). *Les chemins de la persuasion*. Paris: Gauthier-Villars.

³Wilde, G.J.S. (1993). Effects of mass media communications on health and safety habits: An overview of issues and evidence. *Addiction*, 88, 983-996.

Intervention by education

individuals, but depends upon the particular behaviour domain involved: fashion, diet, political choice, etc. Individuals who are opinion leaders in one of these domains may well be opinion followers (late adopters) in other domains.¹

The face-to-face part of this multi-step process is enhanced when the behaviour is conspicuously displayed for all to see. This is why mass communications for safety tend to have greater effect when the advocated change concerns a *conspicuous* target behaviour, for instance, driving with low-beam headlights on under conditions of reduced visibility. Being a smoker or drinker is a more visible characteristic of a person than being a non-smoker or a drinker on rare occasions only. Thus, for the purpose of enhancing the effectiveness of pro-health or pro-safety messages, it may be helpful if the *personal influence* link in the mass communication chain is strengthened. The early adopters may be deliberately encouraged to clearly identify themselves as non-smokers or moderate drinkers, just as people often spontaneously wear buttons or other signs in order to be perceived by others as supporters or opponents of some cause. In the area of road safety promotion, this tactic has been used deliberately and with success to increase the not-so-very conspicuous practice of seatbelt wearing. In comparison with a control area, voluntary seatbelt wearing doubled in a part of France where seatbelt users were encouraged to put a bumper sticker on their car that said; “I wear my seatbelt. How about you?”²

As has been demonstrated by numerous studies, mass media messages for safety and health, if well designed, can have a considerable influence on the general public's knowledge, attitudes and observable behaviours. The fact remains, however, that these messages must compete for attention with numerous other media messages and may, therefore, attract relatively little attention.

Accident reports in the daily press, on the other hand, have been found to be among the most frequently read material of all newspaper content, but they are usually not very educational in the sense of communicating to the readers how they themselves can avoid accidents. For this reason, we collaborated with a local Ontario newspaper (daily circulation approximately 35,000) to develop a prototype of a more educational accident reporting style. Over a period of eight weeks,³ accidents were reported with more detail about the causal chain of events. They were described in the human context of antecedents and aftermath, and weekly accounts of local accident statistics were given—including date, location, and severity.

A crucial feature of this “educational accident journalism” was the fact that information from accident research and documentation in general was included in the accounts of specific accidents. For example: the role of alcohol, driver age and sex, and seatbelts.

¹Schramm, W. and Roberts, D.F. (Eds.) (1972). *The process and effects of mass communication*. Urbana, Illinois: University of Illinois Press.

²Labadie, M.J. and L'Hoste, J. (1978). *Influence sociale et sécurité routière: réalisation d'une campagne expérimentale d'incitation au port de la ceinture de sécurité*. Paris: Organisme National de Sécurité Routière.

³Wilde, G.J.S. and Ackersviller, M.J. (1981). *Accident journalism and traffic safety education*. Ottawa: Transport Canada, Traffic Safety, Report No. TP 3659 E/CR 8202.

Intervention by education

Social surveys, conducted before and after the eight-week application of the modified accident reporting style, took the form of telephone interviews with a total of 1200 licensed drivers in the experimental and in a control community. Significant changes were observed in people's opinions of the way accidents were reported, in their perceptions of the size of the accident problem, and in the importance of the accident problem relative to other issues of social concern.

A special feature of this experiment was that the reporting on the occurrence of specific accident events was used for the dissemination of general knowledge on accident causation and prevention. In that respect it was different from other efforts at educational journalism.^{1,2}

As noted earlier, only a relatively small proportion of mass communication programmes for health and safety has ever been subjected to effectiveness evaluation. Moreover, the programmes that have been evaluated have often been evaluated in a manner that lacks scientific rigour. Both facts have repeatedly been lamented in the past. Even in a problem area as threatening and topical as AIDS, the many campaigns conducted in many countries have rarely been investigated on their effects. Why might this be so? One researcher commented that systematic evaluations of media health education materials are the exception rather than the rule. He attributes this to a lack of funds and to "pressures on government to deliver their campaigns to the voting public with minimal delay."³

From this explanation, new questions arise: why the lack of funds, and why the rush? A possible answer is the following: "For the people involved in these programmes, it becomes important that the public body *be seen as responding* to people's concern and that what the public body does *be seen as successful*... By the time estimation of programme effect becomes possible, the public body has already developed a large stake in its success. Under these circumstances, why would the stewards of public bodies wish to find out what effect their programme has had? Nobody is attracted by the possibility of political, institutional, professional, or personal embarrassment."⁴ Other Canadian researchers have argued that policy makers responsible for road accident reduction may opt for countermeasures that reduce "public official's exposure to future criticism for having fallen short of their commitments."⁵

¹Maccoby, N., Farquhar, J.W., Wood, P.D. and Alexander, J. (1977). Reducing the risk of cardiovascular disease: Effects of a community-based campaign on knowledge and behavior. *Journal of Community Health*, 3, 100-114.

²Ettema, J.S., Brown, J.W. and Luepker, R.V. (1983). Knowledge gap effects in a health information campaign. *Public Opinion Quarterly*, 47, 516-527.

³Baggeley, J.P. (1988). Perceived effectiveness of international AIDS campaigns. *Health Education Research*, 3, 7-17.

⁴Hauer, E. (1990). The behaviour of public bodies and the delivery of road safety. *Proceedings, Enforcement and Rewarding, International Road Safety Symposium* (OECD), Copenhagen, Sept. 19-21, pp. 134-138.

⁵Perl, A. and Berry, C. (2007). Setting on's sights: exploring the dynamics of goal selection in road safety policy. *Canadian Journal of Transportation*, 1; online: <http://journals.hil.unb.ca/index.php/CJT/article/view/738>

Intervention by education

A Norwegian researcher has commented that there are some forces in society resisting evaluation of traffic safety education, and that insistence upon the need to assess actual effects may be viewed as “disloyalty to the established institutions of society.”¹ The true effects remain largely shrouded, that is, shrouded inside the emperor’s new clothes.

Effectiveness evaluation of mass media programmes is rare. Effectiveness evaluation of mass media programmes against the criterion of accident reduction—rather than attitude or behaviour change—is rarer still. One such campaign (in fact, the only one I know of) that seemed successful in this respect was the propagation of the “Green Cross Code,” a repertoire aimed at teaching children seven years and older to judge when it is safe to cross a street:

- First find a safe place to cross, then stop.
- Stand on the sidewalk near the curb.
- Look all around for traffic and listen.
- If traffic is coming, let it pass, look all round again.
- When there is no traffic near, walk straight across the road.
- Keep looking and listening for traffic while you cross.

Some seven million brochures explaining the code and providing a tear-off slip were distributed in Great Britain. These were to be completed by parents certifying that their child had demonstrated understanding of the code by guiding their parents over the road three times. The total media coverage included television, posters, and announcements in movie theatres. It was calculated that the average member of the audience had five opportunities to see the messages on television, and fourteen in the press.

In addition to roadside observation of children’s behaviour, casualty rates projected from long-term trends for this period (in 1971) were compared with actual accident rates. With the application of conservative criteria, an eleven percent drop in the casualty rate of children between five and nine years old was found during the three months in which the Code was heavily publicized. It was calculated also that the monetary savings in medical care outweighed the programme expenditures.

These results look surprisingly good, but there are some puzzling features. According to some researchers, pre- and primary-school children simply do not have the perceptual, motivational, and judgemental maturity to learn to meet the demands of modern traffic. Adults, parents, drivers, or city planners should take responsibility for children’s safety. The apparent contradiction would be resolved if the success of the Green Cross Code was indeed largely mediated by active participation by the parents rather than by a direct mass media influence on the children. It was found that, in the programme period, there was not only a reduction in casualties in the target age group, but also among adults. In one geographical area, the frequency of television

¹Ås, B. (1970). *Trafikantopplæring—Trafikksikkerhet: en kritisk trafikkteoretisk analyse*. Oslo: Utvalg for Trafikksikkerhetsforskning, p. 118.

Intervention by education

broadcasting of the Code was doubled, but this failed to produce any additional effect.¹

Astounding as it may seem, it's fair to conclude this chapter by observing that convincing proof of the effectiveness of education—be it face-to-face or by the mass media—as a means to reduce accidents and improve lifestyle-dependent health still remains to be delivered. Large amounts of money are involved. The saying has it that the world wants to be deceived. People are willing to pay for being lulled into illusions. But at this price?

¹Morris, J.P. (1972). *Road safety publicity: Quantifying the effectiveness of public service advertising*. London: The Advertising Association.

En attendant Godot.
Waiting for Godot.
Samuel Beckett¹

7 Remedy by engineering?

In order to show what may happen when an engineering measure that is unlikely to reduce the target level of risk is introduced, let us first consider the findings of a real-life study conducted in Germany.² This study deserves special interest, because it was commissioned by the federal ministry of transport in that country for the express purpose of testing some empirical implications of risk homeostasis theory under well-controlled conditions of investigation. That explicit purpose was not present in several other studies that will be discussed later in this chapter.

7.1 The Munich taxicab experiment

Part of a taxi fleet in Munich was equipped with an anti-lock brake system—also known as ABS. This type of brake system prevents the wheels from locking up under extreme braking conditions. It offers the advantage of improved steering control over the vehicle during rapid deceleration, especially on slippery road surfaces. The system makes it possible to change the direction of the car and abruptly reduce speed at the same time, at a considerably reduced risk of losing control. ABS brakes offer a perfect example of what was called a change in *intrinsic* risk towards the end of Section 3.4—a change in the objective accident loss expected if drivers don't change their behaviour when a “safer vehicle” is made available. However, according to risk homeostasis theory, drivers are expected to change their behaviour and to maintain their accident likelihood per hour of driving as long as the target level of risk is not altered.

The cars with and without ABS in that Munich taxi fleet were of the same make and identical in all other respects. The majority of cab drivers were randomly assigned to one or the other of the two types of cars and the remaining drivers rotated between driving one type or the other. The exposure to traffic of each of the ABS taxicabs was carefully matched with cabs with traditional brakes over a period that lasted three years. Due to the matching procedure there was no difference in the time of day, the day of the week, the seasons, and the weather conditions in which both types of cabs were in operation.

Among a total of 747 accidents incurred by the company's taxis during that period, the involvement rate of the ABS vehicles was not lower, but slightly *higher*, although not significantly so in a statistical sense. These vehicles were somewhat under-represented in the sub-category of accidents in which the cab driver was judged

¹Beckett, S. (1952). *En attendant Godot, pièce en deux actes*. Paris: Editions de Minuit.

²Aschenbrenner, M. and Biehl, B. (1994). Improved safety through improved technical measures? Empirical studies regarding risk compensation processes in relation to anti-lock braking systems. In R. M. Trimpop and G.J.S. Wilde, *Challenges to accident prevention: The issue of risk compensation behaviour*. Groningen, the Netherlands: Styx Publications.

to be culpable, but clearly over-represented in accidents in which the driver was not at fault. Accident severity was independent of the presence or absence of ABS.

In another part of their investigation, the researchers installed accelerometers in ten ABS and ten non-ABS cars, without the drivers' knowledge. These sensors measured the g-force of acceleration and deceleration once every ten milliseconds for a total of 3276 hours of driving. It was found that extreme deceleration, that is, extremely hard braking, occurred more often in the vehicles with ABS.

A third part of the study consisted of observations of driving style. Observers were trained in the systematic observation of a person's driving style and in recording their evaluations on rating scales. They were then instructed to call a taxi and to observe the traffic manners of the driver while they were passengers. A total of 113 such trips were made, 57 in cabs with ABS and 56 in cabs without. All trips covered the same 18 km route. Speed measurements were taken at four predetermined points of this route.

The drivers were not aware that their driver behaviour was being observed and the observers did not know whether they were in a taxi with ABS or without. The drivers did, of course, know whether or not they were operating an ABS cab, because of their familiarity with the car they were driving.

Subsequent analysis of the rating scales showed that drivers of cabs with ABS made sharper turns in curves, were less accurate in their lane-holding behaviour, proceeded at a shorter forward sight distance, made more poorly adjusted merging manoeuvres and created more "traffic conflicts." This is a technical term for a situation in which one or more traffic participants have to take swift action to avoid a collision with another road user.¹ Finally, as compared with the non-ABS cabs, the ABS cabs were driven faster at one of the four measuring points along the route. All these differences were significant.

In a further extension of their study, the researchers analysed the accidents recorded by the same taxi company during an additional year. No difference in accident or severity rate between ABS and non-ABS vehicles was observed, but ABS taxis had more accidents under slippery driving conditions than the comparison vehicles. A major drop, however, in the overall accident rate occurred in the fourth year as compared with the earlier three-year period. The researchers attributed this to the fact that the taxi company, in an effort to reduce the accident rate, had made the drivers responsible for paying part of the costs of vehicle repairs, and threatened them with dismissal if they accumulated a particularly bad accident record.

To sum up, in response to the installation of ABS brakes, drivers changed their driver behaviour. First, they utilized ABS to their advantage, but no improvement in the accident loss per time unit of exposure to traffic could be seen. Second, regardless of whether they were driving with or without ABS, a reduction in the accident rate did occur when the drivers' target level of risk was reduced by increasing their expected cost of risky behaviour.

¹Hauer, E. and Garder, P. (1986). Research into the validity of the traffic conflicts technique. *Accident Analysis and Prevention*, 18, 471-481.

The Munich taxicab experiment attracted a great deal of attention, not only in the professional circles, but also in the popular press. Newspapers carried articles about it and Bavarian Television wanted to show the viewers what had happened. As the experiment had already been completed, they decided to re-enact the experimental manipulation and the way the drivers had responded. Airing of this documentary added further to the popular debate. The results of this experiment were also discussed by a group of international experts from the Organisation for Economic Co-operation and Development, commonly abbreviated as OECD. In their final report, these experts from sixteen different countries stated that: "Behavioural adaptations of road users which may occur following the introduction of safety measures in the transport system are of particular concern to road authorities, regulatory bodies and motor vehicle manufacturers, particularly in cases where such adaptations may decrease the expected safety benefit."¹

Another federal government wanted confirmation of the idea that drivers show an adaptation effect in response to ABS. The Canadian Ministry of Transport asked 81 drivers, selected from the general population, to perform a set of tasks while driving a car equipped with ABS which could be turned on or off at the turn of a switch. These tasks were carried out at the Transport Canada Test Centre in Blainville, Québec. They involved braking at a stop sign, accelerating to 70 km/h, emergency braking in a straight line, curve following, and emergency stopping in a curve. There was no interaction with other traffic on the test track. All drivers were informed of the features of ABS and told when they were driving with ABS on and when they would have to rely on standard brakes. Some drivers were given an opportunity to practise hard braking with ABS, while others were not.²

The most interesting results include the finding that, with the use of ABS, driving speeds and pressure exerted on the brake pedal were higher when drivers knew they were driving with the ABS system turned on. Further, higher maximum speed was observed in drivers who had experienced emergency braking with ABS as compared with those who had not. Most important, however, was the observation that the stopping distances during the braking manoeuvres were not any shorter in the presence of ABS than with standard brakes. They would have been shorter had the only driver response been to brake harder, without an increase in speed. Thus, the potential occurrence of shorter braking distances did not materialize. It was lost due to the fact that drivers utilized the more sophisticated brakes for higher speeds and harder braking, not for greater safety. Similarly, a 1996 study of 1384 different taxis travelling to the airport in Oslo, Norway, showed that cabs equipped with ABS followed the car in front significantly more closely than cabs without ABS.³

¹OECD (1990). *Behavioural adaptations to changes in the road transport system*. Paris: Organization for Economic Co-operation and Development; Road Transport Research, p. 5.

²Grant, B.A. and Smiley, A. (1993). Driver response to antilock brakes: a demonstration of behavioural adaptation. *Proceedings, Canadian Multidisciplinary Road Safety Conference VIII*, Saskatoon, Saskatchewan, June 14-16.

³Sagberg, F, Fosser, S. and Sætermo, I.A.F. (1997). An investigation of behavioural adaptation to airbags and antilock brakes among taxi drivers. *Accident Analysis and Prevention*, 29, 293-302.

These German, Canadian, and Norwegian findings support another statement in the above-mentioned OECD report: “An important conclusion of the Scientific Expert Group is that behavioural adaptation exists, and does have an effect on the safety benefits achieved through road safety programmes.”¹ A comparative study of cars with and without ABS conducted in the US came to the striking conclusion that “the evidence is clear that anti-lock brakes are associated with increased fatality risk to occupants of the ABS-equipped vehicle.”² This finding may well be due to the same behavioural mechanism as the observation made in Norway that newer cars, that is, cars with more advanced safety features, are more often involved in accidents than older cars; see Section 7.6.

Anti-lock brakes are a recent addition to a long string of supposed safety measures and they have been welcomed by many with great fanfare and heralded as a true life-saving device. It is interesting to note, however, that the limitations of better brakes in providing greater safety were already suspected in a footnote to a paper published in 1938, but the authors failed to identify motivational factors as the dominant determinants of the accident rate:³ “...more efficient brakes on an automobile will not in themselves make driving the automobile any safer. Better brakes will reduce the absolute size of the minimum stopping zone, it is true, but the driver soon learns this new zone and....” You will have no difficulty in guessing the gist of the remainder of the sentence, but will you be able to resist the temptation of believing in the safety benefits promised by the next technological innovation, the next “technological fix,” so to speak? Or will you still be waiting for Godot (the man who never came) and willing to believe in the “unprecedented safety” heralded by the “high-tech” developments that are supposed to result in an “intelligent vehicle and highway system”?⁴ By “safety benefits,” we mean, of course, more safety per head of population, not per kilometre driven.

More difficult to understand are the first few words of the cited sentence, the first part that I left out, “Except for emergencies,” and these words just do not seem to make sense. Maybe the authors were not quite certain that better brakes would fail to add to safety. What *is* certain is that the authors did not emphasize motivation or risk acceptance as the main determinant of safety. The quote comes from a mere footnote in their publication which, in general, emphasizes the importance of skill instead: “Safe and efficient driving is a matter of living up to the psychological laws of locomotion in a spatial field.” As an aside, we may also note that psychological laws are supposed to describe the behaviour of any human being—including your behaviour and mine—whether we like these laws or not; we have no choice. Legal

¹OECD (1990). *Behavioural adaptations to changes in the road transport system*. Paris: Organization for Economic Co-operation and Development; Road Transport Research, p. 6.

²Farmer, C.M., Lund, A.K., Trempel, R.E. and Braver, E. (1997). Fatal crashes of passenger vehicles before and after adding antilock braking systems. *Accident Analysis and Prevention*, 29, 745-757.]

³Gibson, J.J. and Crooks, L.E. (1938). A theoretical field analysis of automobile-driving. *The American Journal of Psychology*, 11, 453-471.

⁴Wilde, G.J.S. (1990). Véhicule informatisé et sécurité routière. *Recherche -Transports -Sécurité*, No. 26, 29-36.

laws are different: we have the choice between compliance and going against them, and whether we do or not depends on psychological laws.

More safety per kilometre driven may well be expected from anti-lock brakes. Under dry pavement conditions, these brakes offer greater braking opportunity than standard brakes, because they are more likely to be activated with maximum foot pressure. Under slippery conditions, they offer the advantage of being able to brake and change direction at a lesser risk of skidding. Therefore, under both types of conditions, they offer an opportunity for greater speed without adding to unsafety. Driving faster means being able to drive a greater distance in the same amount of time. Drivers will thus have an opportunity for more mobility per time unit of driving. If greater mobility is attractive to them, they will drive more, with the end result that the accident loss per head of population does not change, while the accident rate per km driven is favourably affected. There is *progress* in the sense that people are given the opportunity of driving more kilometres per road accident. But at the same time there is *stagnation* in the sense that there's no reduction in the accident rate per person (see Equation 3 in Table 5.1).

7.2. Airbags, studded tires and parachute ripcords.

Airbags seem to be another safety promise that is doomed to remain unfulfilled. In recent years airbags have been advertised by car manufacturers as providing drivers with near-immortality in a crash, and governments in some parts of the world have included them in the required vehicle manufacturing standards. What has been the effect on safety?

There are occasional reports showing that a car occupant survived a crash thanks to the airbag. There are also reports that show that car occupants died because of an inflating airbag. So, what is the over-all effect? More systematic research by economists in the State of Virginia compared the accident experience of passenger cars with and without airbags and came to the conclusion "that insurance industry-generated data reveal that injury claims increase following adoption of an air bag system" and that "Virginia State Police accident reports indicate that air-bag-equipped cars tend to be driven more aggressively and that aggressiveness appears to offset the effect of the air bag for the driver and increase the risk of death to others."¹

This statement is similar to the one made by another economist whose California data "lead to the conclusion that, controlling for other influences, as driving conditions become safer, accidents become relatively more injurious for not-at-fault drivers than for at-fault drivers,"² the latter including pedestrians and bicyclists.

Not surprisingly, winter driving and the potential effects of studded tires on safety have been studied several times in Scandinavian countries. In one of these studies, carefully matched samples of Finnish drivers with or without studded winter tires

¹Peterson, S., Hoffer, G. and Millner, E. (1995). Are drivers of air-bag-equipped cars more aggressive? A test of the offsetting behavior hypothesis. *Journal of Law and Economics*, 38, 251-264.

²Traynor, T.L. (1994). The effects of varying safety conditions on the external costs of driving. *Eastern Economic Journal*, 20, 45-60, p. 59.

were compared on their moving speeds, prudence in negotiating curves and following distance. Drivers without studded tires drove significantly more slowly on slippery roads and in curves and maintained following distances that were longer by as much as 11 metres.¹ In doing so, these drivers may have maintained their accident risk at the same level as the drivers with studded tires. This interpretation is supported by a Norwegian study that found no difference in accident frequency between the two categories of drivers.² A study conducted in Iceland also concluded that the behavioural factor is more important than the equipment, but that studded tires may nonetheless have a small beneficial effect of their own on safety.³

A rather startling case of technical improvements failing to reduce the accident rate is presented by a study on parachute jumping. In the past many of the fatalities in this sport occurred when parachutes did not open. In more recent years, however, the engineering of the ripcord function has been improved and parachute deployment brought more fully under the skydiver's control. Superficially one might have expected a major reduction in skydiving fatalities, but this did not occur. Indeed, the new ripcord did indeed produce a major reduction in accidents where the parachute was closed at the time of landing, but these accidents were replaced by fatalities in which the parachute was open at landing. A graduate student at Western Oregon University wished to test the hypothesis, that he derived from the concept risk homeostasis, that "accident record will show that when fatal skydiving accidents in one category [closed parachute] decline, there will be an increase in fatal skydiving accidents in a different category [open parachute]." This is indeed what he found for the time period in which the new ripcord gained in popularity; the "total annual fatalities have remained the same during this period [because] people adjust their behaviors to maintain arousal at optimal levels."⁴ As people become more confident that the parachute will open, they will open it later, and sometimes too late.

Falls from less dizzy heights have also become a major concern in recent years, particularly falls in children's playgrounds many of which have been closed or modified in numerous places in an effort to provide more safety. In a very careful and detailed study, involving data from a variety of countries, and dealing with accidents as well as safety measures, Prof. David Ball of the School of Health and Social Sciences at the Middlesex University in the UK comes to the following conclusion: "It is noted that over the past decade, during which there have been many playground safety interventions, [...] there is as yet no sign of a downward trend in overall numbers of injury cases." Among these interventions, the installation of softer,

¹Mäkinen, T., Beilinson, L., Rathmayer, R. and Wuolijoki, A. (1994). *The effect of studded tyres on journeys and driver risk taking*. Espoo, Finland: VTT.

²Fosser, S. (1996). Studded or non-studded winter tyres: No significant difference in risk of accidents. *Nordic Road and Transport Research*, No. 1, p. 16.

³Sigthorsson, H. (1998). Studded winter tyres and traffic safety. *Nordic Road and Transport Research*, 10, No. 3, 4-7.

⁴Napier, V. (2000). Open canopy fatalities and risk homeostasis: a correlation study. Department of Psychology, Western Oregon University, March 5.

impact-abating, ground surfaces is directly aimed at reducing the incidence of injuries due to falls. Although the percentage of playgrounds equipped with more compliant surfaces has been estimated to rise from 20 to 80 in a decade, no beneficial effect on accident statistics could be observed. Prof. Ball also notes: “Interestingly, the percentage of falls resulting in fractures is somewhat lower on hard surfaces such as concrete and tarmac than for natural surfaces such as sand, bark and woodchip, and rubber,” and among the explanations that may account for this, he says “[...] a behavioural explanation would be that children modify their play when they believe that the environment is safer.”¹ Similarly, two experimental studies suggest that children who are made to wear protective equipment are likely to take more risks.^{2,3}

In a set of experiments it was found that wildland fire fighters lowered their perceptions of hazard when using personal protection equipment in the form of fire shelters. This was explained - as in the previous studies - as a risk-compensation phenomenon.⁴ This same explanation was offered for the findings of an extensive literature review dealing with the question of changes in sexual behaviour in response to a variety of HIV/AIDS prevention measures. compensation. individuals who are better protected tend to respond by taking more risk in sexual affairs.^{5,6}

7.3 *The wheels of misfortune*

“The wheels of misfortune” is the title of a report that describes the impact of engineering and policy interventions on the number of bicycle accidents on the campus of the University of California at Santa Barbara over a period of nearly seven years.⁷ When classes were in session, some 10,500 bicycles per day entered the

¹Ball, D.J. (2002). *Playground - risks, benefits and choices*. Norwich: Her Majesty's Stationary Office, ISBN 0 7176 2340 8.

²Mok, D., Gore, G., Hagel, B., Mok, E., Magdalinos, H. and Pless, B. (2004). Risk compensation in children's activities: A pilot study. *Paediatrics and Child Health*, 9, 327-330.

³Morrongiello, B.A(Lasenby, J., Walpole, B. and Lasenby J. (2007). Understanding children's injury-risk behavior: Wearing safety gear can lead to increased risk taking. *Accident Analysis & Prevention*, 39, 618-623

⁴Braun, C. C., Fouts, J., Silver, N. C. and Putnam, T. (2005). Effect of fire shelters on perceived fire danger: Implications for risk compensation. *International Journal of Wildland Fire*, 14, 297-306.

⁵Eaton, L.A. and Kalichman, S.C. (2007). Risk compensation in HIV prevention: Implications for vaccines, microbicides, and other biomedical HIV prevention technologies. *Current HIV/AIDS Reports*, 4, 165-172

⁶Peretti-Watel, P., Obadia, Y., Arwidson, P. and Moatti, J.-P. (2008). “Un risque, ça va ! Trois risques, bonjour les dégâts?” Les difficultés de l'éducation pour la santé à prévenir des risques comportementaux multiples. *Promotion & Education*, March 2008; vol. 15, 1: pp. 4

⁷Johnson, M.S., Jurik, N.C., Kreb, A.R. and Rose, T.L. (1978). The wheels of misfortune: A time series analysis of bicycle accidents on a college campus. *Evaluation Quarterly*, 4, 608-619.

campus, which had an average yearly population of about 17,400 people. The use of bicycles was thus very common.

Common, too, were bicycle accidents. The Student Health Service on campus recorded an average of 249 bicycle accidents per year. All of these were accidents with personal injury, and more than one-tenth involved serious head injury, which occasionally led to withdrawal from university. Some of the more serious accidents have given rise to lawsuits against the university.

In order to reduce the number of bicycle accidents, various countermeasures were undertaken. Some of these were of the engineering kind; others were administrative in nature. The engineering interventions consisted of constructing bicycle paths that separated bicycles from both motor vehicles and pedestrians. In addition, a "bicycle traffic circle" was built that allowed two or more lanes of bicycle traffic to meet at an intersection of several bicycle paths without slowing down. Another, already existing, bicycle pathway was widened, and a large area was closed to bicycle traffic because it had been the scene of numerous accidents during periods of congestion.

One of the administrative measures consisted of refusing an automobile-parking permit to students who lived within one mile (1.61 km) of the campus, and this was aimed at reducing parking problems, not bicycle accidents. The administrative measure that was meant to reduce bicycle accidents involved the removal of unsafely parked bicycles to an impoundment lot.

The researchers conducted a time-series analysis in which each of the above interventions was inspected for its effect on the daily bicycle accident rate. They found evidence that most of the engineering measures had the effect of *increasing* accidents, as did the limitation on automobile parking permits. The installation of the "bicycle round-about," when considered alone, also appeared to have increased the accident rate. The authors of "The wheels of misfortune" note that "it is hard to immediately know what to make of this finding. Perhaps the roundabout made bike riding more hazardous or, alternatively, bike riders took advantage of the improved traffic flow to increase their speed. The latter is the interpretation apparently favoured by University engineers."

Of the two administrative measures (restricting automobile parking permits and impounding unsafely parked bicycles), only the first had an effect on the daily bicycle accident rate. A significant increase was the result, which is not surprising because a considerable increase in bicycle use was to be expected as a consequence. Unfortunately, however, this variable was not systematically monitored in this study and the same holds for many other features, as the authors themselves pointed out: "For example, increases in bike use unexplained by [seasonal variations in the size of] our student population variables may have swamped beneficial intervention effects."

This highlights a problem which is, alas, very common in traffic safety research. Some accident countermeasure is introduced and some yardstick of safety is assessed, but little information is gathered as to what happens in between. Why, and how, did the intervention achieve, or fail to achieve, a certain effect? Did people's behaviour change in response to the safety measure and, if so, in what way? Does the change in behaviour or the lack of it explain the subsequent accident rate? The Munich taxicab

experiment referred to above is a model example in the sense that it was designed to provide answers to these questions, but such experiments are rare.

At any rate, in the case of the Santa Barbara bicycle accident study, it would seem fair to conclude (as the authors did) that the engineering and impounding interventions failed to reduce the number of bicycle accidents per time-unit of personal-injury accident recording.

7.4 Traffic lights

Since about one-half of all accidents in urban areas occur at intersections, many efforts have been made to make these traffic locations safer, for instance, by yield signs, stop signs and traffic lights. If we suppose that risk homeostasis theory is valid, what results would be expected when traffic lights are installed at these locations? Because this technical measure would not be likely to influence the amount of accident risk people are willing to take, it would not be expected to lower the accident rate.

This does not mean that traffic lights are not useful for other purposes. They provide an orderly assignment of right-of-way for different streams of traffic at different moments of time, so that the overall flow of traffic may be improved. They may also make it easier for pedestrians to decide when and where to cross.

Traffic lights are not to be condemned, but—contrary to naive opinion among some professionals and the general public—they serve no safety purpose, not even in the intersections proper or in their immediate vicinity. Numerous studies on the effect of traffic lights on accidents have compared the numbers of accidents at intersections before and after installation. The effect is that fewer right-angle accidents happen, but more rear-end accidents, as well as left-turn and sideswipe collisions, occur, and the total frequency remains roughly the same.^{1,2,3} The latter is also true for the average severity of intersection accidents. Although driver actions are drastically altered by these devices, accident loss is not, and the risk remains the same.

A common weakness of before-after comparisons is that traffic light installations are not made at a random selection of intersections. They are installed because of some peculiar characteristics of the intersections in question, for instance, their past accident rate. Accident rates at any specific road location vary from year to year, just as the weather does on the first of May. So if, in a given year, the accident rate at a given location is exceptionally high, one has reason to expect that it will be lower in

¹Box, P.C. (1970). Intersections. Chapter 4 in *Traffic control and roadway elements; their relationship to highway safety*, revised. Highway Users Federation for Safety and Mobility, Washington, D.C., USA.

²Short, M.S., Woelfl, G.A. and Chang, C.J. (1982). Effects of traffic signal installation on accidents. *Accident Analysis and Prevention*, 14, 135-145.

³King, G.F. and Goldblatt R.B. (1975). *The relationship of accident pattern to type of intersection control*. Paper presented at The 55th Annual Meeting of the Transportation Research Board, Washington, D.C., January.

the next year, even in the absence of intervention. Similarly, if the accident rate were particularly low in a given year, a rise in the next would be expected. This is what statisticians call the “regression to the mean” effect.

Moreover, the possibility that drivers may change their routes as a consequence is often not considered, and counts of passing traffic before and after the installation of lights are often not available. Thus, it is difficult to estimate what the accident loss at the intersection would have been had no traffic light been installed.

This is why a cross-sectional study of accidents at 137 intersections in the city of Kitchener, Ontario, is of special interest.¹ There were four types of traffic control at these intersections: traffic lights, a stop sign, a yield sign, or nothing at all (meaning that the basic rule applied, that traffic coming from the right has the right of way).

No change in traffic control at these intersections was carried out. The investigator proceeded as follows. He collected data on the geometry of the intersections, collisions between vehicles, and traffic volumes for each intersection for one calendar year. On the basis of the geometry and volume data, an index of potential hazard was calculated for each intersection. This index is the number of accidents that would have happened theoretically if no driver made any effort to avoid a collision. As you can imagine, this essentially amounts to the number of cars approaching the intersection on one street, multiplied by the number of cars on the crossing street, the product being divided by the amount of space in the intersection.

The index of potential hazard was then compared with the number of accidents that had actually occurred at each street crossing. An index of safety for each crossing was obtained by dividing the number of potential accidents by the actual number of accidents. Thus, the smaller the actual accident rate per intersection relative to its potential hazard, the greater the safety index was. It indicates, therefore, how effective drivers were in avoiding potential accidents.

Finally, the four types of intersections, each categorized according to the type of traffic control in place, were inspected on whether there were any differences in this safety index. No differences were found. Driver effectiveness in avoiding collisions with other vehicles at intersections was not helped by yield signs, stop signs or traffic lights. The author concluded that the four types of “intersection control devices do not affect the total number of collisions between vehicles.”

He noted, too, that the concentration of accidents at intersections has led to countless public demands on city engineering departments for corrective action at these locations, and that at the time of the study some 60% of all intersections in urban areas in Ontario had been equipped with some control device. At that very same period of time, less than 5% of the intersections in Oslo, the capital city of Norway, were controlled by signs or signals. Yet, within the city boundaries of Oslo, about one-half of all accidents happened at intersections, just as they did in Ontario cities. So, as far as yield or stop signs and traffic lights are concerned, whether or not an intersection control device is installed doesn't seem to make much difference to

¹Roer, P.O. (1968). Traffic safety and the use of intersection control devices. *Proceedings of the 1968 Convention of the Canadian Good Roads Association*, Toronto, Sept. 30-Oct. 3, pp. 538-553.

collision frequency, nor does the type of traffic control installed. What *does* reduce the accident rate is discussed in Chapter 11.

Cross-sectional studies, like before-after comparisons and longitudinal studies over extended periods of time, also present their problems of interpretation. One cannot be sure that drivers or their personal characteristics are the same from one intersection to another or from one time frame to another, let alone from one jurisdiction to another, such as Norway and Ontario. What we can say, however, is that the available evidence from both before-after comparisons and cross-sectional studies does not support the notion that traffic control installations at intersections have a beneficial effect on safety. Drivers do *behave* differently at intersections with different control signs and signals, but once again we see no change in risk.

Engineering modifications of the roadside at locations other than intersections bring about rather similar changes in driver behaviour, according to the OECD report we mentioned above in Section 7.1. Here are some illustrations. Increases in lane width of two-lane highways in New South Wales, Australia, have been found to be associated with higher driving speeds: a speed increase by 3.2 km/h for every 30 cm additional lane width for passenger cars, and for trucks, an increase of about 2 km/h for every 30 cm in lane width. An American study dealing with the effects of lane-width *reduction* found that drivers familiar with the road reduced their speed by 4.6 km/h and those unfamiliar by 6.7 km/h. In Ontario it was found that speeds decreased by about 1.7 km/h for each 30 cm of reduction in lane width. In Texas, roads with paved shoulders, as compared to unpaved shoulders, were found to be associated with speeds at least 10% higher. Drivers have generally been found to move at a higher speed when driving at night on roads with clearly painted edge markings.

At this point it may be of interest to call attention to the engineering devices that go under the heading of “traffic calming” and include such things as speed bumps, narrow street passages, rumble strips, pavement undulation, chicanes, speed tables, traffic throttles and pinch points. In contrast to the mobility-enhancing interventions that have been discussed above, these devices are installed in order to reduce traffic and rapid traffic flow. In a sense, therefore, these measures constitute a sort of “traffic safety engineering in reverse.” According to the reasoning developed in this report, if they are successful in serving their stated purpose, they may be expected to reduce the amount of motor-vehicle travel per head of population (km/N), to increase the accident rate per kilometre driven (A/km), while having no effect on the accident rate per head of population (A/N; see Table 5.1 in Section 5).¹ Note also that the co-existence of the traditional safety engineering, taking the form of guardrails, wide shoulders, seatbelts, crashworthy cars and so on, on the one hand and the traffic calming measures on the other, present a puzzling paradox. The first policy aims at reducing the severity of the consequences of risky behaviour such as speeding or inattentiveness, while the second policy increases the severity of the consequences of such imprudent behaviours. Can you have it both ways or are these two policies

¹Wilde, G.J.S. (1998). Can traffic calming devices be expected to reduce the accident rate per head of population or per unit distance driven? Paper presented at Traffic Safety Summit '98, Kananaskis, AB, Canada, Oct. 4-7. www.ama.ab.ca/trafsafe/traf_safe_summit/presnt34.pdf.

logically contradictory?

7.5 Visibility

A Finnish study investigated the effect of installing reflector posts along highways with an 80 km/h speed limit. A total of 548 km of randomly selected road sections were equipped with these posts and compared with 586 km that were not. The fact that the installation of reflector posts increased speed in darkness will no longer come as a surprise. There was not even the slightest indication that it reduced the accident rate per km driven on these roads; if anything, the opposite happened.¹ There appears to be no convincing evidence that another form of increasing visibility, namely the use of daytime running lights that has been mandatory by law in some countries, has led to the intended effect of reducing accidents.² The installation of road lighting at a Norwegian expressway was followed by motorists driving faster at night and paying less attention to the driving task, as evidenced by greater variance in lateral positioning. The proportion of elderly and female drivers increased.³ Cutting, clearing and mowing of vegetation along Swedish roadways was found to lead to improved sight distances as intended, but also to changes in lateral positioning and increased vehicle speeds.⁴

In the past, researchers have been surprised by the fact that poor visibility at unprotected railway crossings does not seem to add to the accident rate at these crossings. As some have said: "This does not seem logical: sight distance should be one of the most important variables. If a driver cannot see the crossing and down the track at an adequate distance, then he and his vehicle are being expected to perform beyond their physical limitations."⁵ *What should be patently obvious, however, is that drivers at these locations can see that they cannot see* and are likely to adjust their behaviour accordingly. This is clearly borne out in a real-life experiment conducted in Canada in which lateral sight distances were improved by removing bush and trees between the road and the railroad. Motorists responded to this by searching for trains earlier, that is, more upstream from the crossing, and by moving at a faster approach speed. The percentage of drivers deemed safe or unsafe, on the basis of their approach behaviour and the arrival of a hypothetical train from the farthest observable point along the track, remained the same. Ergo, behavioural adaptation to better visibility,

¹Kallberg, V.P. (1992). *The effects of reflector posts on driving behaviour and accidents on two-lane rural roads in Finland*. Helsinki: The Finnish National Road Administration Technical Development Center, Report 59/1992.

²Theeuwes, J. and Riemersma, J. (1996). Comment on Willams and Farmer's evaluation of daytime running lights. *Accident Analysis and Prevention*, 28, 799-800.

³Assum, T., Bjørnskau, T., Fosser, S. and Sagberg, F. (1999). Risk compensation – the case of road lighting. *Accident analysis and Prevention*, 31, 545-553.

⁴Sävenhed, H. and Wretling, P. (1997). Rönning och slåtter påverkar siktsträcka, hastighet och sidolägesplacering. *VTI aktuellt*, 20, No. 4, p. 18.

⁵Schoppert, D.W. and Hoyt, D.W. (1968). *Factors influencing safety at highway-rail grade crossings*. NCHRP Report No. 50), Springfield, Virginia: A.M. Voorhees and Associates.

but no apparent safety gain.¹ Like the Munich taxicab experiment described in Section 7.1, this railway crossing experiment was also re-enacted for the purpose of a television documentary on risk taking behaviour. Not surprisingly, another experiment that looked into the effect of installing additional warning signs at unprotected crossings with restricted lateral sight distances came to essentially the same results.²

By now, what may be more surprising instead is that the OECD report, although it frequently refers to changes in the accident rate in relation to some modification in engineering, rarely spells out the denominator of the accident rate under consideration, such as per km driven, per hour of driving or road use, or per head of population. This is puzzling because the report was prepared by an international committee of experts to deal with the challenge posed by risk homeostasis theory, among other views. In that theory, the distinction between the accident rate per km driven and per hour of road use is as essential as the distinction between death per cigarette smoked and death per cigarette smoker, and between the proverbial apples and oranges.

7.6 Motor-vehicle manufacturing regulations

A major package of legislative regulation concerning the “safe” design of new passenger vehicles to be sold in the USA came into effect in 1966. This included the obligatory installation of seatbelts for all vehicle seats, a steering column that would collapse in a crash instead of piercing the driver’s chest, penetration-resistant windshields, a dual braking system, and padded dashboards. The effect of these mandatory construction features upon subsequent accidents was studied by an economist at the University of Chicago.³

Comparing the pre-regulation period 1947-1965 with the 1966-1972 period, in which there were more and more regulated vehicles in use, he came to the conclusion that the newly-legislated vehicle-manufacturing standards had not led to a reduction in the number of fatalities per km driven. While the legislation may have brought about a reduction in fatal accidents to car occupants per km of mobility, it did not reduce the total death rate so defined. It may, in fact, have led to an increase in the death rate of non-occupants, such as bicyclists and pedestrians, per motor-vehicle

¹Ward, N.J. and Wilde, G.J.S. (1996). Driver approach behaviour at railway crossings before and after enhancement of lateral sight distances: An experimental investigation of a risk perception and behavioural compensation hypothesis. *Safety Science*, 22, 63-75.

²Ward, N.J. and Wilde, G.J.S. (1995). Field observation of advance warning/advisory signage for passive railway crossings with restricted lateral sightline visibility: An experimental investigation. *Accident Analysis and Prevention*, 27, 185-197.

³Peltzman, S. (1975). The effects of automobile safety regulation. *Journal of Political Economy*, 83, 677-725.

distance of mobility. A similar shift in risk from drivers to pedestrians has been reported in Australia.¹

The Chicago study was published in 1975, and has been attacked many times since by several other authors who maintained that the vehicle-manufacturing standards have had a reducing effect upon the traffic death rate per unit distance driven by motor vehicles. There have been others who found evidence supporting the controversial findings.² In fact, in 1989, the issue was still not settled, nor was it in 2000.³⁴ You may, however, already have noticed, and justly so, that this debate is, at best, only marginally relevant to the question of the validity of risk homeostasis theory. There is nothing in that theory that says that the accident rate per km driven cannot be reduced by technological interventions, or that it is "useless,"⁵ regardless of whether they are mandated or not. What we are interested in is the accident rate per hour of exposure to the roads and per head of population. As regards the post-regulatory years 1966-1972, one definitely cannot detect in Figure 5.5 a lower per capita traffic death rate than in the preceding years 1947-1956. On the contrary, it was noticeably higher.

What you can see in Figure 5.5 is that the increase in the traffic death rate per capita from 1961 to 1965 did not continue between 1966 and 1972. Was this due to the vehicle-manufacturing standards that came into effect in 1966? This would seem rather unlikely. Note that the period 1966-1972 falls within the 1960-1982 time frame that has shown a high correlation between the rate of employment and traffic fatalities, as was discussed in Section 5.4. That correlation was very high and leaves little room for anything else that may have exerted an independent influence. The effect of the 1966 legislation on the per capita death rate in traffic, if it occurred at all, must have been quite marginal.

In a more recent Norwegian investigation of the relationship between car age and the frequency of injury accidents in a sample of 211,000 vehicles, it was found that new cars crash most. The authors state that, because of the presence of more safety equipment in newer cars, there is little doubt that new cars provide better protection than older cars in the event of an accident. Nonetheless, older cars have fewer injury accidents, and fewer accidents leading to injury in third parties, per kilometre driven than newer cars. This finding is explained by pointing out that "car drivers adapt their driving behaviour to the characteristics of the car. Older cars are driven more carefully or are used in different conditions because the car is of an older model." And

¹Conybeare, J.A.C. (1980). Evaluation of automobile safety regulations: The case of compulsive seatbelt legislation in Australia. *Policy Sciences*, 12, 27-39.

²Blomquist, G.C. (1988). *The regulation of motor vehicle and traffic safety*. Boston: Kluwer Academic Publishers.

³Hedlund, J. (2000). Risky business, safety regulations, risk compensation, and individual behavior. *Injury Prevention*, 6, 82-89.

⁴Zlatoper, T.J. (1989). Models explaining motor vehicle death rates in the United States. *Accident Analysis and Prevention*, 21, 125-154.

⁵Hedlund, J. *op cit*. A reduction in the death rate per km driven allows more kms driven per traffic death, and that is not useless. Failure to clearly distinguish between the spatial and the temporal accident rate leads to an argument that is irrelevant to risk homeostasis. See Section 3.4.

they add: “Putting the focus on safety equipment when marketing new cars may give drivers a false sense of security.”¹ Advertising cars as “safe” may be legal, but is it also responsible?

What is legal and what is not changes over time. So does what is open to litigation and what is not. It will come as no surprise that a California lawyer commented on the relevance of risk homeostasis theory for the assessment of legal liability and compensation for injuries incurred with consumer products that are alleged to be defective in design. He favours a revision of the relevant law and concluded that “[...] in the end, RHT does question the effectiveness of California’s current approach to liability for design defective products, providing a reason to reassess its approach to design defects and to examine alternative methods of dealing with design defects and injuries related to them.”²

¹Fosser, S. and Christensen, P. (1998). *Car age and the risk of accidents*. Report 386/1998. Oslo: Institute of Transport Economics.

²Miller, J.G. (1998). Risk Homeostasis and California Design Defect Products Liability: Rethinking the Consumer Expectations and Risk-Benefit Tests. *University of California Law Review*, 32, 587-627.

Quid leges sine moribus!
What good are laws in the absence of morals?
Horace, Odes¹

8 Enforcement action

8.1 *Drinking and driving*

To be killed while drunk: the wrath of the grape. There is plenty of evidence, from numerous countries, that drivers and other road users who had been drinking before being killed in traffic accidents constitute a very large proportion of all road fatalities. Moreover, in any given year, alcohol-related road accidents tend to be more severe than accidents in which the involved parties were sober.

Figure 8.1 refers to a classic study that was conducted in the city of Grand Rapids in Michigan, USA.² At the time, this city had just over 200,000 inhabitants. A group of some 6000 drivers who had been involved in accidents and survived were tested on their blood alcohol concentration (BAC). They were also interviewed on their drinking frequency. For the purpose of comparison, some 7600 other drivers were stopped while passing the same sites without accident, and interviewed by the researchers.²

As you can see from Figure 8.1, it was found for all drivers that their likelihood of belonging to the accident group was greater as their BAC was higher, regardless of their self-reported drinking frequency. In other words, the higher your BAC, the greater your accident likelihood in traffic—and there is no critical BAC level at which your chances of an accident suddenly rise, as the law in your country may suggest. As long as you remain below the legal limit, your chances of being arrested for driving after drinking will be greatly reduced, but even below that limit, your chances of getting involved in an accident increase with the amount of alcohol taken.

¹Horace, *Odes III*, 24, 35.

²Hurst, P.M. (1978). Epidemiological aspects of alcohol in driver crashes and citations, cited in OECD, *New research on the role of alcohol and drugs in road accidents*. Paris.

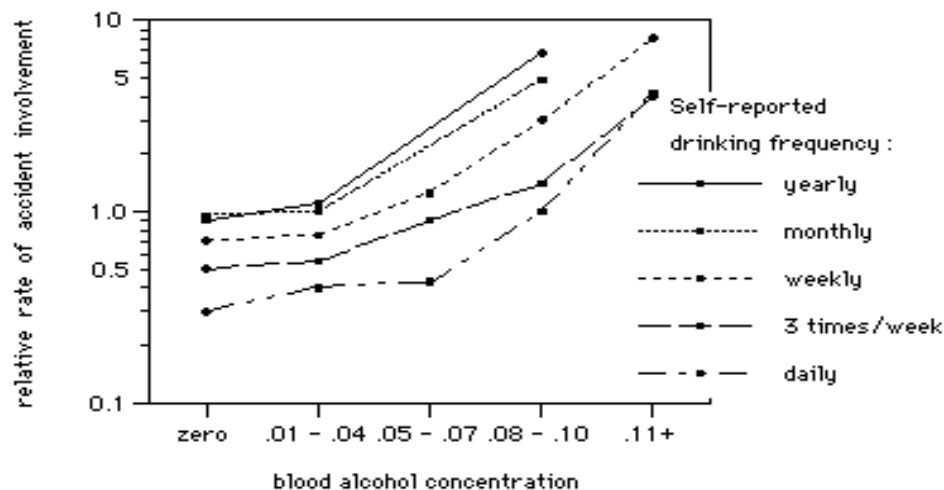


Figure 8.1: Relative probability of crash involvement in subgroups of drivers of different drinking frequency as a function of their blood alcohol concentration (BAC) expressed as percentage weight of alcohol by blood volume.¹

In short, there is no safe BAC. People who drink more often may need a higher BAC to achieve the same accident likelihood as an infrequent drinker, but for all people it is true that the more they drink before participating in traffic, the greater the accident risk they run. (You may have noticed that the vertical axis in Figure 8.1 is logarithmic and that daily drinkers at a BAC of 0.08 were about as likely to belong to the accident group as monthly or yearly drinkers when they were sober.) Clearly, the legal BAC limit has no scientific justification; it is merely a political compromise.

It is no less important to realize that sobriety is no guarantee of safety. A very large proportion—say, one-half or more—of people killed in accidents are sober, i.e., they do not have a measurable trace of alcohol in their bodies at the time of their accident. So, does it really make sense to believe that the traffic accident rate will go down if laws are successful in reducing the amount of drinking before driving? Yes, it would make sense if we had reason to believe that other behaviours that are relevant to safety would not change. But it would not make sense if we had reason to believe that people would become less cautious in other ways. So, the to-be-expected effect upon safety depends on the way people respond to the legislation. If the legislation increases the desire to be safe, it will reduce the accident rate. If the legislation fails to produce an increase in people's desire to be safe, but merely forbids one way of

¹Hurst, P.M., Harte, D. and Frith, W.J. (1994). The Grand Rapids Dip revisited. *Accident Analysis and Prevention*, 26, 647-654.

behaving unsafely, people may obey that legislation, but are likely to behave more unsafely in other ways, and the accident rate will not drop.

Legislation that threatens drivers with severe, swift, and consistently enforced penalties for drunk driving may well be heeded in the sense that fewer people will decide to drive after drinking, or they will decide to drive only short distances, or they will attempt to drive more carefully and less conspicuously, or perhaps a combination of the above. Arrests for drunk driving would then be expected to drop, as would the percentage of all drivers with BACs over the legal limit who are killed in accidents.

Such are the potential effects of the legislation, but would it be reasonable to expect that the fatal accident rate in traffic per head of population would actually go down? Perhaps, but only to the extent that the legislation increases the desire to have no accident, and that extent may be very small.

Figure 8.2 shows a marked reduction in the BAC levels of drivers killed in traffic accidents in the USA between 1980 and 1987. There was a very noticeable increase in the percentage of drivers killed who had zero BACs at the time of accident, but there was no commensurate reduction in the traffic death rate per capita. That something similar seems to have happened in Canada may be seen from Figure 8.3, while Table 8.1 offers more detailed information.¹ These observations prompt the suggestion that the drunk accidents have somehow been replaced by sober accidents. Instead of accident reduction, there has been accident metamorphosis.

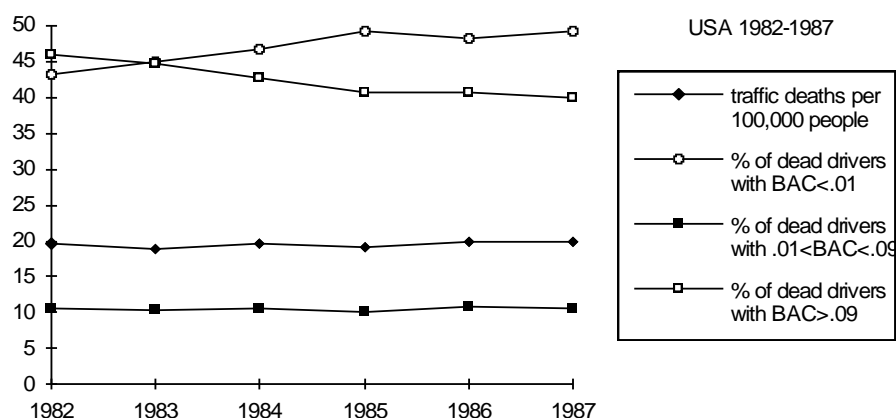


Figure 8.2: Traffic deaths per capita and changes in BAC levels in drivers killed in the USA 1982-1986.³

In general, it has been assumed that the overall fatal accident rate will go down as countermeasures focusing on alcohol reduce the blood-alcohol levels in the

¹Wilde, G.J.S. (1990). Questioning the progress: the matter of yardsticks and the influence of the economic juncture. *Proceedings, 11th International Conference on Alcohol, Drugs and Traffic Safety*, Chicago, Ill., Oct. 24-27, pp. 106-114.

population at risk.¹ It has been further assumed that reduction in BACs can be achieved if the likelihood of being detected is high, and the penalty severe and swift. The second assumption, although the least interesting of the two, has attracted the greater share of attention.² In the light of risk homeostasis, a drop in the nation's BAC does *not* imply a commensurate reduction in the accident rate. Alcohol does not cause accidents in the same way as heat causes metals to expand and ice to melt. That is linear, "open-loop" logic. To say that alcohol is responsible for the accident rate is to say that there was no war before the invention of gunpowder, no music prior to the piano, no traffic deaths before the appearance of the automobile. In short, it amounts to asserting that the demon is in the bottle, not in the person—yet another manifestation of the delta illusion. Unfortunately, many evaluation studies of the effect on enforcement with respect to alcohol only consider alcohol-related traffic accidents, not *all* traffic accidents,³ a practice that has also been criticized by others.⁴

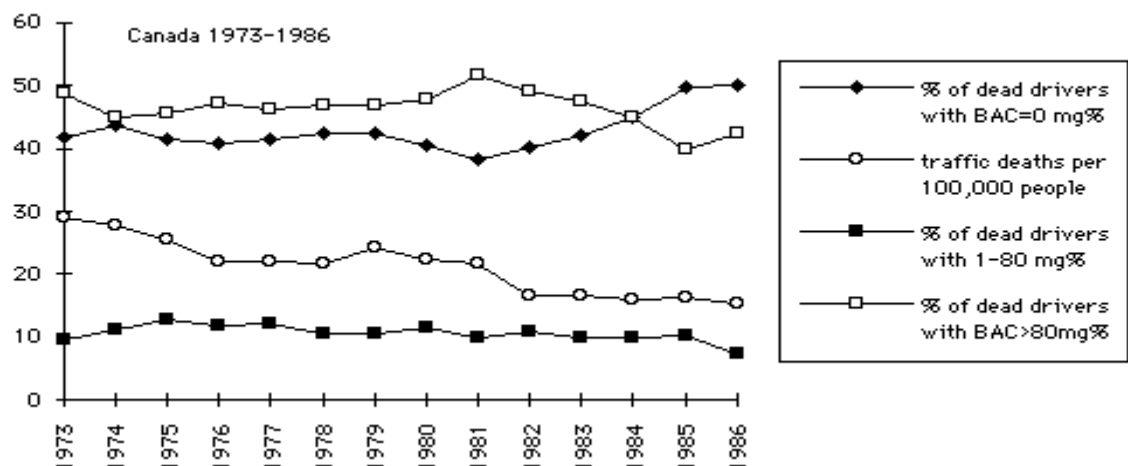


Figure 8.3: Traffic death rate per capita and changes in BAC in drivers killed, Canada 1973-1986.⁵

Putting heavy emphasis on one particular way among the many in which accidents can happen leads to less effective countermeasures development. It would seem more

¹Wilde, G.J.S. (1985). The use of incentives for the promotion of accident-free driving. *Journal of Studies on Alcohol*, Supplement No. 10, pp. 161-167.

²Ross, H.L. (1982). *Detering the drinking driver: legal policy and social control*. Lexington, Mass.: D.C. Heath Co.

³e.g., Beirness, D.J., Simpson, H.M. and Mayhew, D.R. (1997). *Evaluation of administrative licence suspension and vehicle impoundment programs in Manitoba*. Ottawa: Transport Canada (Safety and Security) Publication No. TP-13096-E.

⁴e.g., Hauer, E. (1997). *Observational before-after studies in road safety*. Oxford: Pergamon.

⁵Wilde, G.J.S. (1990). Questioning the progress: the matter of yardsticks and the influence of the economic juncture. *Proceedings, 11th International Conference on Alcohol, Drugs and Traffic Safety, Chicago, Ill., Oct. 24-27*, pp. 106-114.

productive to safety if the countermeasure focuses on the less immediate but more fundamental cause of the accident rate—the accepted level of risk in the road-user population. The target level of risk represents the “*causa causans*,” the “causing cause,” the “cause of causes,” the “root cause,” the “upstream cause”. To believe that the removal of alcohol, as one immediate cause of accidents, will reduce the accident rate, and that it will not be replaced by some other immediate cause, is a reflection of the delta illusion first mentioned in the Introduction. Accident rates per time unit exposure to traffic will not change unless there is a change in the set point level of risk.

By way of example, a crackdown on drunken driving carried out in 1977 in British Columbia may have been counterproductive in that there is a suggestion that it led to an increase in the overall number of road deaths. In that year, without a change in the law regarding drinking and driving, the 2.5 million inhabitants of this part of Canada saw a major and highly visible intensification of BAC enforcement practices by police that was given very prominent attention in the mass media. Conspicuous Mobile Blood (breath) Alcohol Testing Units (the so-called “BATmobiles”) were deployed and located from one high-volume traffic site to another. The total number of times drivers were stopped and checked by the police in 1977 was equivalent to 30% of the total number of vehicles registered in British Columbia! By means of time-series analysis, it has been estimated that the enforcement programme produced an 18% reduction in the number of alcohol-related traffic fatalities, but a 19% increase in the overall number of traffic deaths, alcohol related or not.¹ A Pyrrhic victory: the battle was won but the war was lost; the operation was successful, but the patient died. Is this the price to be paid for well-intentioned but conceptually unsophisticated efforts to reduce the accident rate? *J'accuse*.

The observed pattern of results may have been due to the following mechanism. Let us assume that the programme was effective in reducing the BACs of drivers. Those who used to drink and drive prior to the programme now refrained from drink more often, but as their target level of risk had not been lowered, they adapted by driving more, with more passengers in the car, driving faster, less attentively or whatever. Discouraging drinking and driving by heavy enforcement threats may reduce drinking and driving, but is it reasonable to assume that people who used to display that asocial behaviour will turn into saints on the road? The other drivers, those who did not drink and drive before the crackdown, were under the impression that it was very successful in removing the drunks from the roads and now felt less of a need to refrain from driving during the risky hours or “to watch out for the other guy.”

Such a scenario is neatly illustrated by some items that appeared one day in a Toronto newspaper. The government in Ottawa had just announced an increase in penalties for drinking and driving. On the front page we were told: “Blitz against drunk driving is paying off. The massive Metro Blitz against drinking drivers appears

¹Rockerbie, R.A. (1980). *Counterattack: perspectives and assessment*. Vancouver: Policy Planning Division, Ministry of the Attorney General.

to have been a success. So far this month, a record 71,718 motorists, 22,000 more than last year, have been stopped by police and the number charged with being impaired is 321, down 150 from last year's 471. 'It certainly looks like the lesson is being learned,' a police official said yesterday... On the gloomy side, 11 people were killed on Metro streets and four more on the highways within Metro this month, compared to only four last year." Inside the same issue, a letter to the editor states: "Now that [the government in] Ottawa appears to have picked up the cudgel with harsher penalties for drunk driving, it's going to be a pleasure to drive on our roads once more."¹

Therefore, popular overestimation of the contribution of alcohol to the riskiness of the roads, in combination with the enforcement and mass media activity, may have lulled drivers into an illusion of safety and thus created a short-term increase in the per capita traffic fatality rate. This particular interpretation in terms of the lulling effect (see Section 6.3) may well be speculative. Similar interpretations in the future will likewise remain speculative until programme evaluation research not only looks at the end effect, but also includes the collection of data on the behavioural processes that take place between countermeasure input and accident rate output.

8.2 *Mandatory seatbelt wearing*

A similar course of events seems to have happened following legislation that obliged drivers to use their seatbelts. As a result, seatbelt use increased sharply, and the proportion of drivers who were killed with their seatbelt on, relative to all drivers killed, also showed a marked increase (see Table 8.1). One of the first studies to investigate behaviour change in association with seatbelt use under experimental conditions was conducted in the southeastern USA. The researchers instructed their volunteer subjects to drive a 5-horsepower go-kart either with or without using the seatbelt, and, not surprisingly, observed higher speeds on the track when the seatbelt was in use.² This was an interesting experiment, but go-karts are different from cars, and tracks are different from real highways. Do novice seatbelt users also change their behaviour while driving a car on the highway?

More realistic conditions were created in an experimental study in the Netherlands on the effect of seatbelt wearing on driving style—using a real car on real roads (a 105 km freeway that makes a circular connection between Amsterdam and the cities of Utrecht and Amersfoort). When habitual, "hard-core" non-users of seatbelts complied with the experimenter's request to buckle up, they drove faster than without seatbelts, they followed more closely behind a vehicle in front, they changed lanes at higher speeds and they braked later when approaching an obstacle. A follow-up study

¹*Toronto Star*, (1989). Dec. 27.

²Streff, F.M. and Geller, E.S. (1988). An experimental study of risk compensation: between-subject versus within-subject analysis. *Accident Analysis and Prevention*, 20, 277-297.

over one year showed that these behaviour changes persisted over time.¹ Not surprisingly, car-following behaviour has been found to be understandable along homeostatic principles.²

Table 8.1: Road deaths in the USA 1980-1987, seatbelts and alcohol.

	1980	1983	1986	1987
Road deaths per 100,000 people	22.5	18.2	19.1	19
Dead drivers per 100,000 people	12.7	10.3	11	11
Dead passengers per 100,000 people	5.8	4.6	4.8	4.8
Occupant deaths per 100,000 people	18.5	14.9	15.9	15.8
% of all dead drivers wearing seatbelts	2.5	3.2	14.6	18.2
ditto for dead passengers	2.1	3.9	14.4	18.3
% of all dead drivers having zero BAC	33	40.8	44.9	47.1
ditto, BAC between .01 and .05	6	5.1	5.8	5.2
ditto, BAC between .06 and .09	5.9	5.1	5.1	4.9
ditto, BAC between .1 and .15	15.1	13.4	12.6	11.5
ditto, BAC between .16 and .2	16.4	14.9	13.2	12.8
ditto, BAC greater than .2	23.5	20.7	18.4	18.4

In conclusion, to compel a person to use protection from the consequences of hazardous driving, as seatbelt laws do, is to encourage hazardous driving. A fine for non-compliance will encourage seatbelt use, but the fact that the law fails to increase people's desire to be safe encourages compensatory behaviour. To put it plainly:

“A little safety song”

*Give me a ladder that is twice as stable,
And I will climb it twice as high;
But give me a cause for caution,
And I'll be twice as shy³.*

This would seem quite plausible, but not so, according to some people in the road safety community. Here are the words of a member of the British parliament, quoted in a popular traffic safety magazine in 1986: “It is interesting to note that the only

¹Janssen, W.H. (1994). Seatbelt wearing and driving behavior: an instrumented-vehicle study. *Accident Analysis and Prevention*, 26, 249-261.

² Lu, G., Cheng, B., Wang, Y. and Lin, Q. (2013). A car-following model based on quantified homeostatic risk perception. *Mathematical Problems in Engineering*, 2013, 1-13; <dx.doi.org/10.1155/2013/408756>.

³This four-line rhyme could well serve a summary of this entire book.

arguments that have been advanced against the [proposed seatbelt wearing legislation] have come from the provisional wing of the lunatic fringe of the libertarian lobby.”¹ Human understanding is limited; the inclination to display that limitation publicly and loudly, unfortunately, is not.

How can we explain why some people went so far as to accuse others of lunacy in a case like this? First, there is the evidence they see: drivers who are wearing their seatbelts are much more likely to survive a crash than those who are not. This evidence is reliable; it has been produced in many studies in many different countries. Secondly, they were probably unaware that it does not necessarily and logically follow from this evidence that more people would survive traffic accidents if all drivers were compelled by law to use the seatbelt. That would logically follow only if all other relevant factors, including road-user behaviours, remained the same; and thus they fell victim of the “delta illusion” (see Chapter 1) They did not consider that habitual non-users of the seatbelt might alter their driving style as a consequence of being compelled to buckle up. They did not consider the possibility of behavioural compensation for changes in external hazard. Also, they may simply have been blinded by their zeal to do something quick and easy for safety – and thus doing nothing for it.

But their lack of awareness of compensatory behaviour is astounding because these very people are among the first to proclaim that they would refuse to drive if they did not have a seatbelt in their car. A small amount of introspection should have been sufficient to make them realize that they themselves are subject to the phenomenon of risk compensation, in that they are willing to expose themselves to the dangers of traffic only if they have assured themselves of a degree of protection. They must surely know that the protection is only partial, because even buckled-up drivers get killed in accidents.

To declare that one is willing to drive only if one has a crashworthy car, a seatbelt, a crash helmet, collision and liability insurance, and so forth, is to express the effect of risk compensation upon one’s behaviour. It is of more than passing interest to note that, in the just-mentioned Dutch seatbelt study, there was also a sample of habitual seatbelt wearers. These people were happy to comply with the experimenter’s request to drive the 105 km route with the seatbelt on, but all of them refused to do so with the seatbelt unbuckled. To refuse sexual intercourse unless protected by a condom, to refuse to go skiing unless a first-aid station is nearby, to refuse to stay in a hotel unless it is equipped with smoke alarms, to refuse anything unless at least partial protection from disaster is provided, is to tacitly admit to the essence of risk homeostasis theory.

The people we were speaking of above (the ones who called the opponents of ineffective and repressive legislation “lunatics”) may not have been much inclined to introspection, but had they been more attentive to the already existing evidence regarding the effects of seatbelt legislation, they would have had another reason for

¹Mitchell, A. (February 1988). Quoted in *Care on the Road*, p. 1.

doubting the law's effectiveness. Dr. John Adams of University College, London, UK, had already published his much-discussed analysis of the trends in traffic fatality rates in countries with and without seatbelt-wearing laws.¹ Figure 8.4 summarizes his findings.

This figure clearly shows that the fatal traffic accident rate in the countries that introduced seatbelt legislation dropped to levels well below what had been experienced before. We should, of course, be warned that the economic juncture might have something to do with this (see Section 5.4). But what this figure shows, too, is that traffic fatalities also decreased in countries without such legislation. In fact, the drop was even somewhat greater in the latter. Could this possibly have been due to the lulling effect discussed in Section 6.3? Could it be due to the fact that, in countries in which seatbelt-wearing became mandatory, the public was told over and over again in mass media campaigns that "seatbelts save lives"? In other words, could it be due to the public coming to believe that wearing the seatbelt would give a greater safety advantage than it actually does?

¹Adams, J.G.U. *Risk and freedom: the record of road safety regulation*. London: Transport Publishing Projects.

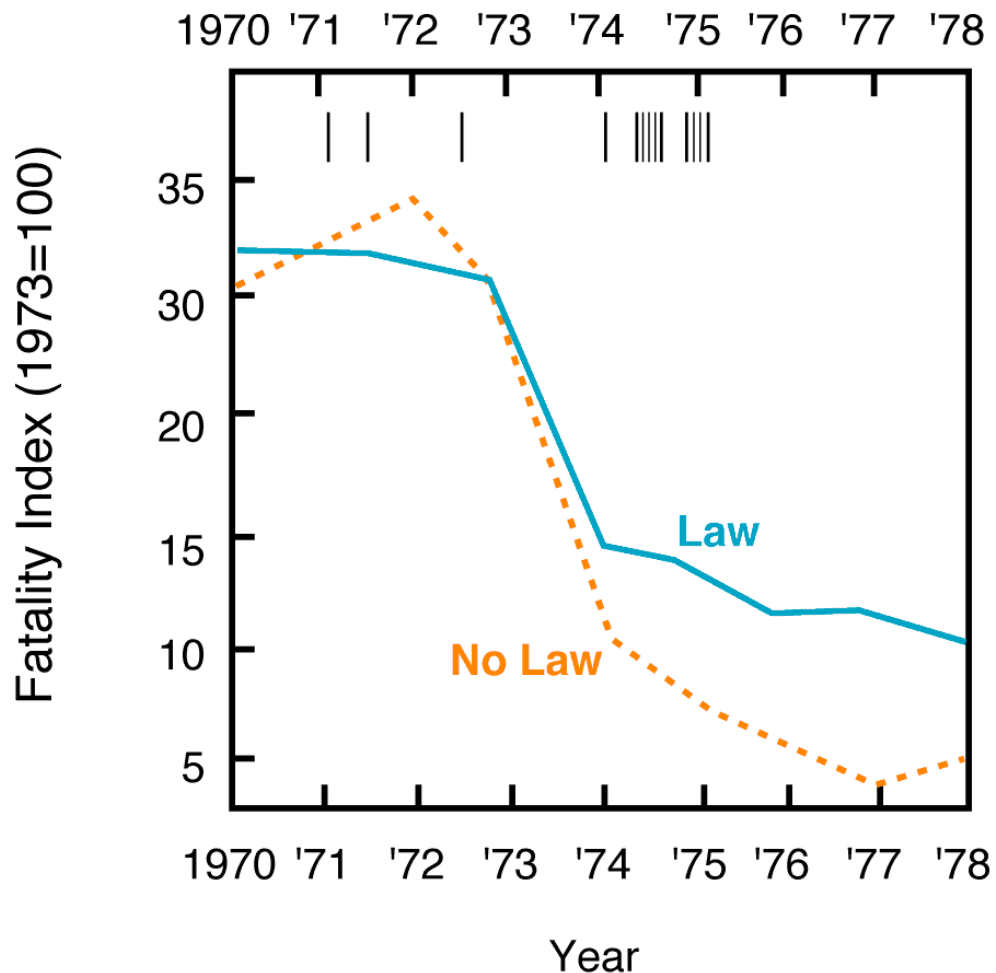


Figure 8.4: Indices of annual road deaths in countries with and without seatbelt-wearing laws. Dots indicate the dates at which legislation came into effect.¹

The answers to these questions may be uncertain, but surely these findings should have been taken into account by British lawmakers in the mid-1980s and again by American legislators several years later. Although British and American legislatures discussed and introduced seatbelt legislation some 10 to 15 years later than did continental Europe, apparently very little had been learned by the latecomers. Is it true, then, that what we learn from history is that we learn very little from history? Even so, there is hope that those who realize this will escape the doom of this

¹Adams, J.G.U. (1985). Smeed's law, seat belts and the emperor's new clothes. In L. Evans and R.C. Schwing (Eds.), *Human behavior and traffic safety*. New York: Plenum, pp. 193-245.

predicament and rise to a level of understanding from which they will be able to take measures towards real progress.

Here, at the end of this section, we quote two more studies that involved many millions of road users and that show the ineffectiveness of so-called accident prevention measures fail to prevent accidents when these measures fail to take the psychology of road users into account.

An American study published in 2002 reported that car-occupant seatbelt usage, as determined by roadside surveys, has risen from a low of 10% (in 1985 in Indiana) to a high of 87% (in 1996 in California), but did not find this to have had a the effect of reducing the traffic fatality rate per head of population (or even per unit distance driven) in 14 years of data.¹

In the period from 1994 to 1996, about half of all 50 American states plus the federal district had laws compelling all motor cyclists to wear a helmet, while the other half of jurisdictions did not. Through a comparison of the law states with the no-law states over this period, it was found that the helmet laws failed to have a significant impact on the fatality rate per 10,000 registered motorcycles.² The authors mention the psychological principle of “risk compensation” as a possible explanation, and quote several earlier authors on the topic of crash helmet legislation in the US who had also referred to this principle in order to explain their findings. .

8.3 *The Nashville crackdown-slowdown study*

To question the assumption of the effectiveness of police surveillance in reducing the rate of undesirable behaviours in society may appear to be sacrilegious. Police forces justify their budgets on that assumption, and citizens seem to subscribe to it too, since they are willing to provide the tax money for those budgets. This dual belief, on the receiving and the providing end, may be one reason why so few experiments to verify this assumption have been carried out. Another reason may be the cost—in terms of money, organizational ability and public relations—of running experiments in which the rate of surveillance is deliberately increased or decreased in order to see what happens to the frequency of violations of the law. It may be much more comfortable to believe than to question. Moreover, good experimentation demands the provision of adequate control data for comparison, and the collection of such data implies that some geographical areas will, at least temporarily, have less police surveillance than experimental areas. Who would willingly deprive anybody of the privilege of police surveillance when it is generally believed that it is beneficial?

¹Derrig, R.A., Segui-Gomez, M., Abtahi, A. and Liu, L.L. (2002). The effect of population safety belt usage rates on motor-vehicle-related fatalities. *Accident Analysis and Prevention*, 34, 101-110.

²Branas, C.C. and Knudson, M.M. (2001). Helmet laws and motorcycle rider death rates. *Accident analysis and Prevention*, 33, 641-648.

The very few experimental studies that have been carried out do not support these general beliefs about the effectiveness of enforcement. That is the opinion of a team of researchers who tried to determine whether there were any effects on the rate of traffic accidents caused by naturally occurring variations in enforcement activity, after these had taken place. Some time ago, the police department of the city of Nashville, Tennessee, decided to crack down on moving violations in traffic. The number of charges rose to 52% above normal. At the same time, there happened to be a salary dispute between the police force and the city, and this was the cause of the next variation in enforcement activity. The heightened enforcement activity was interrupted by a tactic that the police officers undertook in order to strengthen their negotiating position in the wage dispute: they reduced the ticketing activity to as little as 36% of what was normal. Some time later, the dispute was resolved and the number of charges laid for moving violations returned to the usual level.

So, there were four periods in which the frequency of charges was first 100%, then moved upward to 152%, then downward to 36% and finally back to 100%. The slowdown action of the police was widely publicized in the mass media: radio, television, and newspapers. The frequency of accidents with property damage, personal injury, and fatalities was tracked over these periods.

Did the variations in enforcement have any consequences for the frequency or severity of accidents occurring? Not so, according to the investigators, who concluded that "the present retrospective analysis of police traffic enforcement shows that wide variations in the overall levels of enforcement have no immediate measurable impact on the frequency or severity of traffic accidents, even when these interventions are highly publicized."¹ Ironically, a much earlier and well-known 1968 report on the even better known Connecticut crackdown on speeding had come to a similar conclusion, namely that there was "no unequivocal proof" that it led to a reduction in highway fatalities.²

It may be that a much greater intensification of police enforcement would have a measurable effect, but it is questionable that it would last. Suppose it were physically, financially, and politically possible to increase enforcement by a factor of ten or more. This would be expected to lead to a reduction in the rate of traffic violations. Suppose also that it would lead to an increase in the perceived cost of an accident, because associated violations of the highway code would be more likely to be noticed by the authorities, with all the unpleasant consequences thereof. We can assume that a noticeable reduction in traffic accidents would occur.

But as the rate goes down and the accident problem is reduced, the general public's concern for social problems other than road safety will probably increase. Issues other than traffic (violence, theft, vandalism, drug abuse) would become more salient in the political arena and the police forces would no longer receive the pressure or support necessary for maintaining the enforcement rate for driving offences. Traffic

¹Carr, A.F., Schnelle, J.F. and Kirchner, R.E. (1980). Police crackdowns and slowdowns: a naturalistic evaluation of changes in police traffic enforcement. *Behavioral Assessment*, 2, 33-41.

²Campbell, D.T. and Ross, H.L. (1968). The Connecticut crackdown on speeding: Time series data in quasi-experimental analysis. *Law and Society Review*, 3, 33-53.

enforcement activity would diminish again; the driving public would discover this and become more inclined to violate traffic rules and regulations.

A gradual return to the original accident rate would be the end result. This is not to say that a short-term drop in the accident rate could not be worthwhile, but the fact that the reduction is bound to be temporary should be recognized. Here again, it becomes apparent that the crucial variable for lasting reduction in the accident rate per person is the level of demand for safety in the population at large.¹ Crackdowns are aptly called crackdowns: there is a sudden eruption of activity, but that will be followed by a let-up, leading to a return to the previous equilibrium between the rate of violation by road users and the surveillance intensity of the police. No upheaval lasts for long, as the Icelanders say.

8.4 *The road safety record of Japan*

Changes in the traffic accident record in Japan have been proclaimed by one commentator as “one of the most extraordinary success stories in the whole traffic safety business.” They’ve been cited as providing evidence for the effectiveness of engineering methods of various kinds,² and as “totally at variance with the presumed prediction of the risk homeostasis theory.”³ However, both comments would seem to be in error.

Japan’s fatal traffic accident rate per head of population is reported by Professor Koshi, at the University of Tokyo,⁴ to have been reduced by one-half in the period from 1970 to 1983. Part of this may have been due to the energy crisis and a slacking economy, which is known to be associated with a reduced accident toll, as we have seen in Section 5.4. In fact, the average rate of total unemployment (part-timers being considered as employed) virtually doubled from the ten-year period prior to the oil crisis in 1973, to the ten-year period following the crisis.

Moreover, Japanese authorities have taken a number of deliberate measures that might well have had a major reducing effect upon the target level of risk in the actual and potential driving population. Here are some observations in Prof. Koshi’s publication:

“The Japan Safe Driving Centre issues driving record certificates at the request of employers. Driving licensing tests in Japan may be the most difficult in the world. It normally takes one month of time and 1000 US dollars for driving and classroom lessons to pass the test. High school students are not allowed to have a driver’s licence or to own a motor vehicle, including

¹Wilde, G.J.S. (1981). A critical view of countermeasure development and evaluation. In D.L. Goldberg (Ed.), *Alcohol, drugs and traffic safety*. Stockholm: Almqvist, pp. 1145-1159.

²Mackay, M. (1985). Comment in L. Evans and R.C. Schwing (Eds.), *Human behavior and traffic safety*. New York: Plenum, pp. 39.

³Evans, L. (1986). Risk homeostasis theory and traffic accident data. *Risk Analysis*, 6, 81-94, p. 84.

⁴Koshi, M. (1985). Road safety measures in Japan. In L. Evans and R.C. Schwing (Eds.), *Human behavior and traffic safety*. New York: Plenum, pp. 27-41.

motorcycles and mopeds. Accident data [are] filed with the police and regarded as one type of crime data. Government employees and private company employees can be fired without retirement benefits if a fatal or a serious accident is caused while under the influence of alcohol. One speeding violation over 25 km/h over the posted speed will result in a licence suspension for 30 days. In 1983 one out of every 27 drivers had his licence suspended or cancelled and one out of every 3.7 licence holders in Japan was subject to an enforcement action. Enforcement activity, in terms of citations, has been increased from about 5 million in 1970 to about 13 million in 1983”.

To an external observer, these measures would seem draconian enough to reduce people's appetite for driving in general, and for driving in a risky manner in particular. Although it may not be possible to determine to what quantitative extent the level of target risk has been reduced by the various factors above, it would seem that the accident toll can be drastically reduced by severely punitive legislative and enforcement measures, provided that such measures are sustained over time, and further helped along by a weakening economy.

Thus, there would seem to be no justification for interpreting the Japanese experience as “totally at variance with risk homeostasis theory.” On the contrary, the suggestion that it is compatible with RHT appears to be supported by some additional calculations on the data published by Koshi. The death rate per billion km driven (motorcycle and moped kilometrage being excluded) fell on average by 11% per year between 1966 and 1982, while the motorized kilometrage rose by an average of 8% from year to year in that same period.¹ The product-moment correlation between the two annual rates amounts to $r = -0.97$. In other words, those years that were marked by relatively large decreases in the death rate per km, were also marked by relatively large increases in kilometrage per capita. This pattern of findings, which can also be observed in American, British, and Canadian data,² seems to agree surprisingly well with the longitudinal deduction from risk homeostasis theory: within a country there is an inverse relationship between the changes from year to year in the accident rate per km driven and the changes in the motorized kilometrage per head of population (see Table 5.1 and Section 5.2).

¹Wilde, G.J.S. (1988). Risk homeostasis theory and traffic accidents: propositions, deductions and discussion of dissension in recent reactions. *Ergonomics*, 31, 441-468.

²Wilde, G.J.S. (1982). Critical issues in risk homeostasis theory. *Risk Analysis*, 2, 249-258.

*We appeal to the data of laboratory experiments
in much the same way that learned men,
centuries ago, appealed to the authority
of Aristotle or of Thomas Aquinas.*
Alphonse Chapanis¹

9 Risk homeostasis in the laboratory

Not all of the empirical evidence we have discussed so far in support of RHT speaks with perfect clarity. Government statistics such as those mentioned in Chapter 5 suffer from incompleteness, especially with respect to non-fatal accidents. Many of the data quoted were not originally collected with a view to testing RHT and, as a result, may not contain sufficient information to permit a firm decision about the theory. A particular shortcoming of the available evidence is that, with few exceptions, little or no indication is provided about the pathway of behavioural adaptation to changed physical, educational, or legal conditions. Inevitably, some studies suffered from methodological problems.

There are no conceptual problems in designing a real-life experiment that would test RHT under well-controlled conditions, but there are ethical and practical limitations to the deliberate creation of new conditions in which theoretical expectations could be verified. This is particularly true for the behavioural sciences. For instance, hypotheses about the heritability of individual differences in intelligence or personality traits could be settled compellingly if selective breeding of humans in controlled environments were as practicable and ethically acceptable as are current experiments with animals. Like heritability in humans, risk homeostasis may be difficult to test, but *not* because of inherent fuzziness in the theory.

An unrestrained experimenter, for instance, might develop a simple design as follows. Several different geographical areas are selected and treatments randomly assigned. In Area A, a novel non-motivational intervention is implemented, for instance, in the form of physical changes to the roads. These changes are implemented following mass-media publicity effectively announcing the changes as a major safety benefit. In Area B, the same physical modifications are carried out, but these are announced as a minor safety advantage. Areas C and D receive the same physical treatment of the road conditions, but these are announced as a major and a minor *threat* to safety, respectively. This design allows the following expectations to be specified: In Area A there will be a greater upward change in accidents than in Area B. Area C will see a greater downward change than Area D. In all areas the accident rates will, after some time, return to previous rates. Public opinion data may be collected to check how long the intended perceptions of the safety or riskiness of the interventions lasted, and roadside observation may be used to monitor behavioural adaptation.

¹Chapanis, A. (1967). The relevance of laboratory studies to practical situations. *Ergonomics*, 10, 557-577.

Ironically, we actually do many of these things, for example, mandating seatbelt wearing in Area A and equipping cars with daytime running lights in Area B. We order a change from left-hand to right-hand traffic in Area C and remove subsidies to driver education in high schools in Area D. We do all these things as politicians, administrators, safety advocates, or legislators, but not as researchers who would be better equipped to collect evaluation data in a scientifically sound manner. And, of course, researchers might not even obtain ethics approval for some of these interventions because of the hazards involved.

There can be no question that experimentation in the laboratory—that oracle of modernity—offers easier opportunities for including comparison groups, for control over independent variables, and for more precise assessment of the dependent ones. However, laboratory experimentation introduces its own limitations to the unambiguous interpretation of findings. What follows is what a prominent ergonomist had to say on this topic:¹

“First, of all the possible independent variables that influence behaviour in any practical situation, a laboratory experiment selects only a few for test. As a result, hidden or unsuspected interactions in real life may easily nullify, or even reverse, conclusions arrived at in the laboratory. Second, variables always change when they are brought into the laboratory. Third, the effect of controlling extraneous or irrelevant variables in the laboratory is to increase the precision of the experiment, but at the risk of discovering effects so small that they are of no practical importance. Fourth, the dependent variables (or criteria) used in laboratory experiments are variables of convenience. Rarely are they selected for their relevance to some practical situation. Last, the methods used to present variables in the laboratory are sometimes artificial and unrealistic. The safest and most honest conclusion to draw from all these considerations is that one should generalize with extreme caution from the results of laboratory experiments to the solution of practical problems. [emphasis added]”

Adding further strength to this conclusion is the fact that the experimenter must make use of volunteers to make the proposed experiment pass standards of ethical acceptability. Volunteers enter the experiment with their own motivations, expectations, and perceptions. They may respond as they believe the experimenter would like them to, or do the opposite, or be indifferent about their behaviour. People volunteering in experiments have been found to be different from non-volunteers in that they are more often female, younger, higher in intelligence and need for social approval, less conventional, and they have fewer rightist political beliefs.²

Add to this, too, that in the laboratory, volunteers are sometimes exposed to conditions that they would not likely expose themselves to of their own accord—

¹Chapanis, A. (1967). The relevance of laboratory studies to practical situations. *Ergonomics*, 10, 557-577.

²Rosenthal, R. (1975). *The volunteer subject*. New York: Wiley.

especially in real-life situations and in the absence of the protection, or pressure, provided by the experimenter (for example, drinking to a high blood alcohol concentration).

Moreover, the special case of experimentation in the domain of risk taking must be considered. Risk, by definition, cannot be simulated. This is because two main purposes of simulation, and laboratory experimentation in general, are more control afforded to the experimenter and less risk occurring to the participants. Thus, to the extent that some factor under investigation is expected to influence the perception or acceptance of risk as dependent variables, and to the extent that simulation is successful in eliminating risk from the experimental condition, simulation must be judged to be an inappropriate environment for the testing of the effects of that factor upon these dependent variables. In other words, “simulation of risk” is a contradiction on a par with “re-creation of an original.” Consequently, if risk-taking behaviour is to be studied in the laboratory, risk has to be brought into the laboratory.

Further, it should be noted that RHT is a set of interrelated hypotheses developed to explain the accident rate of large numbers (often millions) of socially-interacting road users over a considerable length of time. Breakdown of control causes some people to have accidents. These accidents subsequently serve as danger signals to others and help the majority to avoid them. In contrast, laboratory experiments usually involve relatively small numbers of participants who participate solo, or an even smaller number of small groups of participants if participants are allowed to interact. The time frame in laboratory experiments is usually limited to a few hours at the most.

In the face of the many potential difficulties, it may seem ridiculous to attempt to create laboratory conditions for the purpose of adding support to RHT.^{1,2} One is reminded of the story about the student who entered the research laboratory one night to find his much-respected professor searching for something in all corners of the lab. When asked what he was looking for, the professor announced that he had lost his gloves in the park. “But, professor,” the student asks, “why don’t you look for your gloves in the park?” Came the somewhat miffed reply: “You know, young man, in the park it’s dark. Here there’s light.”

Any risk of ridicule would have been zero had my students and I decided not to go ahead with these experiments. But we would also have missed out on the pleasure this experimentation provided to the numerous student-experimenters in undergraduate and graduate education, as well as many of the participating subjects. Witness the fact that some came back for more, and others spontaneously asked if they could participate. We also think we learned something.

There is no human behaviour that has total certainty of outcome. Any act, because of limitations of skill and other deficiencies in control, may or may not be

¹Wilde, G.J.S., Claxton-Oldfield, S.P. and Platenius, P.H. (1985). Risk homeostasis in an experimental context. In L. Evans and R.C. Schwing (Eds.), *Human behavior and traffic safety*. New York: Plenum Press, pp. 119-142.

²Trimpop, R.M. (1994). *The psychology of risk-taking behaviour*. Amsterdam: North-Holland.

accomplished in accordance with the intent. And the consequences of the act, even when executed in full accordance with the intent, may be different from what was expected. Because of this dual source of uncertainty, any human act may be labelled as an act of risk taking.

To illustrate with a few examples: A young musician aspires to rendering an impressive performance of Beethoven's piano sonatas. She has set her own performance target in terms of pace, timbre, loudness, and melodic expression. She can't be sure if she will perform to her targets. In addition, she can't be certain of the reactions of the audience and the music reviewers. Will they find her rendition too slow or too fast, too harsh or too mellow, too loud or too soft, too romantic or too stark, or just right in each of these dimensions? Similarly, a driver may be uncertain whether he can control his vehicle at a given speed through a particular curve on wet pavement. In addition, if he loses control, he doesn't know how serious the effects will be, whether he might be killed or injured, or walk away without a scratch. To contrast these two sources of risk, the first may be called "uncertainty of performance" and the second "uncertainty of consequence."

Obviously, then, all behaviour is risk-taking behaviour, regardless of whether this is consciously realized by the acting person or not. It is obvious, too, that the challenge of life is not to eliminate risks. "Zero risk" is not a meaningful option, since it can only exist in the absence of behaviour—after death, in other words. Instead, the challenge to the individual is to optimize the level of risk taking in such a way that the overall expected benefits accruing to that person are maximal. This was discussed above, in Chapter 4, and illustrated in Figure 4.2. Note that there is nothing in this description that excludes other forms of risk taking, that is, other than incurring risk to one's health and safety, from the potential operation of the principles of risk homeostasis. Other risks are those of social disapproval, financial risk in investment, failing an examination, risk of damage to property, etc. An interesting case of risk and protective behaviour is what people do in the face of the threat of attack by a computer virus. One study found that, consistent with risk homeostasis theory, as the perceptions of threat of the Michelangelo virus changed over time, so did the protective behaviours with the effect that personally experienced risk remained unchanged.¹

The challenge to psychology is not to determine whether a person is a risk-taker or not, because all individuals are risk-takers at all times, but to determine whether a person takes too much risk, too little, or exactly the right amount of risk for the maximal satisfaction of his or her goals. Another challenge to psychology is to provide people with the means to optimize their risk taking.

Consider a driver's behaviour on a highway. Driving faster than the average driver, following more closely, listening to the radio or a passenger, or having one's attention distracted from the driving task may be associated with a greater likelihood and/or severity of an accident. These behaviours may also be associated with

¹Sawyer, J.E., Kernan, M.C., Conlon, D.E. and Garland, H. (1999). Responses to the Michelangelo computer virus threat: The role of information sources and risk homeostasis theory. *Journal of Applied Social Psychology*, 29, 23-51.

increased gasoline consumption and the chances of being charged with a traffic violation. Thus, the sum total of the expected losses would increase. At the same time, however, the driver who engages in these behaviours may expect the benefit of a shorter travelling time and less boredom during the trip. Surely, at zero speed there is zero traffic accident risk. But zero speed also means zero mobility. Therefore, the challenge to any driver who wishes more than zero mobility is to choose an amount of mobility and a manner of driving such that the net benefit of his or her exposure to risk is likely to maximize. That level is at the location of the arrow in Figure 4.2 in Chapter 4.

For the purpose of risk assessment, the interpretation of observational data can be a problem. For instance, a driver who typically drives faster than other drivers is not necessarily at greater-than-average accident risk, if he or she is more skilful in accident avoidance than the average driver. To estimate such a driver's accident likelihood, an independent measure of skill would be needed. It would take further work to establish whether this driver—even if the level of risk taken by her or him were greater than average—took more than optimal accident risk.

To sum up: what we need is a laboratory task that allows separate identification of a person's skill and degree of risk taking. It should be possible to determine whether this person takes too much or too little risk, or just the right amount to maximize net benefit. The task should be difficult enough that the person experiences a considerable degree of performance uncertainty. Some responses should have outcomes that provide for uncertainty of consequence. Some outcomes should be pleasant, so that the person will be motivated to perform the task. Some potential outcomes should be unpleasant, so that the task will be experienced as one of risk taking. Risk taking is defined here as making responses with a given likelihood of unpleasant consequences, this likelihood being determined by the experimenter and communicated to the subject. Finally, unpleasant consequences should be sufficiently unpleasant that the participants will prefer to avoid them, yet innocuous enough to be practical and ethically acceptable.

Below we describe some of the different, but conceptually related, “computer games” that were developed in view of the above considerations.¹ For the sake of convenience, the techniques have been labelled with nicknames like “Brinkmanship” and “Guessmanship.” Subjects' participation was always rewarded, either with money earned in return for points scored, or with social recognition in the form of public posting of the names of the players in the order of their performance.²

In some cases, people competed for money prizes and only the best three players would win. In others, the participants paid the experimenter a fee for the privilege of playing. In this case, instead of compensating the experimenters for their efforts, the

¹Wilde, G.J.S. (1988) Risk taking in psychomotor and cognitive tasks as a function of probability of loss, skill and other person-related variables. In J.A. Rothengatter and R. de Bruin (Eds.), *Road user behaviour: Theory and research*. Wolfeboro, New Hampshire: Van Gorcum, pp. 120-132.

²Wilde, G.J.S. (1994). New techniques for determining subjects' risk-taking tendency in their task performance. In R.M. Trimpop and G.J.S. Wilde (Eds.), *Challenges to accident prevention: The issue of risk compensation behaviour*. Groningen, the Netherlands: Styx Publications.

monies were added to the prizes awarded for the best competitive performance and thus ultimately returned to the participants, that is, to some of them.¹ Not surprisingly, it was not uncommon for people to spontaneously request participation in the experiments. Thus, the experimenters had reasons to believe that the subjects were usually keenly interested in their own behaviour during the experiments and tried to perform as well as they could. This may be an important benefit of this manner of subject recruitment.

9.1 *Brinkmanship*

Imagine you are sitting in front of a computer screen. Your task is to cancel a 3 x 3 cm bright square at the right point in time, by pressing any key on the keyboard. The square lights up in the centre of the monitor, and stays on until you cancel it. It lights up again at unpredictable time intervals that vary between 700 and 1500 milliseconds (ms). You are to cancel the square at a point in time as close as possible to 1500ms (1.5 seconds) after its appearance.

This is difficult, because you cannot tell exactly when 1500ms have lapsed. A response at 1500ms is rewarded with the maximum number of points. Slower responses earn proportionally fewer points; at 3000ms and beyond, the pay-off is zero. However, responses faster than 1500ms, called “undershoots,” may be followed by a penalty that occurs by chance. These penalties occur in a predetermined proportion of the undershoots, for example, in 20%, 50% or 80% of the cases. Before you begin, you have been told what their probability is. The probability changes after separate sets of usually 25 to 100 trials each. Non-penalized responses at 1499ms or faster yield zero points for the trial in question. The computer assures accuracy at 1ms.

Before the experiment begins, you are allowed a number of trial attempts to get used to the situation and to practise the task without pay-off. Each trial is followed by feedback about the trial number, the actual response time on that trial, the average stray from 1500ms on all preceding trials, plus the accumulated numbers of overshoots and undershoots.

During the experimental trials (with pay-off), each separate response is followed by feedback, to which the number of points gained or lost on the trial is added, as well as accumulated net points earned up to that trial. Furthermore, the computer’s loudspeaker produces a single beep for undershoots that are not penalized and a double beep for those that are.

This task may be viewed as an experimental analogue of the notion of “brinkmanship,” that is, the more you dare, the more you gain—unless you dare too

¹Wilde, G.J.S., Trimpop, R.M. and Joly, R. (1989). The effects of various amounts of ethanol upon risk-taking tendency and confidence in task performance. *Proceedings, 11th International Conference on Alcohol, Drugs and Traffic Safety*. Chicago, Illinois, Oct. 24-27, pp. 494-499.

much. You must balance the desire to gain points against the fear of losing points, and try to optimize your mean response time accordingly.

Obviously, the number of game points you earn depends on your response-timing skill, the precision of your “mental clock.” Note, however, that responding as fast as you can is not the object of the game. If you do so, you will make risky responses only and collect no points. Obviously, too, the number of points you earn depends on your risk-taking tendency. If you shy away from the “brink” too much, you may never incur a penalty, but your gains will be small. If, on the other hand, you make too many undershoots, you may well collect a great number of points on some trials, but you will also incur many penalties.

Response-timing skill can be measured in a variety of ways. One is the average stray around 1500ms during the warm-up trials; another is the average stray around the participant’s own mean response time during the trials with pay-off. The lower the degree of stray (also called the average deviation), the better the skill.

Assisted by computer, the mean response time at which the participant’s point earnings would be maximized is determined for each participant, while leaving the dispersion (the stray) of the participant’s response distribution intact. This is called the participant’s *optimal mean response time*. It is calculated as follows:

First, the computer adds 1 millisecond to the response time in each trial and calculates what the net earnings would have been across all trials. Then it adds 2ms to each actual response time, calculates what the net earnings would have been, then adds 3ms, and so on, up to 300ms. It also subtracts values between 1 and 300ms, one at the time, from each actual response time. This is an ideal job for a computer; people would find it much too tedious a task. The mean response time at which the participant would have earned the highest value of potential net point earnings is the optimal mean response time for that participant. By comparing the optimal mean response time of a participant with his or her actual mean response time, we can derive a quantitative measure of risk taking.

The *optimal* mean response time minus *actual* mean response time is called “deviation from optimality,” or DFO for short. We can use the DFO to identify three types of risk taking. A positive DFO indicates that the participant, on average, responded too fast to maximize net earnings and by how much. This person is called “risk-loving” or “risk-seeking,” because he or she sacrifices points by being too daring and erring on the risky side. “Risk-neutrality” or “risk-optimality” is reflected in a DFO = 0 result, since the player does not increase or diminish the amount of risk beyond the amount of risk-taking that is optimal. Finally, “risk-averse” or “risk-avoiding” participants show negative DFOs; they lose points by being too cautious and erring on the safe side of the brink. Note that, in order to maximize net benefit, a person has to take more than zero risk and that the right degree of “brinkmanship” produces the greatest net gain.

How can this task be used to test risk homeostasis theory? The following nine points elaborate on this question:

1. You would expect that, if the likelihood of a penalty for a risky response is high, players will shy away from the brink and their average response time will be greater than when the probability of a penalty is low. This is what is found.

2. You would expect that, if the penalty for risky responding is made more severe while the likelihood of penalty remains the same, people will respond more slowly and the average response time will be greater. This is indeed what is found.

3. You would expect that, when a person on a given trial happens to be penalized for making a risky response, that person's response on the next trial will be more cautious. In Section 4.7 we wrote, "on the individual level, an increase in caution is likely to occur after a close call or after one hears of somebody else's accident. Similarly, a reduction in caution is likely to occur when all goes well for some period of time." Rephrased in the terms of the computer game, this is indeed what is found.

4. You would expect that the measure of risk-taking tendency (DFO) would not be altered by increases or decreases in the probability of the penalty for making risky responses. The actual mean response time would be expected to change (this was our first expectation above) and so would, of course, the optimal mean response time, but not the difference between the two (DFO). This is indeed what is found.

5. When participants in the game are told that their game points will be doubled if they manage to play the game without incurring a single penalty, you would expect that they will play it much safer, make fewer risky responses and increase their average response time. This is indeed what is found.

6. You would expect skill and risk-taking tendency to be independent, because there seem to be no grounds for suspecting that skilful players should be more or less risk-inclined than less skilful ones. The highly skilled graduates of the Safe Performance Curriculum in DeKalb county in Georgia had more accidents (see Section 6.2) but one does not expect this sort of thing to be the rule. In only a few of the many samples of participants, the less skilful players were found to be more risk-loving. Maybe they felt that taking chances was the only way to potentially obtain the prize for the best players. At any rate, these cases are an exception: skill and risk taking were found to be independent of each other in the majority of samples.

7. You would expect that, with experience, players would gain in response-timing skill. This was investigated by comparing the amount of dispersion of their responses in a series of blocks of trials. Not surprisingly, this is what is found. The next expectation is less trivial.

8. You would expect that players would become more competent risk-takers over time. They should try to optimize the level of risk they take, not minimize it, let alone maximize it. Risk-avoiders, that is, the ones with negative DFOs, and risk-seekers alike should become better able to optimize their level

of risk taking. In other words, DFOs should, on average, come closer and closer to zero as players gain more experience. This is what is found.

9. Does the probability of loss, as controlled by the experimenter and communicated to the player, affect the average amount of game points earned by the player? You would expect that the player would shy away more from making risky responses if the likelihood is high that these will be punished. Average response times should thus be longer. Once again, this is what happened (see the first expectation above). The gains per response should be lower and, therefore, the average amount of game points earned should be lower, too, and this is what is found. A trivial finding? Yes and no: trivial, because the finding contains so little surprise; not trivial, because it corresponds to the fact that, when the accident risk per km driven is high, people will drive fewer kilometres against the same risk of accident per person, and thus their *overall benefit*—here represented as game points—will be lower than when the accident risk per km driven is high.

9.2 *Are you taking too much risk or too little, and how can you tell?*

Some of the above findings were obtained with different versions of the various computer games in our laboratory. Brinkmanship can also be played with knowledge items such as:

- If the population of London in 1950 is set at 100, what was its population in 1980?
- How many kilometres long is the Suez Canal?
- If the population density of the Netherlands in 1987 is set at 100, what was the population density of India at the same time?
- How many symphonies did Haydn compose?
- How many calories are there in 500 grams of butter?

Questions are chosen such that few people would be expected to know the precise answer, but that many would be able and willing to make a guess. The closer the answer comes to the truth (expressed, for example, as a percentage of the actual figure), the more points participants gain. If, however, the answer given is higher than the correct answer, a die is thrown or a coin is tossed to determine whether a penalty will be applied or not. Once again, the higher your estimate, the more you gain, unless your estimate is too high.

In yet another version, the participant is shown sheets of paper with a vertical line on each. Below the line is a dot and the subject is asked to draw (starting at the dot) a horizontal line of the same length as the vertical. Again, the participant is told, “the closer you come to the truth, the more points you make, but you run the risk of a penalty if your line is longer than the vertical.” Other samples of Brinkmanship items are presented in Figure 9.1.

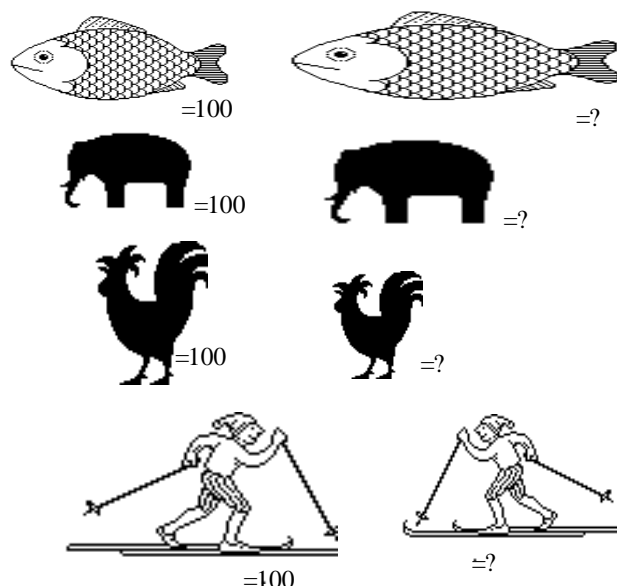


Figure 9.1: Samples of Brinkmanship items. The surface area of the figure on the left equals 100. What is the surface area of the figure on the right?

The principle of Brinkmanship can be applied to all kinds of skilful performance, on the computer and elsewhere, but unless a computer is used, the calculation of DFO and other variables may be a problem.

This is also true for a game that we called “Narrow Escape.” This is another technique that is aimed at simultaneously eliciting in the player the conflicting drives of “fear” and “greed,” i.e., the anxiety about losing points and the desire for gaining them. Questions take the following form: “How many millions of people live in Hungary?,” “How many times is New York City bigger than Miami?” In addition to giving a point estimate (for instance, “ten,” “twelve” or “twenty,” only whole numbers being allowed), the player is asked to indicate an “uncertainty band,” for example, “plus or minus three,” “plus or minus five.”

Points are earned only if the correct answer lies within the uncertainty band—within the safety margins, that is—while the number of points earned on any question is greater to the extent the safety margin is narrower. In one version of this technique, the number of points earned is simply the complement of the safety margin, the sum of the safety margin and the number of points earned always amounting to ten. Thus, if the player chooses a safety margin of “plus or minus three” *and* the correct answer lies within the uncertainty band, seven points will be awarded. Had the player chosen a safety margin of “plus or minus eight,” two points would have been awarded. The largest safety margin the player is allowed is plus or minus nine, the smallest is zero. If the correct answer is outside the uncertainty band, the player does not lose or gain any points whatsoever.

Consequently, participants can reduce their fear of not earning any points by widening the safety margin. On the other hand, in order to satisfy the desire to make a large number of points, the margin must be made narrow—and the correct answer must still lie between the point estimate plus or minus the safety margin. We called this game “Narrow Escape” because the art of playing well is to escape with the truth, but as narrowly as possible.

A computer program determines from the participant’s responses whether, and to what extent, the chosen margins should on average have been wider or narrower for the net number of points to have been maximized. The operation of this program is analogous to the calculation of the deviation from optimality (DFO) as described above. Risk aversion (underconfidence) is reflected in choosing safety margins that are too wide, while risk seeking (overconfidence) is manifested in safety margins that are too narrow for net points to be maximal. Risk optimization is in evidence if the player’s net points earned equal the potential maximum, that is, when the player could not have increased net points earned, either by narrowing or by widening the chosen safety margins by a constant across the questions.

If you wish to explore your own risk-taking tendency or that of your friends or family members, you need an approach that makes it unnecessary to use special computer programs for the calculation of the deviation from optimality. All you need for the next game is to consult two tables (provided here) and use a bit of simple arithmetic. The game is called “Guessmanship,” because the art of playing well is the art of smart guessing in the face of uncertainty. Only yes-or-no answers are allowed. The participant answers a set of, say, 100 questions of the following type:

- Is the Danube longer than the Rhine?
- Is Budapest closer to Prague than to Vienna?
- Did Mozart die at a younger age than Schubert?
- Did electric coffee grinders exist before World War II?
- Is the earth’s north-south axis longer than its east-west axis?

If the player responds by a correct “no,” sure points are earned. If the player responds by an incorrect “no,” no points are earned or lost. If the player responds by a correct “yes,” sure points are earned. If, however, the player responds with an incorrect “yes,” a penalty is applied based on chance (that is, in some cases, but not in all). Therefore, a “no” answer is safe; if correct, points are gained, and if wrong, no points are lost. A “yes” answer is risky; if correct, points are earned, but if wrong, points may be lost. A player who always answers “no” never loses any points but does not gain any on questions where the right answer is “yes.” It follows that avoiding “yes” responses altogether is not necessarily in the player’s best interest.

Obviously, then, how many points a player will obtain does not only depend on the player’s knowledge, but also on strategic skill as to what to do when uncertain: to say “yes” or to say “no.” Two people of equal knowledge, therefore, do not necessarily obtain the same game score. It is possible for a more knowledgeable

person to get a lower game score than a less knowledgeable competitor, because the latter has a better risk-taking strategy.

To obtain a measure of risk-taking strategy, first make sure that in one-half of all the questions, the correct answer is “yes,” and tell the players so, because that simplifies matters. Then assign score points, and tell the players what they are, for instance, as follows:

- A correct “yes” earns 5 points,
- A correct “no” earns 5 points,
- An incorrect “no” answer is given zero points,
- An incorrect “yes” answer is followed by the player tossing a coin. If

heads shows up, the player loses 5 points; if tails, zero points are given.

For the calculation of the player’s level of knowledge and risk-taking tendency, please refer to Tables 9.1 and 9.2. These use some statistics jargon, related to the normal “bell-shaped” curve, which does not need any further discussion here. Statistical jargon is strange indeed, as you yourself may have noticed. Statistics has its “normal deviates;” in the rest of the world, deviates are abnormal. Statistically “significant” does not mean important, sizable or meaningful, but merely that the likelihood that a particular finding had occurred by chance was very small, say, less than 1 in 100, or 5 in 100. To the uninitiated, the term “standard deviation,” as well as “normal deviate,” may sound like an oxymoron (like “thunderous silence,” “profound superficiality” or “civil war”), and there is nothing childish in “regression,” not even in multiple regression.

But, back to the calculations. The measure of skill or knowledge basically depends on the proportion of questions answered correctly, but it considers the two kinds of questions separately (those where the correct answer is “yes” and those where it is “no;” see Section A in Table 9.1).

Now for the measure of risk-taking tendency. This involves a quantitative comparison between the two types of errors that a person can make: the frequency of saying “no” when the correct answer was “yes,” relative to the frequency of saying “yes” when the correct answer was “no” (Steps 6 through 10 in Table 9.1). A cautious person will prefer to give a safe answer when in doubt, and thus the first type of error will be more frequent than the second. That much is obvious. But how safe is safe enough? What is the optimal level of safety? Or, stated differently, what is the *optimal* level of risk?

In Section 4.1 we argued that the optimal (or target) level of risk depends on the costs and benefits of safe and risky behaviour alternatives. In the Guessmanship game, costs are given in terms of points lost or gained for incorrect “no” and incorrect “yes” answers, while the benefits are given in terms of points gained for correct “no” and correct “yes” answers. Therefore, the optimal level of risk can easily be calculated (as is done in Steps 11 through 13 in Table 9.1) The only thing that remains to be done is to compare the person’s risk-taking tendency with the optimal risk-taking tendency (and this is done in Step 14). So, any individual who is seen to take

more than optimal risk in the Guessmanship game may be labelled as “risk-seeking.” When the amount of risk taken is less than optimal, we may label this as risk avoidance, and whenever the actual amount of risk taken is equal to the optimal amount, we have a case of risk optimization.

Table 9.1: Procedure for calculating an individual’s level of knowledge and degree of risk taking in the Guessmanship game.

A. THE SCORING OF KNOWLEDGE:

1. Determine the percentage of times the player responded “yes” to questions where the correct answer is “yes.”
2. Look up the “normal deviate” equivalent of this percentage.
3. Determine the percentage of times the player responded “no” to questions where the correct answer is “no.”
4. Look up the “normal deviate” equivalent of this percentage.
5. Add up the values obtained in Steps 2 and 4. This measure of knowledge will vary between a minimum of zero and a maximum of 4.6 or so.

B. THE SCORING OF RISK-TAKING TENDENCY:

6. Determine the percentage of cases in which the player said “no” in response to the questions where the correct answer is “yes.”
7. Look up the “ordinate” equivalent of this percentage.
8. Determine the percentage of cases in which the player said “yes” in response to the questions where the correct answer is “no.”
9. Look up the “ordinate” equivalent of this percentage.
10. Divide the value obtained in Step 7 by the value obtained in Step 9.
11. Add the points value of a correct “no” to the cost of an incorrect “yes.”
12. Add the points value of a correct “yes” to the cost of an incorrect “no.”
13. Divide the sum obtained in Step 11 by the sum obtained in Step 12.
14. Subtract the ratio obtained in Step 10 from the ratio obtained in Step 13. Risk-seeking tendency is reflected in positive differences, risk-avoidance in differences less than zero.

Table 9.2: Normal deviates and ordinates for percentages ranging from 99 down to 50; to be used in conjunction with Table 9.1. Note: for error percentages (p) smaller than 50, look up values for 100-p.

%	normal deviate	ordinate	%	normal deviate	ordinate	%	normal deviate	ordinate
99	2.326	0.027	82	0.915	0.263	65	0.385	0.371
98	2.054	0.048	81	0.878	0.272	64	0.358	0.374
97	1.881	0.068	80	0.842	0.280	63	0.332	0.378
96	1.751	0.086	79	0.806	0.288	62	0.305	0.381
95	1.645	0.103	78	0.772	0.296	61	0.279	0.384
94	1.555	0.119	77	0.739	0.304	60	0.253	0.386
93	1.467	0.134	76	0.706	0.311	59	0.228	0.389
92	1.405	0.149	75	0.674	0.318	58	0.202	0.391
91	1.341	0.162	74	0.643	0.325	57	0.176	0.393
90	1.282	0.176	73	0.613	0.331	56	0.151	0.394
89	1.227	0.188	72	0.583	0.337	55	0.126	0.396
88	1.175	0.200	71	0.553	0.342	54	0.100	0.397
87	1.126	0.212	70	0.524	0.348	53	0.075	0.398
86	1.080	0.223	69	0.496	0.353	52	0.050	0.398
85	1.036	0.233	68	0.468	0.358	51	0.025	0.399
84	0.994	0.243	67	0.440	0.362	50	0.000	0.399
83	0.954	0.253	66	0.412	0.367			

Note that the smallest value of the percentage column in Table 9.2 is 50. Any percentage smaller than 50 would indicate that the player's performance is worse than would be expected by chance. The implication is that this technique will only work for players who get at least half of the questions right, that is, at least half of both types of questions, the ones where the correct answer is "yes" as well as the ones where the correct answer is "no." The technique cannot be applied to people with "negative knowledge." It is useless also for people who get each and every question right; no ratio of the two types of errors can be calculated if the number of errors in one or both types of questions is nil. If the ratio of the number of questions where the correct answer is "no" to the number of questions where the correct answer is "yes" is different from one, the optimal error ratio as calculated above should be multiplied by that ratio (Table 9.1, Step 10). Intuitively, that is obvious: it would be wiser to say "no" to the extent that the chances are greater that one is dealing with a question where the correct answer is "no." The other terms in the calculation of the optimal error ratio are no less plausible: one should say "no" more often if the value of a correct "no" and/or the cost of an incorrect "yes" are greater, and if the value of a correct "yes" are smaller and/or the cost of an incorrect "no" are smaller.

The techniques described in this chapter may be useful for the purpose of experiencing risk and realizing that risk should be optimized, not minimized, to obtain maximum benefit. They may also serve empirical testing of specific hypotheses such

as the ones that are pertinent to risk homeostasis theory, as well as for the exploration of various other questions. What follows is a list of examples:

- Are individual differences in seeking or avoiding risk a reflection of a general trait across different situations and across different categories of potential loss such as physical injury, monetary loss, social disapproval?
- Is there a relationship between the experimental measures of risk-taking tendency and personality traits such as primary psychopathy, introversion-extraversion, sensation seeking, state or trait anxiety, self-control, high-risk personality as measured by self-report questionnaire, and unrealistic optimism?
- Is there a relationship between the experimental measures of risk taking and concern for road safety, and past or future accident and violation records?
- Are people who are more skilful in a given task generally more risk-averse or more risk-seeking in that task than those who are less skilful?
- Can people be taught to optimize their risk-taking strategy in a given task, and does this learning generalize to other tasks? This indeed seems to be the case.¹
- Do people take more risk when operating in teams rather than individually?
- Is there assortative mating or dating for risk taking in humans, that is, do risk-seekers tend to choose risk-seeking partners rather than risk-avoiding partners?
- What is the relationship between over/underconfidence and risk taking?
- Do the following factors influence risk-taking tendency: age, gender, socio-economic status, alcohol ingestion, fatigue, caffeine, exciting background music, distraction, or left-handedness?

Students and I have explored the above questions in the context of tens of student research projects involving some 2500 players/participants. Some of these were students themselves; others were taxi-drivers, prison inmates, shopping mall patrons, motorcycle enthusiasts. We will discuss some of the findings in the next chapter. To our satisfaction, we have found that people were usually quite motivated to apply themselves to the tasks described above, and keenly interested in their performance as well as in their standing comparative to others. We feel, therefore, that we are tapping behaviour of a relatively high level of ego-involvement, behaviour that is of interest to the participants themselves and, therefore, possibly to the study of human behaviour.

Instead of experiencing difficulties in recruiting sufficient numbers of indifferent or reluctant subjects, we have at times been approached by people who spontaneously volunteered their participation. Even when we demanded a few dollars from a person

¹Wilde, G.J.S., Gerszke, D. and Paulozza, L. (1998). Risk optimization training and transfer. *Transportation Research Part F*, 1, 77-93.

for the privilege of participating in our experiments, we experienced no major difficulty in attracting subjects.

Most of the tasks described above are highly portable. They can be performed in the lab, at home in the family room, in shopping centres, in pubs, on beaches, and other locations of the experimenter's imagination.

One major theoretical limitation should be pointed out. With the above methods, the degree of risk optimization by people can only be calculated against a specified criterion (such as monetary gain or social recognition), not against other criteria, for instance, the satisfaction of curiosity, maintaining comfortable psycho-physiological arousal, the psychomotor challenge of cancelling the stimulus as close as possible to 1500 ms after onset regardless of points gained or lost, the desire to finish the experiment quickly. It is conceivable, therefore, that a person is actually optimizing the degree of risk taking in his or her behaviour against the composite criterion of all of his or her goals, although the calculated deviation from optimality against the criterion of monetary gain, for instance, is substantially different from zero. We will not know whether the person is actually optimizing risk until we develop techniques that allow us to determine the extent of risk taking in behaviour aimed at the satisfaction of these additional motives and the degree of satisfaction obtained. So, it must be admitted that we cannot even obtain a truly complete measure of a person's risk taking in the laboratory, let alone in real life.

One striking consequence of this is that we cannot be sure whether the amount of risk taking that is reflected in a nation's traffic accident rate is too high, too low or optimal. Are we collectively taking too much risk or too little, and how can we tell? Until we find out, it would seem totally inappropriate to label death on the road as "useless death," as some have done.¹ Death on the road is saddening, shocking, regrettable, but to call it useless is paternalistic, arrogant, and insulting to the victims, their survivors and the population at risk.

¹Gerondeau, C. (1979). *La mort inutile*. Paris: Plon.

10 Individual differences

Several studies have tried to identify the relationship between individual differences in driver behaviour and the risk-taking measures derived from the Brinkmanship and Guessmanship tasks described in the preceding chapter. Such relationships were found to exist, but they are weak. Sometimes no statistically reliable relationship was found, but when it was, this went in the expected direction, meaning that people with the larger risk-seeking deviations from the optimum had incurred more demerit points in the past.² They reported more moving violations, and took more economic and social risks.³ The experimental measures of risk taking, however, showed no clear and convincing relationship to accident records.^{4,5}

10.1 Personality, attitude and lifestyle

In general, it has been found that correlations between personal characteristics and accident record, when they exist at all, are weak and often statistically unreliable. In other words, the likelihood that the observed association could have been due to mere chance was greater than 5 in 100. The weakness of association should not come as a surprise, for a variety of reasons that will be discussed below.

To begin with, consider the special case of relating the experimental risk-taking measures to accident records. The most salient feature of traffic accident risk is the risk of physical injury. In our games, the participants did incur a risk, but the risk usually consisted of not making any financial gain or losing out on an opportunity for acquiring social recognition. The expected strength of the relationship between the experimental outcomes and accident record would thus depend on the degree of consistency in people's risk-taking tendencies from one type of risk to another.

Some researchers have distinguished four types of risk: physical, financial, social, and ethical. Social risk is the risk of incurring social disapproval as a consequence of one's actions, and ethical risk refers to doing something one may feel guilty about afterwards. Positive association between the four types of risk has been observed, but

¹Tillmann, W.A. and Hobbs, G.E. (1949). The accident-prone automobile driver. *American Journal of Psychiatry*, 106, 321-331.

²Dickenson, R.A.V. (December, 1987). An experimental investigation of risk homeostasis theory. M.A. Thesis, Department of Psychology, Queen's University, Kingston, Ontario.

³Trimpop, R.M. (1994). The psychology of risk-taking behaviour. Amsterdam: North-Holland.

⁴Heino, A., van der Molen, H.H. and Wilde, G.J.S. (1992). *Risk-homeostatic processes in car-following behaviour: Individual differences in car-following and perceived risk*. Report VK 92-02, Traffic Research Centre, University of Groningen, the Netherlands, p. 31.

⁵Heino, A., van der Molen, H.H. and Wilde, G.J.S. (1996). Risk perception, risk taking, accident involvement and the need for stimulation. *Safety Science*, 22, 35-48.

the association is weak.¹ People who take more-than-average risk of one type do take more risk of another type, but only slightly more so.^{2,3} Risk-taking tendency and the ensuing accidents appear to highly domain-specific in the general population, and this also seems to be true for children; Canadian researchers found that children who took more risk in a gambling task did not take more physical risk in a situation involving the possibility of injury.⁴ No salient personality trait of all-pervasive risk seeking or risk avoidance across different situations has been identified. In other words, no *general* (transsituational) risk-taking personality trait emerges from the research studies. This is not surprising, for two reasons. First, if people's deviations from optimal risk taking were quite similar in all four types of risk taking, that would have been so obvious that we would have known it all along and it would no longer be a subject for research. Second, a general risk-taking trait would also be highly counterproductive to success in life, since it would mean that people who are less likely to be successful in obtaining satisfaction in one area would also be less likely to obtain satisfaction in another, other things being equal (including skill).

If there is one particular habit that is often believed to be associated with risk-taking personality traits, it must be gambling, especially pathological or compulsive gambling. In everyday language, "to gamble" is almost synonymous with "to take a risk." Yet, the many studies undertaken in order to identify the personality traits that might characterize these people have failed to indicate that gamblers are more-than-average risk takers in other aspects of life as well, and they do not systematically differ from non-gamblers in their personality traits. Even the trait of stimulation seeking—called "sensation seeking" by some—shows no consistent pattern. Some studies find gamblers higher than average on this trait, others lower. The same holds for extraversion.

Just as gambling is the proverbial form of risk taking, the sensation-seeking questionnaire⁵ has become a frequently-used instrument for the assessment of individual differences in risk-taking tendency.⁶ Maybe this is because the author of this questionnaire defines sensation seeking with specific reference to risk: "the need for varied, novel, and complex sensations and experiences and the willingness to take physical and social risks for the sake of such experiences." Maybe, too, the questionnaire does not quite measure up to the author's definition, because recent

¹Jackson, D.N., Hourany, L. and Vidmar, N.J. (1972). A four-dimensional interpretation of risk taking. *Journal of Personality*, 40, 483-501.

²Miller, P., Plant, M., and Duffy, J. (1995). Alcohol, tobacco, illicit drugs, and sex: An analysis of risky behaviors among young adults. *International Journal of the Addictions*, 30, 239-258.

³Salminen, S. and Heiskanen, M. (1997). Correlations between traffic, occupational, sports, and home accidents. *Accident Analysis and Prevention*, 29, 33-36.

⁴Morrongiello, B., Lasenby-Lessard, J. and Corbett, M. (2009). Children's risk taking in a gambling task and injury-risk situation: Evidence for domain specificity in risk decisions. *Personality and Individual Differences*, 46, 298-302..

⁵Zuckerman, M. (1983). *Sensation seeking: Beyond the optimal level of arousal*. Hillsdale, New Jersey: Lawrence Erlbaum, p.10.

⁶Jonah, B.A. (1997). Sensation seeking and risky driving: A review and synthesis of the literature. *Accident Analysis and Prevention*, 29, 651-665.

research evidence—including his own¹—seems to indicate that people who get high scores on this questionnaire feel that the personal risks involved in the risky activities they like are less severe than is true for the people who dislike those risky activities and obtain low scores. Similarly, Dutch drivers with high sensation-seeking scores were found to follow more closely to the car in front of them than drivers scoring low on the questionnaire. Their self-reports and physiological measures of arousal, however, indicated that the sensation seekers experienced about the same sensation of risk as those with low scores.² Thus, “the seeking of sensation” is largely reduced to “estimating that the risk is low.” Although sensation seekers have been reported to be more inclined to engage in apparently risky driving habits like speeding, drinking and driving, and to run up a record of moving violations,³ various studies found no relation between sensation-seeking scores and traffic accident history.^{4,5} In one study, high sensation seeking was found to be associated with more traffic accidents in the early stages of a driver’s career, but with fewer at a later date, while there was no difference in accident involvement between sensation seekers and sensation avoiders across the total duration of driving experience.⁶ Skiers with high sensation-seeking scores have been found to have significantly *fewer* skiing accidents than sensation avoiders.⁷

A comprehensive review of the literature on the relationship between the habit of gambling and any personality traits of habitual gamblers has this to say: “What little agreement exists suggests a difference in locus of control, with high-frequency gamblers being more external than low-frequency gamblers. However, if such a relationship is a reality, then it is just as likely that the gambling causes the trait as that the trait causes the gambling.”⁸ For the meaning of “locus of control,” see Section 10.3 below. If a habit as risk-riddled as gambling has not been found to be strongly related to personality traits that one associates with a positive inclination toward risk taking, there would seem little hope for finding any marked relationships between accident involvement and personality.

Yet, numerous studies have been conducted in hopes of identifying individual characteristics that are related to accident history. Some have met with a degree of

¹Horvath, P. and Zuckerman, M. (1993). Sensation seeking, risk appraisal and risky behavior. *Personality and Individual Differences*, 14, 41-52.

²Heino, A., van der Molen, H.H. and Wilde, G.J.S. (1992). *Risk-homeostatic processes in car-following behaviour: Individual differences in car-following and perceived risk*. Report VK 92-02, Traffic Research Centre, University of Groningen, the Netherlands, p. 31.

³Trimpop, R.M. (1994). *The psychology of risk-taking behaviour*. Amsterdam: North-Holland.

⁴Burns, P.C. (June, 1992). *Risk taking in male drivers: Relationships among personality, experimental measures, observational data and driver records*. M.A. Thesis, Department of Psychology, Queen’s University, Kingston, Ontario.

⁵Clement, R. and Jonah, B.A. (1984). Field dependence, sensation seeking and driving behaviour. *Personality and Individual Differences*, 5, 87-93.

⁶Heino, A., van der Molen, H.H. and Wilde, G.J.S. (1996). Risk perception, risk taking, accident involvement and the need for stimulation. *Safety Science*, 22, 35-48.

⁷Bouter, L.M., Knipschild, P.G., Feij, J.A. and Volovics, A. (1988). Sensation seeking and injury risk in downhill skiing. *Personality and Individual Differences*, 9, 667-673.

⁸Walker, M.B. (1992). *The psychology of gambling*. Oxford: Pergamon Press, p.100.

success, although it is not uncommon for significant findings in one study to find either no support or even contradictory results in another. Greater accident involvement has sometimes been found for introverts and, in other investigations, for extraverts. Similarly, sensation seekers were sometimes found to have had more accidents, and sometimes sensation avoiders were found to have more. Greater accident involvement has been found for people who tend to attribute the occurrence of important events in their lives to fate or chance rather than to their own doing. The same holds for impulsivity, easy-goingness and low self-control.

Some studies find more accident involvement in people with what is called a “field-dependent perceptual style.” But a larger number of investigations found no relationship. This is also true of reaction time, or quick reflexes, and accidents. As noted in Chapter 1, field dependence characterizes people who do not have an analytical style in the way they look at the world that surrounds them, and are more likely to fall victim to erroneous syllogisms. Perhaps not surprisingly, differences in intelligence have not been found to be related to accident history.

Individual differences in attitudes, however, *have* been found to be related to involvement in past as well as future accidents: drivers with less aggressive, less macho, less authoritarian, and more socially-oriented values show safer driving careers. The same holds for people with a history of better school marks for citizenship (diligence and proper behaviour as rated by their school teachers) and stable employment histories. Some of these studies found biographical characteristics, including increased incidence of criminal records, more strongly associated with accidents than personality variables were.¹

Contrary to what may seem to be suggested here, crash rate has not invariably been found to be associated with traits that are generally considered to be socially undesirable by mainstream society. For instance, accident-involved bus drivers in the USA and in India were found to more frequently display a Type A personality.² This label refers to people marked by a patent display of energy, competitiveness, alertness, ambition, and a view that action is urgent because time is short. However, a subsequent study of the same kind of drivers, conducted in Britain, did not find them to be more often involved in accidents, although they more often reported fast driving.³ To sum up this paragraph: weak, inconsistent, and contradictory findings galore!

¹Lester, J. (1991). *Individual differences in accident liability: A review of the literature*. Research Report 306. Transport and Road Research Laboratory, Crowthorne, Berkshire UK.

²Evans, G.W., Palsane, M.N. and Carrere, S. (1987). Type A behaviour and occupational stress: A cross-cultural study of blue-collar workers. *Journal of Personality and Social Psychology*, 52, 1002-1007.

³West, R., Elander, J. and French, D. (1993). Mild social deviance, Type “A” behaviour pattern and decision-making style as predictors of self-reported driving style and traffic accident risk. *British Journal of Psychology*, 84, 207-219.

10.2 *The unreliability of accident liability*

Even if there were such a thing as a general risk-taking trait, there is a further reason for the weakness of association between a personality trait such as this, or any other personality trait, and accidents. This is because the tendency to have accidents is not a stable human characteristic. Test-retest reliability is very low. No variable can correlate better with some criterion than the reliability of that criterion, that is, the correlation of that criterion with itself.

The facts contradict the notion that most accidents are due to a small minority of people with dangerous, anti-social personalities. To think so, however, seems very tempting. After all, about one-half of all whisky is being drunk by no more than some 5% of all consumers; 100% of all murders are committed by a very small number of people; 100% of all venereal disease is carried by a small proportion of people. Almost 100% of all pianos in a country are found in a small percentage of homes. Moreover, there is evidence that 100% of all automobile accidents in a given year are incurred by less than 10% of all drivers. So, why should the bulk of accidents not be due to a small minority of people?

However, the evidence is clear that this is *not the same minority* every year. Consider some findings of a study conducted in North Carolina in the USA.¹ Of all drivers who had two accidents in two consecutive years, 87% did not have a traffic accident in the third year. The 13% who were involved in accidents in the third year accounted for 1.6% of all accidents in that year. It is clear what this means. Although it is true that their accident rate in the third year was about twice that of the average driver, an action even as drastic as deporting drivers with accidents in two consecutive years (or any other action that effectively eliminates them from the roads) would reduce the total accident rate in the third year by no more than 1.6%. Obviously, this offers no justification for the assumption that the accident rate can be reduced substantially by preventing those who have had accidents from further driving.

In passing, we may note that there is also precious little in these North Carolina data to support the beliefs of those who think that cracking down on violators of traffic laws might bring about a major reduction in the accident rate: "If you took all drivers with three or more violations in the past two years [that is, about 1.3% of all drivers] off the highway and kept them off effectively for two whole years, North Carolina would still experience 96.2% of the accidents it would have had anyway. Moreover, of the drivers removed from the highway, 71% would not have been involved in an accident anyway."

The ability, though very limited, to predict future accidents from past accidents or violations might still be useful to insurance companies in their effort to select low-risk customers from among the large numbers of all those who seek insurance, or to set fees in accordance with the level of risk. It would be nearly useless, however, to attempt to predict the accident career of specific individuals and restrict their legal rights accordingly. This fact has long—though not universally—been recognized: "It

¹Campbell, B.J. (1971). Who really causes the accidents? *Traffic Safety*, December, 22-24.

is not to be expected that within a democracy, the authorities could impose selective treatment on any class of operators, the majority of whom show no need for it.”¹

A very similar pattern of results has been obtained in several other studies. There is, indeed, a difference in the accident rate between drivers with previous accidents or previous violations, but the difference is so small that it accounts for only a minor fraction of all accidents that happen. From data collected in California, it can be calculated that only about 2% of all accidents in a given year were due to drivers who had experienced accidents in both of the two preceding years. About 87% of these drivers were accident-free in the third year. Not surprisingly, the researchers concluded: “Consequently, it is unrealistic to expect that programs toward reducing accidents by focusing on the accident repeater can effect a large reduction in the total accident picture.”² Accident countermeasures aimed at accident repeaters and violation repeaters cannot diminish the accident rate by a substantial amount, even if they were 100% effective in reducing to zero the accidents of these individuals in the near future. If complete elimination of their accidents is viewed as unrealistically high, and the accident rate of accident and violation repeaters were reduced instead to average levels in the population, the reduction in the future accident rate of course, would be even smaller.

That the removal of accident-involved drivers from the road can reduce the future accident rate only by a few measly percentage points was already established some time before the Second World War—at least as far as the USA is concerned—in a publication aptly called “The normal automobile driver as a traffic problem.”³ Yet, cracking down on accident-involved drivers continues to have some political appeal, and this is probably why such action is being proposed from time to time by individuals or advocacy groups in one country or another. But from a public health promotion point of view, this approach is virtually useless. Human history is replete with cases in which an identifiable minority of people is blamed for society’s ills. They are made to suffer injustices as a consequence, while the ills are not remedied. The fact is that the accident problem is not located at the far side of society’s bell curve. Therefore, accident countermeasures, if they are to have a significant effect upon a nation’s accident rate per inhabitant, have to be directed at the driver population as a whole, that is, basically all of us, or at least at large subgroups in the population.

It is evident that risk taking is not a personality trait that is consistent from one situation to another. Similarly, the tendency to have accidents is not consistent from one time period to another. To believe otherwise may well be an example of the “fundamental attribution error.” This expression is used by social psychologists to

¹Johnson, H.M. (1946). The detection and treatment of accident-prone drivers. *Psychological Bulletin*, 43, 489-532.

²Peck, R.C., McBride, R.S. and Coppin, R.S. (1971). The distribution and prediction of driver accident frequencies. *Accident Analysis and Prevention*, 2, 243-299.

³Forbes, T.W. (1939). The normal automobile driver as a traffic problem. *Psychological Bulletin*, 20, 471-474.

refer to the fact that people typically attribute another person's behaviour to that person's lasting character and not often enough to that person's passing state or the prevailing environmental condition. Steal once and be forever called a thief—hence the use of the term “error,” and the error is called “fundamental” because the first and natural impulse of people (psychologists not excepted!) is to make an attribution of this kind. The development of a more considered and controlled opinion does not occur unless a more deliberate and conscious effort is made.¹

Nevertheless, in a fashion reminiscent of the delta illusion mentioned in Chapter 1, there seems to be a persistent urge to search for stable personality features that might predict accidents. The dogged search may be due to the occasional success in identifying a relevant factor, however small its influence.² Many researchers, this author not excepted, seem to have been thinking (but yours truly no longer so) that a clearer relationship would emerge if we had more valid tests of attitude and personality and more trustworthy measures of accident involvement. The notion that current measures of accident involvement are not trustworthy is justified, since a considerable proportion of all accidents remains unreported.³ Maybe this problem could be overcome by looking at professional drivers. Not only do these drivers cover a much greater annual kilometrage under comparable circumstances (which would give personality traits a greater opportunity to become apparent in the safety record), but it is also rather difficult, in the environment in which these people operate, to hide any accidents from the record keepers.

And indeed, a somewhat greater stability in the tendency to incur accidents from one period to another has been observed in professional drivers. These are people (such as taxi drivers and long-haul truckers) who drive very large distances per year under relatively comparable conditions from one year to another. Bus drivers and streetcar drivers in Helsinki, Northern Ireland, Belgrade, Israel, and England have been found to show greater-than-zero correlation between the number of accidents they had in one period and in a subsequent period of one or more years. Still, earlier crash involvement correlated no more than about $r = +0.30$ with accident involvement in the next period. There being no rule without exception, a small sample of 35 streetcar and bus drivers in the city of Mannheim in Germany showed much higher correlation, with coefficients between $r = 0.70$ and $r = 0.80$, in their accident involvement from one four-year period to another four-year period.⁴ In passing, it may be noted that even with this exceptionally stable criterion-to-be-predicted, correlations between personality traits and accidents were either weak, inconsistent or ran counter to expectations and earlier findings. Assuming that the stability in

¹Gilbert, D.T. (1989). Thinking lightly about others: Automatic components of the social inference process. In J.S. Uleman and J.A. Bargh (Eds.), *Unintended thoughts*. New York: Guilford, pp.189-211.

²Ulleberg, P. and Rundmo, T., (2003). Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. *Safety Science* 41, 427-443.

³Hutchinson, T.P. (1987). *Road accident statistics*. Adelaide, South Australia: Rumsby Scientific Publishing, p. 223.

⁴Bach, H., Bickel, H. and Biehl, B. (1975). Validierung von Testverfahren zur Fahrer-Auslese am Unfallkriterium. *Zeitschrift für Verkehrssicherheit*, 21, 27-38.

individual differences in accident involvement in this study is an exception indeed, let us accept a correlation of $r = 0.30$ as the general rule.

Translated into everyday arithmetic, this means the following. Suppose you have a sample of 1000 drivers who were accident-free in one period, and a sample of 1000 drivers who were not. Suppose, too, that you predict that all the accident-involved drivers will have accidents again in the second period, and those who were free of accidents would remain so. A correlation $r = +0.30$ implies that your prediction would turn out to be correct for a little less than 60% of all drivers and wrong for just over 40%.¹ So, you are doing better than chance; 60-40 is better than 50-50, but not by a whole lot.

The authors of the studies mentioned above, in reviewing the evidence, concluded: "This implies that *transient* factors must play by far the most important role in crash causation"² [emphasis added]. As they are saying this, one hears the echo of a conclusion, drawn some twenty years earlier, that "certain people are accident-prone, but sometimes only for short periods of time, and that there are others who are accident-prone over extended periods of time, perhaps for several years or most of their remaining lifetime. Furthermore, different persons are accident-prone for different reasons, and the same person may move in and out of a state of accident-proneness each time because of different circumstances."³ Among those different circumstances that have been identified in the literature are interpersonal problems, loss of a loved one, problems of work and with money, episodes of suicidal thoughts and gestures. One study found that female and male drivers with marital difficulties were more often involved in accidents in the period surrounding the date at which they filed for divorce.⁴

Another factor causing the lack of stability in drivers' accident records is that people may learn from past accidents, other people's, as well as their own, as is argued in Section 4.2. Once bitten, twice shy, in other words. A recent accident may be followed by a period of increased caution. This is what we saw in the laboratory (see Chapter 9) and what was also observed in a German study. Drivers who had been injured in accidents rated the risk of road accidents significantly higher and adopted more safety-compatible attitudes and driving behaviours.⁵ In Finland, after having been involved in a serious crash, drivers of private cars have been found to make comparatively few adjustments in their driver behaviour that lasted more than one

¹The 2 by 2 contingency table with the percentage entries mentioned yields a tetrachoric correlation of about $r = 0.30$.

²Elander, J., West, R. and French, D. (1993). Behavioral correlates of individual difference in road-traffic crash risk: An examination of methods and findings. *Psychological Bulletin*, 113, 279-294.

³McGuire, F.L. (1976). Personality factors in highway accidents. *Human Factors*, 18, 433-442.

⁴McMurray, L. (1970). Emotional stress and driving performance: The effects of divorce. *Behavioral Research in Driving Safety*, 1, 100-114.

⁵Echterhoff, W. (1985). *Verletzung durch einen Kraftfahrzeugunfall als Ausgangspunkt für Sicherheitswerbung*. Bergisch Gladbach D: Forschungsberichte der Bundesanstalt für Strassenwesen.

year after the accident, while truck drivers involved in such accidents tended to make more permanent changes in the way they drove.”¹

On the other hand, having had no accident may dull people’s alertness and make them more daring, at least until an accident follows. As a result, the accident likelihood of an individual would fluctuate from one time period to another, rather than be stable. The search for personality traits in accident causation appears even less rewarding than the proverbial search for a needle in a haystack. Even if you find one, by the time you do, the haystack will likely no longer be the same.

And then there is the rambling role of chance. Whether a driver error results in a reportable accident or not, depends largely on factors unforeseen, if not unforeseeable. These are factors that we usually call chance, a matter of good or bad luck. Drivers losing control of the vehicle or driving through a red light, for instance, may crash or go scot-free, depending on whether there are other vehicles in their path. Even if there are other vehicles, their drivers may perceive the danger and take evasive action so that no accident occurs. This is why even consistent poor driving does not lead to consistent accident careers. We are, in fact, so used to the environment being forgiving in one way or another that, when a crash does occur, this is called “an accident” in everyday language.

10.3 *Prospect and retrospect*

Some studies may actually lead to overestimation of the relationship between personality and what little stability there is in accident involvement. This can happen when current scores on personality tests are investigated on their association with past accident record. Take the case of “external locus of control.” This term refers to persons who attribute the occurrence of important events, such as accidents, to external factors, rather than to their own doing. The latter is called *internal* locus of control. When applied to driving, external locus of control is measured in terms of the respondents’ agreement with statements like “driving with no accidents is merely a matter of luck” and “most accidents happen because of bad roads, lack of appropriate signs, and so on.” Internals typically endorse statements such as “accidents happen because drivers have not learned to drive carefully enough.”²

We have already noticed that far more than 50% of drivers feel that they are better than average drivers (see Section 4.6). People like to present themselves in a favourable light, not only to others, but also to themselves. Thus, it is to be expected that the very human eagerness to justify oneself will lead people to attribute any accident they had to factors other than their own incompetence, carelessness, inattention, hurry, or what-have-you. So, *after* an accident they may become more inclined to agree with external-type statements, while before the accident they were

¹Rajalin, S. and Summala, H. (1997). What surviving drivers learn from a fatal road accident. *Accident Analysis and Prevention*, 29, 277-283.

²Montag, I. and Comrey, A.L. (1987). Internality and externality as correlates of involvement in fatal driving accidents. *Journal of Applied Psychology*, 72, 339-343.

actually more internal. Bus and streetcar drivers in Helsinki, having had accidents in the past, attributed the occurrence of traffic accidents more often to their tight schedules, fatigue, and duration of work shifts than did accident-free drivers.¹

Performance on tests of skill may, of course, also be influenced when people know or suspect that they are being tested because of their accident history. It has been said: "Drivers tend to explain their traffic accidents by reporting circumstances of lowest culpability compatible with credibility."² In this effort they may be more or less successful. Witness some excerpts of supposedly true-to-life letters from Canadian drivers to their automobile insurance firms:

- I knocked over a man. He admitted it was his fault, as he had been run over before.
- The guy was all over the road; I had to swerve a number of times before I hit him.
- The pedestrian had no idea which way to go, so I ran over him.
- An invisible car came out of nowhere, struck my vehicle and vanished.
- I bumped into a lamppost that was obscured by a pedestrian.
- I pulled away from the side of the road, glanced at my mother-in-law, and headed over the embankment.
- I was on the way to the doctor with rear end trouble when my universal joint gave way, causing me to have an accident.

Most studies in the current information base are of a retrospective nature: a sample of individuals with valid driver's licences is drawn from the population, or happens to be conveniently available. They are given tests of personality, and other personal characteristics are ascertained, with the inclusion of their *past* accident career. It is worth noting that the correlations calculated from this information do not include the very people who, in a sense, are the most interesting from the point of view of accident prediction and accident prevention. These are the people who have had a fatal accident or were so severely injured that they cannot participate in investigations, as well as those whose driving behaviour was so deviant that their driving licences have been withdrawn. These people are not included in the samples. Thus, the most dramatic (and possibly the most telling) extreme of the distribution of accidents or violations is missing. This, in turn, may have the effect that the correlations obtained between personal characteristics and accidents underestimate the true strength of association.

One remedy for this problem is to conduct *prospective* studies: a sample of drivers is drawn from the general population, for instance, at the moment of licensing or even before. This is a point in time at which no accident, or at least no culpable accident, has yet occurred. Demographic data (age, gender, occupational status, and so forth)

¹Häkkinen, S. (1979). Traffic accidents and professional driver characteristics: A follow-up study. *Accident Analysis and Prevention*, 11, 7-18.

²Aronoff, C.J. (1971), cited in Shinar, D. (1978). *Psychology on the road: The human factor in traffic safety*. New York: Wiley.

and personality information are obtained from these people, who are then followed up over a multi-year period. At various points in time after the starting date, information on whether they had an accident or not is gathered and checked for any association with the personal data collected earlier.

Prospective investigations are expensive, in part because they demand large samples. This is because no more than 10 in a hundred drivers can be expected to get involved in an accident in any one year. Thus, if you wish to have a sub-sample of 100 accident-involved drivers at a point in time one year into the study, you have to start with an initial sample size of 1,000. In fact, you need even more, because a general problem of prospective studies is attrition of participants. People move, change names, or they themselves or their accident careers cannot be traced for other reasons.

Another potential problem of prospective studies is that people may change their behaviour as a consequence of participating in an investigation. Jocular minds have called opinion surveys the art of asking people about the opinions they don't have. They may then form an opinion as a consequence of being asked for one. Physicians may question their patients at annual check-ups on their eating, exercising, drinking, and smoking habits. Having been asked, people may start thinking about these matters and possibly change their behaviour.

Researchers in Ottawa, Canada, obtained a sample of 1273 Grade 9 and 10 high-school students in an effort to determine whether future traffic accidents could be predicted from information collected from these youngsters, most of whom (more than 86%) did not have a driver's licence at the outset of the investigation although, three years later, 96% did.¹ Participation attrition amounted to 20% in the second year, despite repeated attempts by the investigators to make contact. In the third year, the loss amounted to 30%, and reached 66% in the fourth year, meaning that follow-up data in the fourth year could be collected on only 34% of the original sample. Nevertheless, significant relationships between several personal characteristics and future accident involvement were reported, including that greater accident likelihood was found among those with lesser adherence to traditional social values regarding school and religious worship, as well as greater tolerance for deviance. The individuals with accidents had more liberal attitudes towards alcohol use, drank more regularly, and drank larger quantities per occasion. As well, they indicated more risky driving behaviour, including driving after the use of alcohol or street drugs, and failure to use seatbelts. Among them there were more cigarette smokers, and they reported fewer behaviours conducive to health such as having dental check-ups, a balanced diet, and regular exercise. They also reported a greater frequency of unhealthy behaviours such as eating junk food and not allowing themselves enough sleep. As regards their personality traits, they scored higher on "thrill and adventure

¹Simpson, H.M. and Beirness, D.J. (1993). Traffic accidents and youth: Alcohol and other lifestyle factors. *Proceedings of a Symposium "A*

seeking “and “experience seeking,” which are two of the subscales in the sensation-seeking questionnaire mentioned above.

The researchers reported that combined consideration of all these personal characteristics allowed correct identification of 78% of the study participants as either accident-involved or not accident-involved during the follow-up period.

This finding, however interesting it may seem at first sight, does not detract in any way from our general observation that individual differences in personality characteristics only have a limited bearing on individual differences in accident involvement. This is because it can be calculated from the researchers’ report that the percentage of participants who remained accident-free during the follow-up period was 77.6. In other words, if one had predicted that all participants would have been accident-free in the subsequent period of time under study, this prediction would have been correct in 77.6% of the cases. The percentage of correctly predicted cases on the basis of knowing something about the individuals should, of course, be compared with the percentage of correct prediction on the basis of not knowing something about the individuals, that is, on the basis of mere chance. In this study, there was no clear evidence that prediction based on knowledge of individual characteristics was better than prediction ignorant of individual differences.

And even if it had been better, such a finding might give an unrealistically optimistic impression of the true predictive power of the personality and lifestyle characteristics just mentioned. This is because the number of predictor variables that were found to be related to the accident criterion was appreciably smaller than the number that was tested. The implication is that some of the supposedly significant findings may have been due to chance.¹ The larger the number of correlations calculated, the greater the likelihood that the “significant” ones are due to chance.

If you find this notion of “significance by chance” a little puzzling, think of tossing a coin. Throwing heads five times in a row has a small chance likelihood, namely $0.5 \times 0.5 \times 0.5 \times 0.5 \times 0.5$, which is about 3%. If you stopped tossing at that point, you would have a “significant” finding and might suspect that the coin is not balanced. But toss each of 100 perfectly balanced coins five times and you may expect five heads to turn up in about three of the 100 coins; that is three cases of “significance by chance.” Now toss each of the coins five times again. Once more, you will expect to see the five-heads pattern in about three of the coins, but not in the same three. Hence, when one personality characteristic among several tested emerges as “significantly” related to accidents, one should not consider this a reliable finding until the same characteristic does so again in further investigations.

Consider a prospective study that was carried out on male Finnish army conscripts.² Two personality traits—boldness and the tendency to be trusting—among the sixteen traits measured when they were enlisted, showed significant relation to

¹Wilkinson, B. (1951). A statistical consideration in psychological research. *Psychological Bulletin*, 48, 156-158.

²Hilakivi, I., Veilahti, J., Asplund, P., Sinivuo, J., Laitinen, L. and Koskenvuo, K. (1989). A sixteen-factor personality test for predicting automobile driving accidents of young drivers. *Accident Analysis and Prevention*, 21, 413-418.

accident occurrence during their military service. Do these results justify any confidence in the notion that individual differences in accident involvement can be predicted on the basis of personality? You would probably wish to suspend judgement until you know how these traits stand up in subsequent validation studies, especially since the study found no significant correlation for any of the six other traits which, in various earlier studies, had been reported to be associated with traffic accidents. Your confidence would probably be further reduced by the fact that individual differences in the accident rate of the soldiers before induction into the armed forces bore no relation to their accident involvement while in military service. This reflects zero-order reliability of individual differences in the accident rate from one period to another. There was no relationship between the number of traffic fines obtained before and during military service, or between the number of traffic fines incurred by the men before they entered the service and while they were in the army, and their pre-army violation rate was not related to accidents while in the service. In short, there was no connection between violations and accidents, and both were unstable over time.

On the other hand, the men who had more than the average of 64,000 km of driving experience before being enlisted were found to be less likely to have an accident during their military service. This is a finding that deserves more general credence.

10.4 Demographic characteristics

In contrast to personality traits, there are other characteristics that have *repeatedly* been shown to be related to accidents. These are gender, age, socio-economic status^{1,2} and driving experience, although, even here, the association is not strong enough to produce individual differences in accident likelihood that are stable from one time period to another.

In the last several years, in Ontario, about 16% of all licensed drivers were between 16 and 24 years of age, yet they accounted for about 30% of all fatalities. They were thus 1.9 times more likely to be killed in road accidents than drivers on average. This overrepresentation, although it varies in size from country to country and from time to time, is an international phenomenon. It holds true both per km driven, as well as per person. There is also some indication that elderly drivers have more accidents per km driven than those of middle age, but not necessarily more per person-year. This is because they tend to drive much less, thus reducing their exposure to accident risk. Furthermore, males are more often involved in accidents as compared to female drivers, both per km driven and per person-year.

¹Murray, A. (1998) The home and school background of young drivers involved in traffic accidents. *Accident Analysis and Prevention*, 30, 169-182.

² Cho, H.J., Khang, , Yang, S., Harper, S. and Lynch, J.W. (2007). Socioeconomic differentials in cause-specific mortality among South Korean adolescents. *International Journal of Epidemiology*, 36, 50-57.

It takes novice drivers some five to seven years for their accident rate to drop to the average accident rate of the driver population as a whole, and the younger the driver at the time of licensing, the longer this period. This implies that the overrepresentation of novice drivers in the accident statistics is due to two different factors, immaturity and inexperience. In Ontario data, for instance, the overrepresentation of 16-year-old males during their first year of driving is about twice as great as the overrepresentation of male drivers aged 30 or older during their first year of driving. In their fourth year of driving, male drivers who obtained their licence when they were 30 years or older had about the same accident rate per 1000 drivers as the average of all male drivers in the population. In contrast, males who had acquired their licence when they were 16 incurred accidents at a rate about 40% higher during their fourth year of driving than was true for all males drivers in the population.¹

This raises two questions: what is it about being a late teen, or a sprouting adult, that makes young people more likely to have accidents, and why is inexperience related to greater danger? Before attempting to answer these questions, let us first consider what requirements a driver must fulfill to prevent a potential accident from occurring.

There is a hierarchical set of conditions that must be fulfilled for a driver to reduce the likelihood of a potential accident due to his or her own doing (see Figure 10).

Obviously, (1) the driver must be awake. But to be awake is not enough. The driver may be fully awake, but inattentive to the driving task and paying attention to other things, for instance, the cellular telephone, the radio or conversation with a passenger. Thus, (2) the driver must be attentive to the traffic situation.

But paying attention to the traffic situation is not enough, because the driver may not have the sensory abilities (vision and hearing, among other things) to clearly perceive the danger-relevant aspects of the traffic situation. Thus, (3) the driver must have the necessary sensory abilities.

But having the necessary sensory acuity is not enough, because the driver may fail to be aware of the amount of risk that is contained in the traffic situation he or she perceives. Risk perception, like the perception of beauty, is a product of experience and reasoning, however rudimentary, intuitive or subconscious these may be. Thus, (4) the driver has to be able to infer the amount of accident risk that is contained in the traffic situation.

¹Select Committee on Highway Safety (1977). *Final Report*. Toronto: Government of Ontario, September, Exhibit III-2.

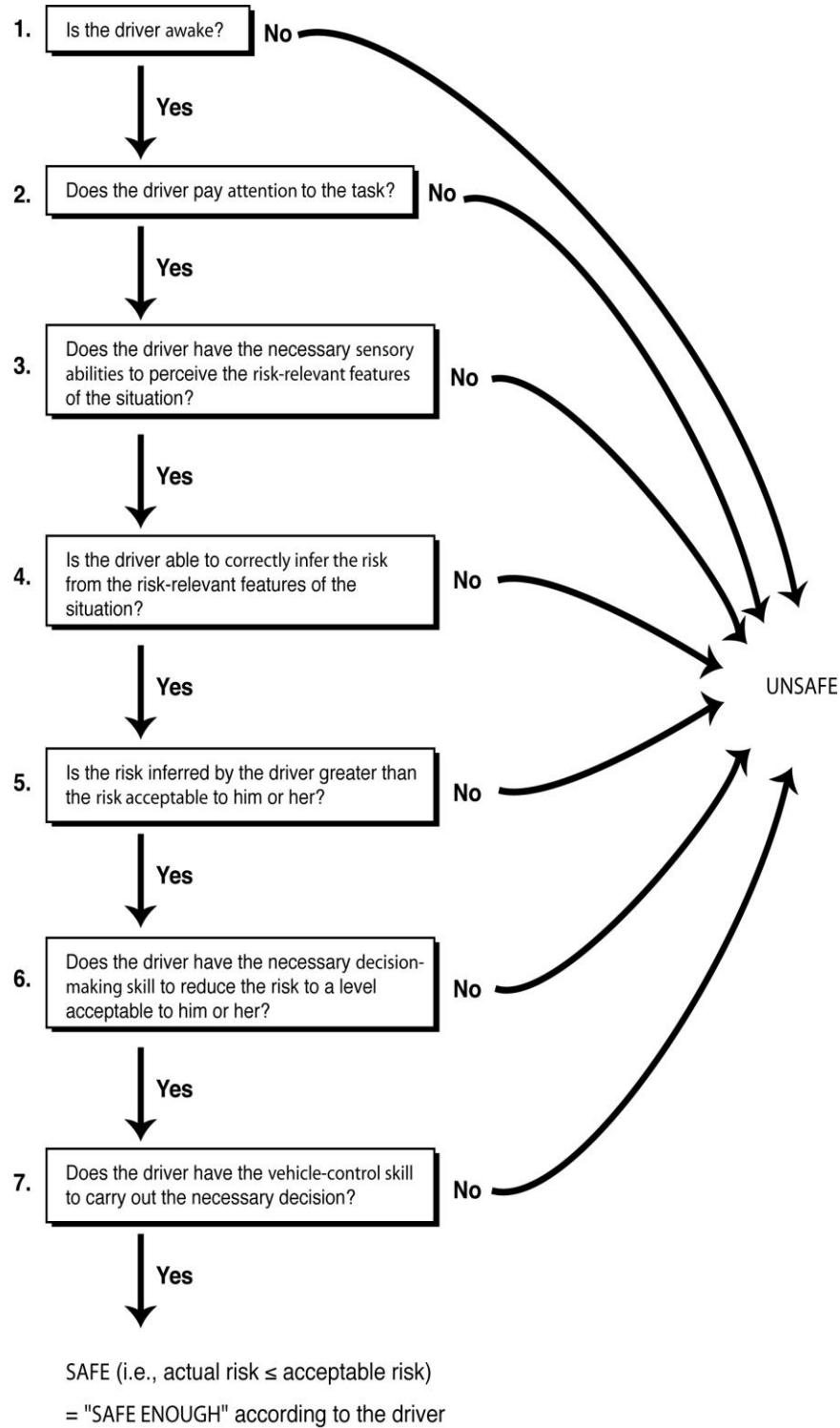


Figure 10: A hierarchy of necessary conditions for being "safe enough"

But risk recognition is not enough, because for the driver to be motivated to take action to reduce the accident risk, the amount of risk acknowledged must be greater than the level of risk the driver is willing to accept. So, (5) the risk must be greater than the driver is willing to tolerate.

But the wish to reduce the risk is not enough, because the driver may or may not have the ability to decide what should be done in order to reduce the risk. Therefore, (6) the driver has to have the necessary decision-making skill for risk reduction.

But to have the decision-making skill is not enough, because even the driver who knows what ought to be done may not have the vehicle-handling skill to carry out the necessary manoeuvre. Hence, (7) the driver has to have the necessary vehicle-control skill. Moreover, all these conditions must be fulfilled at a point in time at which an imminent accident can still be averted.

This simple logic might suggest that there are as many as seven separate factors involved in accident avoidance, but this is a misconception since these factors do not operate independently of one another. If a person's decision-making or vehicle-handling skills are poor, that person's level of perceived risk should be high, and if it is not, this reflects overconfidence in one's skills. The same holds for sensory abilities. To be colour-blind or hard of hearing does not imply a significant increase in accident liability, provided the driver considers these handicaps in the estimation of risk. Poor night vision will not increase a person's accident risk unless the person is unaware of it or is willing to accept high levels of accident risk. Deficiencies in skills and sensory functioning, other things being equal, can increase a person's accident likelihood only to the extent that these deficiencies are being underestimated by the person in question, and thus lead to an inappropriately low level of perceived risk.

Poor skill will not enhance a person's accident risk if that person is fully aware of his or her poor skill, because—risk acceptance level being the same—that person is less likely to engage in manoeuvres he or she cannot handle very well. It is not surprising, therefore, that sensory abilities and other driving skills have generally been found to show no association, or weak association, with accident involvement.^{1,2,3} In Section 6.3 we noticed that better-than-average driving skill—presumably both on the level of decision making and vehicle handling—may sometimes be associated with *greater* accident likelihood, because the driver is being lulled into an illusion of safety.

Inattentiveness to the driving task implies either that the driver estimated the risk of accident as very low and permitted paying more attention to other things, or that the driver considered other things to be at least temporarily more important than safety, thereby accepting a higher level of accident risk.

¹Shinar, D. (1978). *Psychology on the road: The human factor in traffic safety*. New York: Wiley.

²Ball, K., Owsley, C., Sloane, M.E., Roenker, D.L. and Bruni, J.R. (1993). Visual attention problems as a predictor of vehicle crashes in older drivers. *Investigative Ophthalmology and Visual Science*, 34, 3110-3123.

³Grayson, G. and Noordzij, P. (1990). Facteurs individuels et sociaux influençant la probabilité d'accidents. *Proceedings, International Symposium organised by La Prévention Routière*, May 16-18, 1989. Caen F: Paradigme, pp. 635-641.

Finally, lapses in wakefulness during driving will not occur unless the driver underestimated the chances of falling asleep behind the wheel or accepted them. Here again, the underlying cause is either risk underestimation or increased risk acceptance.

It may thus be concluded that the seven factors in our original analysis shrink to only two that are truly relevant to increased accident likelihood. It may further be argued that individuals with a very low risk acceptance will be motivated to ensure that they do not underestimate risk and that, therefore, only one dominant factor remains: risk acceptance.

We now will attempt to explain why inexperienced drivers have more accidents than experienced drivers. Obviously this is not because of their lower level of skill per se. *In principle*, unskilled people can reduce accident risk by choosing manoeuvres that match their level of skill in driving, and by reducing their exposure. However, *in practice*, this is not so. They cannot fully adjust their driving manners to their driving skill, because they operate as a minority in a road system in which most drivers are experienced. There are strong forces at work that compel inexperienced drivers to drive at a certain speed and at a certain following distance, and to do other things similar to what the more experienced majority does. Thus, in order to acquire experience, they have to drive above their own level of competence and comfort, and that is why they experience more risk when driving.^{1,2} Their elevated experience of risk corresponds with the increased risk they incur.

The point made here is neatly illustrated by the case of "Mrs. Cautious Driver." This is the name we will give to a lady whose problems were presented at the Grand Rounds in Psychiatry in the Kingston General Hospital in Ontario in the mid-'70s. She suffered a serious nervous breakdown and an acute case of driving phobia. This is her story.

In the course of four years she experienced four traffic accidents. This is a rare occurrence, with a frequency of less than one in 10,000 drivers. In none of these accidents was she at fault. That makes her predicament a much rarer occurrence still. In all cases she was driven into at an intersection by another car. She was an extremely cautious driver in the sense that she drove her station wagon well below the speed limit on four-lane highways and she always buckled her seatbelt in a period before this was compulsory by law. At stop and yield signs, she was in the habit of waiting very long before she would accept a gap wide enough to her liking and go ahead. In such circumstances she would sometimes brake and stop again. Three times she was rear-ended in this situation, the third time by a police patrol car.

Mrs. Cautious Driver presents an interesting paradox. She was very careful indeed, in fact, so careful that her behaviour was rather unpredictable to other drivers. This made her liable to having accidents where others were at fault. On the other hand, if everybody were to behave as cautiously as she, there would be fewer crashes.

¹Taylor, D.H. (1964). Driver's galvanic skin response and the risk of accident. *Ergonomics*, 7, 439-451.

²Ganton, N. and Wilde, G.J.S. (1971). *Verbal ratings of estimated danger by drivers and passengers as a function of driving experience*. Report prepared for the Roads and Motor Vehicle Traffic Safety Division, Ministry of Transport, Ottawa.

Greater risk, and acceptance thereof, is inevitable if one wishes to become experienced. Experience must be bought; accidents are part of the price. Nobody can expect to be able to learn to play the violin and perform a piece at the required tempo without making many mistakes in the learning process. There is no royal road to learning.

The number of mistakes made by the novice violinist and the inexperienced driver could be reduced if they were allowed to perform at a reduced pace, solo, and in concert with other inexperienced persons. In other words, there are reasons for assuming that the accident rates of novice drivers would have been lower if there were only novice drivers making use of the roads. It is not their inexperience per se, but the *experience mix* in the collective of road users that makes the inexperienced driver more prone to having accidents.

This view is supported in findings obtained by the method of verbal risk ratings described in Section 3.3. Drivers of different levels of experience orally express, on a numerical rating scale, the level of risk they perceive while driving. An observer sitting in the front passenger seat, who may be either experienced or inexperienced as a driver, makes observations using the same scale. The experimenter does not allow any communication between driver and observer and keeps a record of their independent risk estimates.

It is found that inexperienced drivers' danger ratings tend to agree more with other inexperienced drivers' ratings than with those of experienced drivers. Similarly, ratings by experienced drivers do not agree with those by inexperienced observers as much as with experienced ones. In simpler words: drivers of similar levels of experience show greater similarity in the amount of risk they perceive. In a situation of traffic conflict, an experienced driver will, therefore, be better able to predict what another experienced driver will do to avoid a collision. Similarly, inexperienced drivers will predict the reactions of other inexperienced drivers more accurately than they will predict those of experienced ones.

The implication is that the overrepresentation of novice drivers in accident statistics—insofar as it is due to lack of experience—might be reduced by techniques that speed up the process of learning to perceive the risks of the road in the same manner as experienced drivers do. The current research interest in risk-perception skills^{1,2} may thus lead to the development of new didactic methods.³

In order to explain the overrepresentation of novice drivers—especially male—in relation to their youthfulness, a variety of factors may be surmised. Young people have higher stimulation-seeking scores,⁴ and we know that such scores are associated

¹Elander, J., West, R. and French, D. (1993). Behavioral correlates of individual difference in road-traffic crash risk: An examination of methods and findings. *Psychological Bulletin*, 113, 279-294.

²Lester, J. (1991). *Individual differences in accident liability: A review of the literature*. Research Report 306. Transport and Road Research Laboratory, Crowthorne, Berkshire UK.

³Wilde, G.J.S. (1993). Improve risk perception and reduce risk acceptance: Two proposals for driver education. *Proceedings, Working Conference on Novice Driver Education*, Edmonton: University of Alberta, April 22-23.

⁴Ball, I.L., Farnill, D. and Wangeman, J.F. (1984). Sex and age differences in sensation seeking: Some national comparisons. *British Journal of Psychology*, 75, 257-265.

with a tendency to view the risk in “risky” activities as rather low (see Section 10.1). Moreover, young people tend to have fewer responsibilities to others; they are less likely to be married and have children, and they have fewer accomplishments. Thus, apart from the potential loss of a few more years of life, they have less to lose by taking risks. These are factors that may be assumed to have an increasing effect on the level of risk they are willing to accept. At the same time, they have more to gain from risky behaviour. For example, by showing bravado they may gain prestige among their peers. Furthermore, the general culture expects them to be daring and venturesome: young colts will canter. They often drive cars that are not their own. Thus, they would seem to lose less and gain more from risky conduct. Similar factors may well explain why men have more traffic accidents, per person-year, as well as per km driven, than women.

Returning, finally, to the motto at the heading of this chapter, should we conclude that people drive as they live? The original study which affirmed this “has serious methodological shortcomings.”¹ For one thing, the drivers were questioned by interviewers who knew their accident history and thus could keep asking questions until they received answers which satisfied their need to explain the interviewee’s accident record. This has led to a gross overestimation of personality and lifestyle factors in the causation of accidents. In other words, an association does exist, but it is so tenuous that it would seem unwise to focus upon it in prevention efforts that wish to achieve more than accident reduction by just a few percentage points. It may be more promising to attempt to alter the driving style of the population as a whole, or a demographic subgroup, and to do this by focusing on the level of risk people are willing to accept. This is the topic of the next two chapters.

¹Lester, J. (1991). *Individual differences in accident liability: A review of the literature*. Research Report 306, Transport and Road Research Laboratory, Crowthorne, Berkshire UK.

11 Motivating for safety and health

In Chapter 9 we have seen that people can be discouraged from behaving in a risky fashion by extending to them the promise of reward for safe conduct. The demonstrating data, however, were collected in the laboratory and, as has been noted in that same chapter, “variables always change when they are brought into the laboratory.” Risk homeostasis theory is primarily concerned with health and safety, not with risk taking in the pursuit of money or social recognition, or other risk taking that may be fit for laboratory experimentation. There is, however, no fundamental reason why the same principles should not hold in these domains as well. In fact, since risk is ubiquitous, it may be argued that RHT is a general theory of human behaviour.

At any rate, it is in this chapter that we will demonstrate that it is possible to motivate people to adopt a safer behaviour repertoire under real-life conditions, and that accident rates per person can be greatly reduced. The target level of risk—in other words, the level of risk at which people prefer to operate—can be reduced by interventions in four categories of tactics. Thus, the safety measure may aim to:

- Increase the perceived benefit of cautious behaviour Tactic A
- Decrease the perceived cost of cautious behaviour ...Tactic B
- Increase the perceived cost of risky behaviourTactic C
- Decrease the perceived benefit of risky behaviourTactic D

As examples of Tactic A, one might think of instituting administrative rewards for accident-free and violation-free driving through discounts in insurance premiums, free licence renewal, discounts in vehicle permits and medical insurance premiums, rewards for being healthy, and discounts for people with appropriate health habits. Examples of Tactic B might be the institution of flexitime so that the need to rush to work will be reduced, subsidies for public transportation, enhancing the efficiency and comfort of public transit, tax exemptions on safety equipment, making safety equipment more pleasant to use. Using Tactic C, the perceived cost of risky behaviours may be enhanced by actions such as increased taxes on tobacco, increased penalties for traffic violations, building vehicles that become uncomfortable (noisy and vibrating) when driven at high speeds, manufacturing vehicles with frail exteriors and crashworthy interiors which would increase repair costs but reduce the severity of injury, reduction of the right to restitution for damages incurred by individuals who don't wear a seatbelt, reduced sick pay for employees who were not complying with safety rules and regulations at the time of their accidents. Finally, Tactic D might be the rationale for measures such as paying taxi drivers per time unit instead of per kilometre, making it mandatory that all employees involved in risky work be paid by the hour and not per unit of productivity.

A word of warning! The above examples are meant to illustrate and are not necessarily recommended. Many of them would likely fail to produce lasting

reductions in the rate of accidents or lifestyle-dependent poor health. This is because they are directed at particular behaviours, such as speeding, drinking and driving, or smoking tobacco. They do not, in themselves, stimulate the desire to be safe and in good health. If you tax alcohol beyond people's financial reach, they may try making the stuff themselves, with the potential for much greater damage to health due to poisoning. To increase the likelihood of being stopped for a traffic violation is to increase surrogate risk. This may motivate drivers to avoid a penalty, but does not heighten the desire to be safe; neither does it reduce the accident rate (see Chapter 8).

Countermeasures that are oriented towards specific behaviours instead of towards the outcome—having, or not having, an accident—do not prevent behavioural adaptation from occurring. Those who fail to realize this suffer from the delta illusion. Reduction in the frequency of one particular immediate accident cause may simply make room for other immediate causes to become more prominent.

Decades ago, this phenomenon was referred to as *equifinality*.¹ Centuries ago, a British playwright expressed it as “I know death has ten thousand several doors for men to take their exits.”² Millennia ago, a Roman philosopher and poet said: “Anyone can stop a man's life, but no one his death; a thousand doors open onto it.”³ The same final outcome, for instance, the same accident rate per person-hour, may emerge although the pathways are different. Sobriety is no guarantee of safety; neither is driving at the average speed. Abstinence is no guarantee of health; neither is jogging. Similarly, accidents may be avoided and safety achieved through a variety of different behaviours.

11.1 Punishing unsafe acts

The notion that safety may be enhanced by acting upon motivation has a long history, as is clear from the universal presence of punitive law. Although enforcement of punitive law is one of society's traditional attempts at motivating people towards safety, the evidence for its effectiveness has not been forthcoming.⁴ This has already been discussed in some detail in Chapter 8, where we found that even if selective enforcement and increased police surveillance of some aspect of road-user behaviour were to reduce the prevalence of a particular circumstance in accident occurrence (the presence of alcohol, for instance) this does not imply a reduction in the overall accident rate, since the rate of sober accidents may increase.

Instead of making police surveillance more prominent and thereby the likelihood of detection, one might consider increasing the penalty for the offence. Such action, however, may take insufficient account of the social context in which the law has to operate. Drinking and driving is folk crime; large segments of the population admit to

¹Bertalanffy, L. (1968). *General system theory*. New York: G. Braziller.

²Webster, John (1623). *The Duchess of Malfi*, Act 4, Scene 2.

³Seneca (c. 4 BC to AD 65). *Phoenissae* 1. 152.

⁴Bonnie, R.J. (1985). The efficacy of law as a paternalistic instrument. *Nebraska Symposium on Motivation*, 29, 131-211.

it. Of nearly 10,000 Canadian drivers surveyed, 72% reported they had been driving after drinking at least once during the 12 months preceding the interview, while 22% said they had been driving while “high” on alcohol during that period. Analogous American statistics indicated 60% and 29%, respectively. Canadian roadside surveys found as many as 6% of all passing drivers to have BACs over the legal limit. And prior to the introduction of the statutory BAC limit in the Netherlands, the percentage of nighttime drivers exceeding this limit varied between 13% and 17%. Between two and four o’clock in the morning, these percentages were no less than between 31% and 36%. Roadside surveys are conducted over a few hours only, during a few days. One wonders what percentage of drivers exceeds the legal limit at least once a year.

It is one thing to declare a frequently committed act a crime, but quite another to treat it as such on the level of police enforcement and court action. Can it be surprising that police officers are hesitant to charge, that defence lawyers find many grounds for clemency, that juries are reticent in passing a guilty verdict, and that judges, very serious cases excepted, tend to refrain from severe sentences?

In what is known as the “Chicago Crackdown” on drunk driving, judges in that city agreed to impose a seven-day jail sentence on all persons deemed guilty of the offence, but in a period of six months, only 6% of over 6,000 drivers arrested for driving under the influence had actually received such a sentence. In New York State it was found that about 27% of all individuals arrested for violations including driving under the influence were never prosecuted.¹

Even when laws are made stricter and are actually applied, greater deterrence may not be achieved. In more recent years, we have learned that the abandonment of mandatory jail sentences for impaired driving in Norway and Sweden has not led to an increase in the traffic fatality rate², although the severe and automatic penalties had often been credited with achieving exceptionally low rates of impaired driving in these countries. An American study, which took the form of a quasi-experiment in Minnesota, found that the imposition of jail sentences on first-time impaired drivers failed to reduce their frequency of recidivism.³ The evidence from many sources shows overwhelmingly that the beneficial effects of punitive measures continue to be weak, marginal, or transient,⁴ while implementation costs are high. The costs of legislation, police enforcement, courts and incarceration are very considerable, but seem to yield little benefit.

If this situation is compared with the benefit/cost ratios of accident prevention in occupational settings, one is struck by a remarkable similarity, as well as a remarkable

¹Wilde, G.J.S. (1981). A critical view of countermeasure development and evaluation. In D.L. Goldberg, *Alcohol, drugs and traffic safety*. Stockholm: Almqvist and Wiksell, pp. 1145-1159.

²Ross, H. L. and Klette, H. (1995). Abandonment of mandatory jail for impaired drivers in Norway and Sweden. *Accident Analysis and Prevention*, 27, 151-157.

³Martin, S.E., Sampson, A. and Forst, B. (1993). The special deterrent effects of a jail sanction on first-time drunk drivers: A quasi-experimental study. *Accident Analysis and Prevention*, 25, 561-568.

⁴Lonero, P.L., Clinton, K., Wilde, G.J.S., Roach, K., McKnight, A.J., MacLean, H., Guastello, S.J. and Lambie, R.W. (1994). *The roles of legislation, education and reinforcement in changing road user behaviour*. Ministry of Transportation, Safety Research Office, Report SRO-94-102, ISBN 0-7778-2827-8, Toronto, Ontario.

contrast. In the domain of industrial safety too, it has been found that punitive approaches tend to have few beneficial effects on safety (as well as sometimes major negative side effects). On the other hand, positive incentives for safe performance produce substantial reductions in accidents.¹ We will present detailed evidence on this point in Chapters 11 and 12.

One problem with severe punishment seems to be that a law cannot be enforced if its strictness exceeds popular opinion about the immorality or deviancy of the act concerned. That the deterrent effect of a law is greater, when that law is made more severe, is a misconception that is often used by politicians to make themselves popular with the electorate. The factors that do significantly contribute to deterrence are certainty and swiftness of punishment, not the size of the penalty.² The approach that takes the form of punishing people for specific unsafe acts suffers from several other problems as well, some of which have been identified in the context of organizational psychology.³

First, there is the self-fulfilling effect of attribution: labelling people with undesirable characteristics, and expecting that they will show them unless kept in check by the threat of punishment, may cause individuals to behave as if they had these characteristics. To illustrate this by its classic example: suppose you pretend that a perfectly solvent bank is about to go bankrupt (your attribution), and you spread that rumour. The rumour you spread may cause depositors to withdraw their funds, with the end effect that the bank develops solvency problems and ends up by going bankrupt. Similarly, the very imposition of a speed limit may provoke some people to drive faster than they otherwise would. It is well known that some drivers find pleasure in activating the electronic devices installed along highways that tell the speeding driver: "You are going too fast."

Second, the emphasis is on "process controls," or specific behaviours (such as using a piece of safety equipment or obeying the speed limit), instead of focusing on the outcome of safety. Process controls are cumbersome to design and implement. Prohibitive process controls do not clearly communicate what course of action should be taken instead. Research on traffic signs has clearly indicated that prohibitive signs such as "no left turn" have less of a guiding effect upon drivers' decision making than signs that tell them what turns *are* allowed, i.e., permissive signs.⁴ In passing, we may note that, although they are not more conducive to safety, the near-universal use of prohibitive signs may be due to the fact that they make it easier to establish blame when they are not heeded. Moreover, process controls cannot effectively cover all undesirable specific behaviours in any situation. Roadside observation of driving

¹Geller, E.S. (1996). *The psychology of safety: How to improve behaviors and attitudes on the job*. Radnor, Pennsylvania: Chilton.

²Ross, H.L. (1982). *Detering the drinking driver: Legal policy and social control*. Lexington MA: D.C. Heath Lexington Books.

³Arnold, H.J. (1989). Sanctions and rewards: Organizational perspective. In M.L. Friedland (Ed.), *Sanctions and rewards in the legal system: A multidisciplinary approach*. Toronto: University of Toronto Press.

⁴Dewar, R.E. (1972). Permissive versus prohibitive symbols for regulatory traffic control signs. *Proceedings, International Conference on Highway Sign Symbolology*, Washington, DC, June.

speeds on an urban expressway in Montréal, for example, has shown that the ratio of incidences of drivers speeding by at least 10 km/hr over the posted limit relative to the number of charges laid for speeding was in the order of 7,000-to-1.¹ Similar and even higher ratios have been found elsewhere.² And, in Canada, it has been estimated that about 25,000 km of driving with blood alcohol levels over the legal limit are accumulated for every charge that is laid for this offence. During the same time period in which this study was done, the impaired kilometrage per charge was about 136,000 kms in the Netherlands and 150,000 kms in France.³

Punishment brings negative side effects; one of these is a dysfunctional social climate, a climate of resentment, uncooperativeness, antagonism, and sabotage. As a result, the very behaviour that was to be prevented may in fact be stimulated. Punishment may increase the inclination to beat the system. It has been estimated that between 40% and 70% of drivers whose licences have been suspended or revoked continue to drive. American, Dutch and Swedish studies found that the longer the period of disqualification, the *more* likely that the driver will continue to drive without a licence.⁴

A Swedish investigator compared drivers who had obtained a relatively severe sentence for driving while under the influence, with another group who had received relatively light punishment. The heavily punished drivers were found to be *more* likely to repeat the offence! This is not so surprising if one realizes that the likelihood of being caught for the offence is very small. The ones unlucky enough to get caught know that too, and feel unfairly treated by a system of arbitrariness. Their resentment may be further fed by factors such as long delays between the incident and the announcement of suspension. Thus, they become even more antagonistic towards authority and the law of the land. These hostile feelings may not only overshadow any guilt and shame, but also create a state of mind that is incompatible with effective re-education and rehabilitation. Some convicted Swedish drivers went so far as to complain that the state had committed a crime against their person!⁵

11.2 *Reactance, or the boomerang hits back*

The reaction of these convicted Swedish drivers may be viewed as a case of reactance, which is one of the more interesting negative side effects of a punitive,

¹D'Arcy St. Pierre, M. (1968). Personal communication. Police Department, Montréal.

²Cramton, A.C. (1969). Driver behaviour and legal sanctions: A study of deterrence. *Michigan Law Review*, 63, 421-454.

³NATO Committee on the Challenges of Modern Society (1974). *Alcohol and traffic safety: A review in quest of remedies*. Ottawa: Transport Canada. Road Safety, Report No. CTS-1a-74.

⁴Wilde, G.J.S. (1975). Evaluation of effectiveness of public education and information programmes related to alcohol, drugs and traffic safety. In S. Israelstam and S. Lambert (Eds.), *Alcohol, drugs and traffic safety*. Toronto: Addiction Research Foundation of Ontario, pp. 813-823.

⁵Klette, H. (1972). *Om social kontroll av grovre trafikbrottslighet*. (On legal control of serious traffic offences). Lund, Sweden: University of Lund, Departments of Law and Sociology.

authoritarian approach to undesirable behaviour. No small part of its interest lies in the fact that policy makers do so often ignore it. Reactance is a term used by psychologists to denote the tendency of individuals not only to disobey commands, to reject persuasive communications, to disregard warnings, but to change behaviour in a direction opposite to the intent of the command, message, or warning. There are, in principle, three possible reactions to such exhortations:

- compliance,
- lack of responsiveness, and
- reactance.

Reactance effects are also known sometimes as "boomerang effects,"¹ or "forbidden fruit effects." The likelihood of these occurring is greater to the extent that the exhortations or impositions are perceived by individuals as coercive, limiting personal liberty and reducing freedom of choice. It has been documented in many domains of life, as will be seen below. The desire to assert one's psychological identity, independence and autonomy can be strong enough for people to act in ways that may be viewed as contrary to their own interests (except for serving a sense of self-worth through active opposition). Well over 100 years ago, it has been phrased in what is now world literature as follows:

*"What man needs is simply independent choice, whatever that independence may cost and wherever it may lead. [...] I repeat for the hundredth time, there is one case, one only when man may purposely, consciously, desire what is injurious to himself, what is stupid, very stupid – simply in order to have the right to desire for himself even what is very stupid and not be bound by an obligation to desire only what is rational. After all, this very stupid thing, after all, this caprice of ours, may really be more advantageous for us, gentlemen, than anything else on earth, especially in some cases. And in particular it may be more advantageous than any advantages even when it does obvious harm, and contradicts the soundest conclusions of our reason about our advantage – because in any case it preserves for us what is most precious and most important – that is, our personality, our individuality."*²

Although most people would – when honest – admit to instances in their lives of reactance to rules, regulations and generally accepted beliefs and practices, there are considerable individual differences in the tendency toward reactance. Some people

¹Zimbardo, P.G., Ebbesen, E.B. and Maslach, C. (1977). Influencing attitudes and changing behavior. Philippines: Addison-Wesley.

²Dostoevski, F.M. (1894) (translated by Matlaw, R.E.). Notes from Underground and the Grand Inquisitor. New York: Dutton, 1960, pp. 23 and 26. xxx

are much more reactant than others and procedures for the measurement of this characteristic have been developed.¹ This has enabled researchers to show that it is especially strong in young people.²

Reactance has been documented in many domains of life, including consumer behaviour in response to advertising.^{3,4} It has frequently been identified as a factor explaining the lack of effect of anti-smoking and anti-drinking warnings. In one experiment, the effect of warning messages on alcohol consumption was assessed by exposing heavy and light drinkers to either “high-threat” or “low-threat” messages, then having the drinkers participate in a taste-rating task while their beer consumption was unobtrusively monitored. The effect of the heavy threat messages was the most counterproductive to moderate alcohol use by the male heavy drinkers: they drank more than the male heavy drinkers who had been exposed to low-threat messages did.⁵ Earlier, in Section 6.5.2, we have come across the observation that strong fear appeals in messages intended to persuade are not productive towards behaviour change.

A study among more than 2000 college students in the USA was carried out to test the hypothesis that under-age collegiate alcohol consumers would drink more than their legal-age peers if psychological reactance were a contributing factor to consumption. On the other hand, these two groups would show no difference in the use of illicit substances, as these had not been subjects of recent law changes. As this pattern was actually observed, the authors conclude that their findings support the operation of reactance.⁶ Canadian researchers also reported a high incidence of Grade 10 students who had been drunk at least twice (about 45%) and stated that “More restrictive alcohol policies appear to be associated with a greater incidence of adolescent drunkenness.”⁷

Authors of another study also reported that they felt that the alcohol restrictions upon American undergraduate students would make drinking more attractive in the future, a prediction that was borne out by an increased alcohol consumption among the affected age group 13 months after passage of the law.⁸ Still another study came to the conclusion that the “findings support reactance theory and suggest that raising

¹Hong, S.M., Giannakopoulos, E., Laing, D. and Williams, N.A. (1994). Psychological reactance: Effects of age and gender. *Journal of Social Psychology*, 134, 223-228.

²Hong, S.M. and Faedda, S. (1996). Refinement of the Hong Psychological Reactance Scale. *Educational and Psychological Measurement*, 56, 173-182.

³Ringold, D. J. (1988). Consumer response to product withdrawal: The reformulation of Coca-Cola. *Psychology and Marketing*, 5, 189-210.

⁴Lessne, G.J. and Notarantonio, E.M. (1988). The effect of limits in retail advertisements: A reactance theory perspective. *Psychology and Marketing*, 5, 33-44.

⁵Bensley, L.S. and Wu, R. (1991). The role of psychological reactance in drinking following alcohol prevention messages. *Journal of Applied Social Psychology*, 21, 1111-1124.

⁶Allen, D.N., Sprenkel, D.G. and Vitale, P.A. (1994). Reactance theory and alcohol consumption laws: Further confirmation among collegiate alcohol consumers. *Journal of Studies on Alcohol*, 55, 34-40.

⁷King, A., Boyce, W. and King, M. (1999). Tobacco, Alcohol and Drugs. In *Trends in health of Canadian youth*. Ottawa: Health Canada.

⁸Gordon, R.A. and Minor, S.W. (1992). Attitudes toward a change in the legal drinking age: Reactance versus compliance. *Journal of College Student Development*, 33, 171-176.

the legal drinking age in the US may have contributed to increased drinking among underage students through the arousal of reactance motivation.”¹

Reactance may also occur in response to a different kind of attempt to improve safety or health, namely mass media communications campaigns conveying persuasive messages to the public. In the research literature dealing with the effects of communications that try to persuade, the counterproductive impact of messages that provoke reactance in the audience is often referred to as a “boomerang effect.” This has, for instance, been observed with respect to publicity aimed at a reduction in drinking and driving.^{2,3,4}

In 1980, a prominent researcher in the area of persuasive communications remarked the following: “Although one generally assumes that there is deterrent value in warning a person that a practice is risky, one should not overlook the possibility that riskiness has also some positive motivational force. The popularity of such practices as gambling, frightening amusement park rides, high-speed driving, sky-diving, etc., shows the appeal of taking risks. For some subpopulations the positive component might even exceed the negative. For example, among young people (and especially young males), warning labels about the risk involved in pharmaceuticals, cigarettes, alcohol, driving styles, certain sporting equipment and practices, etc., may actually have a net positive incentive power, drawing the person to the practise (especially in public situations) rather than being a deterrent.”⁵ Policy makers, are you listening?

The initial ascent of the mountain called Uluru, also known as Ayer’s Rock, in the centre of Australia, is very steep and exposed. Several climbers have been killed when straying from the recommended safer route. Crosses were put in place to commemorate the dead and to warn the living. Subsequently, tourists had their pictures taken on the side of the crosses and then proceeded on the more dangerous course. The crosses have since been removed.⁶ That the threat of death may not deter people from unhealthy behaviour as is also shown in a experimental study with respect to smoking.⁷

¹Engs, R. and Hanson, D.J. (1989). Reactance theory: A test with collegiate drinking. *Psychological Reports*, 64, 1083-1086.

²Wilde, G.J.S., L’Hoste, J., Sheppard, D. and Wind, G. (1971). Road Safety Campaigns: Design and Evaluation. The Use of Mass Communications for the Modification of Road User Behaviour. Paris: OECD. Also published in French: Campagnes de Sécurité Routière, Calcul et Evaluation.

³Swinehart, J.W. and Grimm (Eds.) (1972). *Public information on alcohol and highway safety*. Ann Arbor, Michigan: Highway Safety research Institute.

⁴Wilde, G.J.S. (1993). Effects of mass media communications upon health and safety habits of individuals: An overview of issues and evidence. *Addiction*, 88, 983-996.

⁵McGuire, W.J. (1980). The Communication-Persuasion Model and health-risk labeling. In Morris, L.A., Mazis, M.B. and Barofsky, I. (Eds.), *Banbury Report 6: Product labeling and health risks*. Cold Spring Harbor, New York: Cold Spring Harbor Laboratory, pp. 99-122.

⁶Smith, R.M. (1999). *The National Geographic Traveler Australia*. Washington, D.C.: National Geographic Society, p. 205.

⁷ Hansen, J., Winzeler,, S. and Topolinski, S. (20010). When the death makes you smoke: a terror management perspective on the effectiveness of cigarette on-pack warnings. *Journal of Experimental social Psychology*, 46, 226-228.

11.3 *Extending incentives for accident-free operation*

In contrast to the interventions that often backfire, incentive programmes for safety have both the effect for which they are intended—greater safety—and usually the positive side effect of creating a more favourable social climate.^{1,2}

In the mid-1970s an innovative and relatively large-scale experiment was conducted in California.³ The Division of Highways in that state contacted 9,971 drivers who had caused collisions or committed violations in the previous year and, thus, had incurred recent demerit points. These drivers were informed by letter that they would receive a free 12-month extension to their driver's licence on the condition that they achieve a clean record during the coming year. Apart from the financial incentive, amounting to a few dollars per year, this offer also implied deferral of the obligation to submit oneself again to the written part of the driver's examination, which, in California, is administered repeatedly throughout a driver's career.

A control sample of another 9,976 drivers was not approached in this manner, but they too were followed up, along with the experimental group, over a period of several years. The findings include the following: In the first follow-up year, there were significantly fewer accident-involved drivers in the experimental group, particularly among the younger drivers and among those drivers whose licence renewal was to come up within one year after receipt of the letter. In this latter group, the accident rate was 22% lower than in the appropriate controls. The drivers who actually earned the bonus after one year showed 33% fewer accidents in the second follow-up year than did the controls.

A report published about a long-lived incentive project in Germany has not, as yet, received the amount of attention that it deserves from the road safety community. Professional drivers employed by the German branch of Kraft Foods Corporation, with a fleet of about 600 trucks and vans, were told in 1957 that they would receive a bonus of 350 German marks for every half-year of driving without culpable accidents, that is, without accidents in which they were judged to be at fault.

In the first year after the initiation of this incentive scheme, the frequency of culpable accidents per 100,000 km driven fell abruptly by about one-third, and subsequently continued to drop more smoothly; in 1981, the accident rate per km amounted to about 14% of what it had been in 1956, prior to the programme. The rate of all accidents, culpable or not, fell to 25% of what it had been in 1956. The direct financial accident costs per km driven showed a steeper decline than the accident

¹Steers, R.M. and Porter, L.W. (1991). *Motivation and work behavior*. Fifth edition. New York: McGraw-Hill.

²Wilde, G.J.S. (1992). Accident prevention through incentives for safety in industry and road traffic: An analysis of international experience. *Proceedings, International GfS Summer Symposium*, Gelsenkirchen D., June 15-17, pp. 61-67.

³Harano, R.M. and Hubert, D.E. (1974). *An evaluation of California's 'good driver' incentive program*. Report No. 6, California Division of Highways, Sacramento.

frequency per km driven. This indicates that the incentive programme was particularly effective in reducing the occurrence of more serious accidents. The total implementation costs of the programme were estimated at some \$35,000 US per annum, but these costs are reported to be far outweighed by the reduction in insurance fees resulting from the much-improved safety record.¹ This programme has been in force for over three decades without showing signs of waning effectiveness.² An American team-based incentive programme addressed at transit bus operators yielded a 25-35% reduction in accident rates as compared to randomly selected controls within the same company. The ratio between programme costs and benefits was estimated at almost seven-to-one. After the programme was withdrawn, the safety records of the incentive group dropped to a level that was still better than that of the no-treatment employees, but no longer significantly so.³

The effectiveness of incentives programmes in enhancing safety has been very clearly established.^{4,5} In a review of over 120 published evaluations of different types of occupational accident prevention, incentives were generally found to be more effective in enhancing safety than were engineering improvements, personnel selection and other types of intervention (including disciplinary action, special licensing, and exercise and stress reduction programmes).⁶ Reductions in accidents per person-hour of between 50% and 80% of the base rate are not uncommon in manufacturing, construction, and other industries. In another study involving incentive programmes in 73 companies, it was found that the average reduction in accidents in the first year of implementation amounted to 26% and to 69% by the fifth.⁷

The degree of cost-effectiveness of any accident countermeasure is naturally of great interest to those who are responsible for such programmes. These are often expressed as benefit/cost ratios: the amount of money saved through the programme divided by the money needed to run it. This can be calculated and constitutes a benefit over and above the reduction in human pain and suffering, which are more difficult to quantify in monetary terms. The ratios are usually greater than two-to-one, while any ratio greater than one means that the company is making money on the accident

¹Wilde, G.J.S. (1988). Incentives for safe driving and insurance management. In C.A. Osborne, *Report of inquiry into motor vehicle accident compensation in Ontario*, Vol. II. Toronto: Queen's Printer for Ontario, pp. 464-511.

²Gros, J. (1989). Das Kraft-Fahr-Sicherheitsprogramm. *Personalführung*, No. 3, 246-249.

³Haynes, R.S., Pine, A.R.C., and Fitch, H.G. (1982). Reducing accident rates with organizational behaviour modification. *Academy of Management Journal*, 25, 407-416.

⁴Fox, D.K., Hopkins, B.L. and Anger, W.K. (1987). The long-term effects of a token economy on safety performance in open pit mining. *Journal of Applied Behavior Analysis*, 20, 215-224.

⁵Zimbardo, P.G. and Boyd, J.N. (1999). Putting time in perspective: a valid, reliable individual-differences metric. *Journal of Personality and Social Psychology*, 77, 1271-1288.

⁶Guastello, S.J. (1991). *The comparative effectiveness of occupational accident reduction programs*. Paper presented at the International Symposium, Alcohol Related Accidents and Injuries, Yverdon-les-Bains, Switzerland, Dec. 2-5.

⁷Krause, T.R., Seymour, K.J. and Sloat, K.C.M. (1999). Long-term evaluation of a behavior-based method of improving safety performance: a meta-analysis of 73 interrupted time-series replications. *Safety Science*, 32, 1-18.

prevention effort. The economic attractiveness of incentive plans is largely due to discounts in fees payable to workers' compensation boards and other insurance; companies with favourable safety ratings pay lower insurance premiums.

These favourable effects continue to last over time. In fact, we have just seen that effectiveness may actually increase over time. Incentive plans in two American mines were studied over periods of 11 and 12 years, respectively. In one mine the number of days lost due to accidents was reduced to about 11% of baseline, and in the other to about 2%. From year to year, benefit/cost ratios varied between 18 and 28 at one mine and between 13 and 21 at the other. There was no sign that the effectiveness of the incentive plans diminished over time at either mine.¹

A benefit/cost ratio as high as about 23-to-1 has been observed for incentives for safety in the resort hotel business.² A housekeeping and maintenance company in the US reported that \$5 paid out in incentives saved the company an average of \$95 in the cost of injuries. With a benefit/cost ratio of 19-to-1, in the course of two years' time, this company saved US\$2.4 billion off its workers' compensation bill.³

Incentive programmes generally meet with approval from the people to whom they are addressed, and in this respect they compare favourably with the much less popular action of the law and of the police. To put it popularly: a small carrot is not only much better liked than a big stick, it is also much more effective.

Only one negative side effect that has been noticed so far, and that is the tendency of people to under-report accidents when incentive programmes are in effect. Fortunately, however, in a review of some 25 published reports on incentive programmes, such under-reporting has been found to occur with respect to minor accidents only.⁴ It is easy to hide a laceration, much more difficult to hide a corpse.

As we have argued repeatedly, safety incentive programmes owe their effectiveness in reducing accidents to the fact that they motivate operators toward acting safely because the very existence of these incentives enhance the expected benefits of safe behaviour (see Section 4.1). Thus, these incentives counteract the tendency to behave in a risky fashion, which in actual work settings is motivated by the expected advantages of risky behaviour. An experiment conducted in the Netherlands asked the participants to drive and instrumented vehicle that they were told could measure the degree of safety of their driving. When offered a financial reward for safer driving, there were two behavioural effects: the drivers drove more slowly and maintained a longer following distance to the car in front.⁵ In a later experiment, conducted in North-America, a monetary incentive was extended to

¹Fox, D.K., Hopkins, B.L. and Anger, W.K. (1987). The long-term effects of a token economy on safety performance in open pit mining. *Journal of Applied Behavior Analysis*, 20, 215-224.

²Bruening, J.C. (1989). Incentives strengthen safety awareness. *Occupational Hazards*, 51, 49-52.

³Greenberg, J. and Baron, R.A. (1997). *Behavior in organizations: Understanding and managing the human side of work*. Upper Saddle River, New Jersey: Prentice Hall, p. 485.

⁴McAfee, R.B. and Winn, A.R. (1989). The use of incentives/feedback to enhance work place safety: A critique of the literature. *Journal of Safety Research*, 20, 7-19.

⁵Heino, A.H. (1996). Risk taking in car driving: perceptions, individual differences and effects of safety incentives. Doctoral thesis, University of Groningen, the Netherlands.

drivers for refraining from speeding, rather than for greater caution..This study also made use of in-vehicle instrumentation and saw a significant reduction in speeding behaviour.¹ Insurance discounts were the effective incentive for refraining from speeding in still another experiment.²

Two other examples of the crucial role of motivation in the causation of accidents or safety will be mentioned here, one from aviation, one from mining.

After noting that, according to studies conducted by Boeing in the US and by aviation authorities in Russia, more than one-half of jet aircraft accidents could have been avoided if the pilot had adhered to the safety rules, an American researcher wished to determine why pilots do not follow the procedures. The findings led the author to the conclusion that non-compliance with the rules was not due to inadequate perception of the ensuing risk of accident, but inspired by the motive to save time, money, or both.³

Following a coal mining disaster in Nova Scotia in May 1992 in which 26 miners were killed, a public inquiry was established to investigate the causes of the accident.⁴ Part of the inquiry took the form of trying to determine whether the miners were aware of the dangerous conditions in the mine and, if so, why they accepted the risk. Here too, it was concluded that the miners, as well as the mine managers, did indeed perceive the risk, but accepted it, this in part being due to a highly motivating bonus scheme for production that led them to neglect and actually undo safety precautions for the sake of maximizing financial benefit.⁵

11.4 Disincentives

A well-controlled field trial, in which the expected cost of being at fault in an accident was increased, resulted in a marked reduction in the accident rate of the driver population involved.⁶ Military personnel at a US air force base in Texas were informed that their ranks were in jeopardy, and that they even ran the risk of dishonourable discharge from the service, if they were found to be at fault in an

¹Reagan, I.J., Bliss, J.P., van Houten, R and Hilton, B.W. (2013). The effects of external motivation and real-time automated feedback on speeding behavior in a naturalistic setting. *Human Factors*, 55, 218-230.

²Bilderdijk, J.W. and Steg, L. (2011). Pay-as-you-drive vehicle insurance as a tool to reduce crash risk: Results so far and further potential Discussion Paper No. 2011-23, Discussion Paper No. 2011-23. Prepared for the Roundtable on Insurance Costs and Accident Risks, Paris, Sept. 22-23. <<http://www.internationaltransportforum.org/jtrc/DiscussionPapers/DP201123.pdf>>.

³Huntzinger, D.L. (1994). *The motivating factors and perceptions of risk associated with intentional rule breaking among aviators*. Doctoral dissertation, The Union Institute, Cincinnati, Ohio.

⁴Richard, K.P. (1997). *The Westray story: A predictable path to disaster*. The Province of Nova Scotia.

⁵Wilde, G.J.S. (1999). The awareness and acceptance of risk acceptance at Westray. In McCormick, C. (ed.), *The Westray Chronicles. A Case Study in Corporate Crime*, Halifax, Nova Scotia: Fernwood Publishing, pp. 97-116. <http://pavlov.psyc.queensu.ca/faculty/wilde/westray.html>

⁶Barmack, J.E. and Payne, P.E. (1961). The Lackland accident countermeasure experiment. *Highway Research Board Proceedings*, 40, 513-522.

accident. Referral to a psychiatrist was another unpleasant possible consequence. These measures were put into effect for one year and the results were compared with the accident rate before the measures were instituted, as well as with the accident rates of military personnel at other bases without the programme and with general trends. The authors concluded that the number of accidents of personnel at the experimental base diminished by 50%, the total frequency of personal injuries by 54% and of personal injury to the driver by 60%.

Merely engaging in the risky act of driving was economically discouraged in another case. As a consequence of the elimination of Connecticut state subsidies for driver education in high schools, nine school boards decided to drop the courses from the curriculum, while others continued to offer them. Obtaining a driver's licence thus became more expensive. Subsequently, the total number of "licensed years" of 16- and 17-year-olds diminished by 18% in the communities that eliminated high-school driver education, as compared with 7% in communities where this education was retained. The former communities showed a 27% decrease in the traffic accident rate of 16- and 17-year-olds, in comparison with 7% in the other communities. These figures may be calculated from graphs in a report on the Connecticut experience.¹ In passing, you may notice that the reduction in crash rate was considerably greater than the reduction in the number of young drivers who obtained high-school driver education. Once again, one wonders if this type of "education" lulls its graduates into an illusion of safety and thus leads them to behave more dangerously (see Sections 6.2 and 6.3).

11.5 *Requirements for effective incentive programming*

The recorded experience with incentive programmes shows that some programmes have had much greater effect than others. For instance, the German incentive plan, which promised professional truck and van drivers a financial bonus for each half-year of driving without being at fault in an accident, reduced direct accident cost to less than one-third in the first year of application, and remained at that level for over three decades. In the California "good driver" experiment, in which drivers in the general population were offered free extension of their driver's licence by one year in return for each year of accident-free driving, the accident rate dropped by 22% in the first year of the programme. It may be of interest to note that the reduction in accidents was greatest for drivers under 25 years of age.² Reductions in accident rates to between 2% and 11% of the pre-incentive base rates were seen in the two American mines. Thus, the question arises as to what are the distinctive features of the more successful incentive schemes.

¹Robertson, S. (1980). Crash involvement of teenaged drivers when driver education is eliminated from high school. *American Journal of Public Health*, 70, 599-603.

²Harano, R.M. and Hubert, D.E. (1974). *An evaluation of California's 'good driver' incentive program*. Report No. 6, California Division of Highways, Sacramento.

An effort has been made to cull the ingredients of the most effective incentive plans from the various published reports.^{1,2,3,4,5} This has, by necessity, been an effort largely based on inference, because to date there are no well-controlled experiments in which one particular incentive characteristic is being varied and all other factors are kept constant. For obvious reasons, such experiments are not likely to be forthcoming either; industry is not in the business of running such experiments. Yet, the items that appear in the checklist below would seem to make very good sense.

Managerial vigour. The introduction and long-term maintenance of incentive programmes should be conducted with managerial vigour, commitment, and coherence. Workers or drivers should not only be informed of the programme in existence, but they should also frequently be reminded of it in attention-catching ways. In order to motivate and to inform the relevant audience, those in charge of incentive programmes should provide clear and frequent knowledge of results to the audience.

Rewarding the bottom line. Incentive programs should reward the outcome variable (the fact of not having caused an accident), not some process variable like wearing the seatbelt, driving when sober, obeying the speed limit. This is because rewarding specific behaviours does not necessarily strengthen motivation towards safety, and a potential safety benefit due to an increased frequency of one specific form of “safe” behaviour may simply be offset by road users less frequently displaying other forms of “safe” acting. “The risk is there that while the rewarded behavior may improve, other related safe behaviors may deteriorate.”⁶

Attractiveness of the reward. Incentive programmes can be expected to be the more successful the more they widen the utility difference between the perceived benefit of not having an accident and the perceived disadvantage of having an accident. Rewards for accident-free operation in industry have taken many different forms, ranging from cash to public commendation. They include trading stamps, lottery tickets, gift certificates, shares of company stock, extra holidays,⁷ and other

¹Wilde, G.J.S. (1988). Incentives for safe driving and insurance management. In C.A. Osborne, *Report of inquiry into motor vehicle accident compensation in Ontario*, Vol. II. Toronto: Queen’s Printer for Ontario, pp. 464-511, p. 507.

²Lonero, P.L. and Wilde, G.J.S. (1992). Get your incentive program off the ground. *Occupational Health and Safety Canada*, 8, 62-71.

³Wilde, G.J.S. (1998). Incentive Programmes. Chapter 60.16 in Jeanne M. Stellman (Editor-in-Chief), *ILO Encyclopaedia of Occupational Health and Safety* (4th edition). Geneva, CH: International Labour Office.

⁴Wilde, G.J.S. (1996). Improving Trucking Safety and Profitability through Safety Incentive Schemes. In F.F. Saccomanno and J.H. Shortreed (Eds.), *Truck Safety: Perceptions and Reality*. Waterloo, Ontario, Canada: The Institute for Risk Research, 1996 (ISBN 0-9696747-7-5). pp. 217-252.

⁵Wilde, G.J.S. (1998). The concept of target risk and its implications for accident prevention strategies. In A. M. Feyer and A. Williamson (Eds.), *Occupational Injury: Risk, Prevention and Intervention*. London: Taylor and Francis, pp. 82-105.

⁶McAfee, R.B. and Winn, A.R. (1989). The use of incentives/feedback to enhance work place safety: A critique of the literature. *Journal of Safety Research*, 20, 7-19.

⁷Karasina, N.I. (1977). *Psychological and material incentives for the improvement of workplace conditions* (in Russian). Moscow: Scientific Research Institute for Occupational Safety.

privileges. While the flexible uses of money prevents satiation from occurring, merchandise, especially customized merchandise, may have the advantage of constituting a lasting reminder of the value of safety. Merchandise items also have a value-added component in the sense that they can be obtained at a lower price than the recipients would likely have to pay if they bought the items at retail. Not surprisingly, in the United States a substantial industry has sprung up to provide companies with merchandise for safety prizes. Gift certificates hold a middle ground between cash and merchandise; they can be put to flexible use and yet be personalized and imprinted with a commemorative message. As noted above, drivers have also been rewarded with cash, free licence renewal, and automobile insurance rebates.¹

Awards do not have to be very large to be effective. In fact, a case can be made for relatively small awards being preferable. Small awards make it possible to hand out awards more frequently, they are probably less conducive to under-reporting of accidents, and they may foster the internalization of pro-safety attitudes through the process of cognitive dissonance reduction.² When a small reward changes a person's behaviour, that person may justify that change by reasoning that the change was for safety's sake rather than due to the insignificant inducement. No such internalization of pro-safety attitudes is necessary when the external inducement is large, because in that case, it fully justifies the behaviour change.

It should be noted, however, that the attitude-shaping effect of modest awards can only take place *after* the operators have changed their behaviour for some minor external inducement. So, the award should be big enough to achieve some behaviour change to begin with.³ In some cases, a small material reward might imply a major social reward because of its symbolic function. Safe behaviour may thus become "the right thing to do." This might help explain why a modest incentive such as free licence renewal for one year produced a major reduction in the accident rate of California drivers.⁴

Moreover, earlier studies that found that wage increments for dangerous work were exponentially related to increases in the accident rate (to the third power), suggest that small increments in wages as a reward for not having an accident should reduce the accident rate by a comparatively large amount.⁵ This is exactly what seems to have been the case in the German company mentioned above (see Section 11.2).

Progressive safety credits. The amount of the incentive should continue to grow progressively as the individual operator accumulates a larger number of uninterrupted

¹Vaaje, T. (1991). Rewarding in insurance: Return of part of premium after a claim-free period. *Proceedings, OECD/ECMT Symposium on enforcement and rewarding: Strategies and effects*. Copenhagen DK, Sep. 19-21, 1990.

²Geller, E.S. (1990), quoted by Bruening, J.C. Shaping workers' attitudes toward safety. *Occupational Hazards*, 52, 49-51.

³Gregersen, N.P., Brehmer, B. and Morén, B. (1996). Road safety improvement in large companies: An experimental comparison of different measures. *Accident Analysis and Prevention*, 28, 297-306.

⁴Harano, R.M. and Hubert, D.E. (1974). *An evaluation of California's 'good driver' incentive program*. Report No. 6, California Division of Highways, Sacramento.

⁵Starr, C. (1969). Social benefits versus technological risk. What is our society willing to pay for safety? *Science*, 165, 1232-1238.

accident-free periods. It is more difficult to achieve 10 consecutive accident-free years than to simply accumulate 10 years that were accident-free. Proper motivational stimulation demands that the bonus for 10 uninterrupted years of accident-free driving should be greater than 10 times the bonus for one year of accident-free driving.¹

Simple rules. The operational rules of the programme should be kept simple so that they are easily understood by all persons to whom the programme applies.

Perceived equity. The incentive programme should be perceived as equitable by those to whom it is addressed. The bonus should be such that it is viewed as a just reward for not causing an accident in a given time period. Similarly, incentive systems should be designed in such a way that those workers who are not eligible for an award do not resent this, and those rewarded will be seen by others as justly receiving the award.² Since chance plays a part in whether any behaviour is followed by an accident, the actual receipt of the award may be made to depend upon the additional requirement that the accident-free worker in question also maintains cleanliness and safety in his or her workstation.³ In the event that disincentives are used as well, it is necessary that the public view the imposed penalty as justified. In a study of the use on incentives in the trucking industry in Canada, it was found that the provision of an appeal procedure, which accident-involved drivers could invoke when they disagreed with the judgement of management that they had been at fault, greatly enhanced the perceived equity as well as the effectiveness of an incentive scheme.⁴

Perceived attainability. Programmes should be designed in such a way that the bonus is viewed as attainable. This is of particular importance if the bonus is awarded in a lottery system. Lotteries make it possible to hand out greater awards, and this may enhance the attention-getting appeal of an incentive programme. But fewer of the people who have accumulated the safety credit will receive the bonus, and this may discourage some people from making an active attempt to accumulate the safety credit to begin with.⁵

Short incubation period. The specified time period in which the individual has to remain accident-free in order to be eligible for the bonus should be relatively short. Delayed rewards and penalties tend to be discounted, and are thus less effective in shaping behaviour than more immediate consequences. Periods as short as one month have been used in industry. In the cited California experiment (see Section 11.2), those drivers whose licences were coming up for renewal within one year after being

¹Wilde, G.J.S. and Murdoch, P.A. (1982). Incentive systems for accident-free and violation-free driving in the general population. *Ergonomics*, 25, 879-890.

²Markus, T. (1990). How to set up a safety incentive program. *Supervision*, July, pp.14-16.

³Bacher, K. (1989). Erfahrungen mit dem Sicherheitswettbewerb "Sicher arbeiten und 100 Mark gewinnen" bei der Hoogovens Aluminiums Hüttenwerk GmbH. In B. Ludborzs (Ed.), *Psychologie der Arbeitssicherheit*, 4. Workshop, 1988. Heidelberg: Roland Ansager Verlag, 345-346.

⁴Barton, R., Tardif, L.P., Wilde, G. and Bergeron, J. (1998). *Incentive programs for enhancing truck safety and productivity*. Report TP 13256E, Montreal: Transportation Development Centre, Safety and Security, Transport Canada. Also available in French.

⁵Bartels, K. (1976). *Über die Wirksamkeit von Arbeitssicherheitsprämien*. Dortmund, Germany: Bundesanstalt für Arbeitsschutz und Unfallforschung.

informed of the incentive programme showed a greater reduction in accident rate than did people whose licences were not to be renewed until two or three years later.

Rewarding group as well as individual performance. Incentive programmes should be designed in such a way that they strengthen peer pressure towards the objective of having no accident. Thus, the plan should not only stimulate individual operators' concern for their own safety, but also motivate them to influence peers, so that their accident likelihood is also reduced. In industrial settings this is achieved by offering a bonus for accident-free performance to the work team as well as to the individual. The team bonus has been found to increase competitive motivation towards winning the team award. A dual bonus plan—individual *and* team—for drivers in the same age bracket and living in the same city has been suggested and is known as the "Saskatchewan plan."¹ Social pressure towards safe conduct can also be enhanced by informing families about the safety award programme, its safety goals, and potential rewards.² Team awards add a material incentive to act as "one's brother's keeper," and they have also been found effective in isolation, that is, in the absence of awards for individual performance.³

Operator participation in programme design. Any incentive scheme should be developed in cooperation and consultation with those people

to whom it will be applied. People are more likely to achieve goals they themselves have helped define.^{4,5,6} An "incentive" can be an incentive only to the extent it is considered to be an incentive by the audience to whom it is addressed. A programme that fails to have the endorsement of the target audience may be resented and lead to unwanted consequences similar to those observed when unsafe acts are being punished (see Section 11.1).

Prevention of accident under-reporting. Thought should be given to the question of how to counteract operators' tendency not to report their accidents. The stimulation of such tendencies seems to be the only currently identified negative side effect of incentive programmes, although, occasionally, moral objections have been raised against rewarding people for obtaining a goal they should aspire to on their own, without being "bribed into safety." Some incentive programmes have clauses providing for deduction of safety credits if accidents are not reported.⁷ Fortunately,

¹Wilde, G.J.S. (1985). The use of incentives for the promotion of accident-free driving. *Journal of Studies on Alcohol*, Supplement No. 10, 161-168.

²Morisey, M. (1988). Award programs reduce costs, improve worker safety records. *Occupational Health and Safety*, Sept., 64-66.

³Vogel, C.B. (1991). How to recognize safety. *Safety and Health*, January, 54-57.

⁴Komaki, J., Barwick, K.D. and Scott, L.R. (1978). A behavioral approach to occupational safety: Pinpointing and reinforcing safe performance in a food manufacturing plant. *Journal of Applied Psychology*, 63, 434-445.

⁵Latham, G.P. and Baldes, J.J. (1975). The practical significance of Locke's theory of goal setting. *Journal of Applied Psychology*, 60, 122-124.

⁶Pettinger, C.B., Boyce, T.E. and Geller, E.S. (no date). Effects of employee involvement on behavior-based safety 1, <http://safetyperformance.com/involvement.doc> (consulted 2003.03.01)

⁷Fox, D.K., Hopkins, B.L. and Anger, W.K. (1987). The long-term effects of a token economy on safety performance in open pit mining. *Journal of Applied Behavior Analysis*, 20, 215-224.

only minor accidents tend to go unreported, but the greater the safety bonus, the more frequent this phenomenon (as well as hit-and-run accidents) may become.

Reward all levels of the organization. Supervisors and middle management, as well as shop-floor workers, should be rewarded for safe performance. This creates a more cohesive and pervasive safety orientation within a company.^{1,2,3,4}

Whether or not to supplement rewards with safety training. Although educating towards safety is different from motivating towards safety, and a person's ability to be safe should be clearly distinguished from that person's willingness to be safe, some authors in the field of incentives in industrial settings feel that it may be helpful to safety if workers are told what specific behaviours will help avoid accidents.^{5,6,7}

Maximizing net savings versus maximizing benefit/cost. In the planning of an incentive programme, thought should be given to the question of what actually constitutes its primary goal: the greatest possible cost-effective accident reduction or a maximal benefit/cost ratio. Some programmes may reduce the accident frequency only slightly, but achieve this at a very low cost. The benefit/cost ratio may thus be higher than is true for another programme where the ratio between benefits and costs is lower, but the capability to reduce accident rates is much greater. As distinct from the issue of the size of the benefit/cost ratio, the total amount of money saved may well be much greater in the latter case.

Consider the following example. Safety programme A can save \$700,000 at an implementation cost of \$200,000. Programme B can save \$900,000 at a cost of \$300,000. In terms of benefit/cost, A's ratio is 3.5, while B's ratio equals 3.0. Thus, against the benefit/cost criterion, A is superior, but if net savings are considered, the picture is different. While programme A saves \$700,000 minus \$200,000, or \$500,000, programme B saves \$900,000 minus \$300,000, or \$600,000. In terms of net savings, programme B is to be preferred.

Research component. Like any other accident countermeasure, an incentive plan should not be introduced without prior research into its short-term and long-term feasibility and its best possible form. Nor should it be introduced without provision for scientifically adequate evaluation of its implementation costs and its observed effectiveness in reducing the accident rate. The knowledge base of the safety research and application community is unlikely to grow without proper evaluation and ready

¹Bartels, K. (1976). *Über die Wirksamkeit von Arbeitssicherheitsprämien*. Bundesanstalt für Arbeitsschutz und Unfallforschung, Dortmund.

²Bruening, J.C. (1989). Incentives strengthen safety awareness. *Occupational Hazards*, 51, 49-52.

³Doherty, E.M., Nord, W.R. and McAdams, J.L. (1989). Gainsharing and organization development: A productive synergy. *Journal of Applied Behavioral Science*, 25, 209-229.

⁴Zohar, D. (1980). Promoting use of personal protective equipment by behavior modification techniques. *Journal of Safety Research*, 12, 78-85.

⁵Doherty, E.M., Nord, W.R. and McAdams, J.L. (1989). Gainsharing and organization development: A productive synergy. *Journal of Applied Behavioral Science*, 25, 209-229.

⁶Peters, R.H. (1991). Strategies for encouraging self-protective employee behavior. *Journal of Safety Research*, 22, 53-70.

⁷Tschnernitschek, E. (1978). Verkehrssicherheitsprogramm eines Vertriebsunternehmens. *Berufsgenossenschaft*, February.

access to publications. Without such research, the surprising effect of one particular reward programme would never have come to light. There seems little chance for safety incentives to have a negative effect, but one variation of a series of California reward/ incentive programmes for the general driving public produced *worse* driving records. In this programme, a benefit was given to drivers with no accidents on their records, without their prior knowledge of that benefit. It took the form of an unexpected reward rather than an incentive, and this highlights the importance of the distinction between incentive and reward for effective motivational safety programming. The term “incentive” refers to a pre-announced gratification or bonus extended to workers or drivers on the specific condition that they do not have an accident that is their own fault within a specified time period.

11.6 Comparing workers with drivers

Although incentives for accident-free performance have been shown to be effective in making industrial workers safer, as well as drivers in the general population, there are differences between these two types of operation that have implications for programme design and application. For one thing, workers usually operate in relatively small teams of people who know each other. Drivers in the general population operate in a situation of near-anonymity. Workers in industry occupy positions within a clear line of command, while there is no formal hierarchy amongst drivers beyond the content of the highway code.¹ Thus, it is more difficult, though not impossible, to design an incentive system that enhances peer pressure towards safe conduct on the road.^{2,3}

In industry it is relatively easy to keep the incubation period of the award quite short, for instance, as short as a month, like the pay cheque; for drivers in the general population, this would be unmanageable for administrative reasons.

More importantly, perhaps, it is obviously advantageous to companies to institute incentive systems, because the savings (including discounts in insurance fees) are usually very much greater than the implementation costs. The most attractive incentives to drivers in the general population are likely to be those that could, in principle, be offered by automobile insurance companies, and that might take the form of tangible discounts or rebates for claim-free driving.

¹It is noteworthy that in a world-wide study of about half a million fatal employee accidents, 32% occurred during commuting, 19% in driving while-at-work, 50% in the workplace proper. So, at least 50% occurred in highway traffic. It is hard to think of a better justification for including road safety issues in discussions about occupational safety and *vice versa*. See Takala, J (1999). Global estimates of fatal occupational accidents. *Epidemiology*, 10, 640-646.

²Wilde, G.J.S. (1985). The use of incentives for the promotion of accident-free driving. *Journal of Studies on Alcohol*, Supplement No. 10, 161-168.

³Wilde, G.J.S. (1988). Incentives for safe driving and insurance management. In C.A. Osborne, *Report of inquiry into motor vehicle accident compensation in Ontario*, Vol. II. Toronto: Queen's Printer for Ontario, pp. 464-511.

On the other hand, the very fact that one can purchase insurance against certain hazards diminishes the threat of the consequences of these hazards. Insurance, therefore, may be expected to increase people's willingness to expose themselves to these hazards, with an increase in the number of casualties as a consequence. Similarly, it is not surprising that increases in workers' compensation payments for injuries may increase the rate of workplace accidents.^{1,2}

11.7 What a government can do

Suppose a government actually wants to do something about the road-safety problem, rather than merely to be seen to do something about the problem. Suppose a government is more interested in effective road safety action than in "mere road safety rhetoric."³ Thus, suppose a government wishes to develop an incentive programme. What potential incentives does it have available? In industry many varieties of incentives have been used: merchandise; tokens (coupons, stamps) that can be saved up by the recipients and then exchanged for merchandise; cash awards; extra holidays; or other privileges and symbols of social recognition. It is obvious that not all of these would be relevant. Moreover, since cultures, social climates, nations and their governments differ, some incentives may be more useful in one case than another. For one thing, it would make a great deal of difference whether the government in question rules over a jurisdiction where automobile insurance is placed under public or under private control. At this point we will assume that it is in private hands.

Following the California example mentioned above, a government might offer a one-year free driver's licence extension for each year drivers are accident-free. In addition, and as a disincentive, the validity of a driver's licence might be shortened by one year as a penalty for each year in which the driver had one or more culpable accidents. Another way of using driver's licence renewal as a source of incentives/disincentives could consist of discounts and surcharges in the renewal fee.

Following the Connecticut example, a government might abolish any existing subsidies for the provision of driver training. Such subsidies effectively stimulate driving. When they are discontinued, fewer young people obtain a driver's licence and expose themselves to the risk of an accident while driving a car. This, naturally, would be a one-time intervention, rather than an ongoing one.

Another opportunity for incentives is offered by reducing the charge for the annual validation sticker of vehicle permits (the annual road tax). This incentive could be based on the "culpable accident experience of the vehicle," that is, regardless of the

¹Worrall, J.D. (1983). *Safety and the workforce: Incentives and disincentives in workers' compensation*. New York State School of Industrial and Labor Relations, Cornell University: ILR Press.

²Butler, R.J., Durbin, D.L. and Helvacian, N.M. (1996). Increasing claims for soft tissue injuries in workers' compensation: Cost shifting and moral hazard. *Journal of Risk and Uncertainty*, 13, 73-87.

³Køltzow, K. (1993). Road safety rhetoric versus road safety politics. *Accident Analysis and Prevention*, 25, 647-657.

identity of the driver(s) of the vehicle, but depending upon whether the driver was at fault. The incentive would be extended to the owner. Surcharges in annual permit fees might be used as an analogous disincentive.

Discounts and surcharges on income taxes paid by holders of driver's licences might be considered, and this would be justified if a government's expenditures for medical treatment of people injured in accidents exceeds revenue from contributions to medical insurance. Similarly, discounts and/or surcharges related to drivers' culpable accident experience might be applied to their medical insurance fees.

Finally, a government might attempt to exert pressure on private automobile insurance companies to install incentive and disincentive schemes of their own. Other companies, like the ones that sell gasoline and tires, might be requested to provide free merchandise or discounts to drivers who are accident-free over a specified period of time. The companies in question might well find this an appealing proposition in their attempt to attract loyal and creditable customers.

Obviously, some of these bonus and penalty systems would be more cumbersome to implement and administer than others. Part of the administrative difficulty arises from the need for verification of driver and vehicle record accuracy and recency.¹

We will refrain from elaborating here on the procedural details of the above suggestions, for two reasons. First, each of the suggestions offered is in need of an in-depth feasibility study by officials in administrative domains, and in countries in which the present author cannot claim to have expertise. Secondly, although there is reason to believe that the potential accident-reducing effect of the above suggestions is sizable enough to warrant serious consideration, this effect is likely to be relatively modest in comparison with what may be achieved in terms of accident prevention through discounts and surcharges in automobile insurance.

11.8 *The role of automobile insurance*

What *can* insurance companies do to improve traffic safety? The ability to widen a driver's utility gap between having or not having an accident, and thus to lower the target level of risk, would seem considerably greater for automobile insurance companies than is true for any other social agency. This is simply due to the fact that automobile insurance fees in most jurisdictions are much larger than the annual cost of a driver's licence or a vehicle permit, so insurance fees offer much more room for differential incentives and disincentives. Consequently, insurance fee discounts and surcharges, with the inclusion of deductibles, are the best available source for incentives and disincentives.

But what are insurance companies *likely* to do? This is a highly interesting question for a number of reasons, and the striking diversity in points of view is just one of them. Consider, for instance, the following quotations:

¹Harrington, D.M. and Ratz, M. (1978). *The effectiveness of an at-home driver's licensing law test*. Report No. 60, California Department of Motor Vehicles, Sacramento.

“...it is obviously of great interest for the insurance companies [...] to reduce the number of traffic accidents and consequently their cost.”¹

“...insurance...is essentially neutral and indifferent with regard to the occurrence of the events that society defines as accidents...Hence, one can rightfully ask if the very mention of ‘preventive action by insurance’ is not stupid, though well-intentioned.”²

In a similar vein, an insurance commentator writing in Lloyd’s List while commenting on inventors and their safety gadgetry:

“All it needs is the insurance industry to require such equipment to be mandatory, suggest these hopeful people—once again falling into the age-old trap of assuming that the purpose of insurance is in some way to increase safety, or alter human nature, or dramatically to affect statistics. It is an argument which apparently has right and justice on its side, until the truth dawns that insurers are not philanthropists or safety agencies, but merely takers of commercial risks—nothing more, nothing less. Consider the conflict of sentiment which would flash through an underwriter’s mind if a wild-eyed inventor burst into his office, waving plans for some equipment that would make ships virtually unsinkable.”³

According to the first view, the insurance industry has a positive interest in accident reduction. The second holds the view that the insurance industry is not interested in this objective and that it is nice but naive to suggest that preventive action be undertaken by the insurance industry. A third view—expressed by the present author—states that the interests of the insurance industry would actually be served if the accident rate remained at a high level.

“Substantial reductions in the per-driver accident rate may not be welcomed by the automobile manufacturing, retail, repair and insurance industries, as such reductions would likely decrease the demand for new cars and car parts, as well as people’s willingness to pay current insurance fees against a level of risk that would no longer exist. Profits and employment opportunities in these sectors would thus go down.”⁴

¹Vaaje, T. (1991). Rewarding in Insurance. Return of part of premium after a claim-free period. *Proceedings, OECD/ECMT Symposium on enforcement and rewarding: Strategies and effects*. Copenhagen, Sept. 19-21, 1990, pp. 154-156.

²Chich, Y. (1991). L’Assurance automobile peut-elle et veut-elle investir dans l’action préventive? *Proceedings, OECD/ECMT Symposium on enforcement and rewarding: Strategies and effects*. Copenhagen, Sep. 19-21, 1990.

³Gray, M. (1989). Insurance logic that is blind to safety inventions. *Lloyd’s List*, No. 54340, Nov. 2.

⁴Wilde, G.J.S. (1986). Beyond the concept of risk homeostasis: Suggestions for research and application towards the prevention of accidents and lifestyle-related disease. *Accident Analysis and Prevention*, 18, 377-401, p. 398.

“This is another way of saying that the higher the accident rate, the greater the insurance industry’s opportunity for absolute profit. Apart from a sudden and short-term drop in accidents, the insurance companies cannot rationally be expected to show a positive concern for the reduction of the accident rate.”¹

The insurance industry is in a peculiar situation. It offers a much-wanted, even compulsory, service in providing protection against the more serious financial consequences of accidents that happen to its customers. On the other hand, the very fact that insurance can be bought against certain hazards diminishes the threat of the consequences of these hazards and, therefore, may be expected to increase people’s willingness to expose themselves to these hazards, with an increase in the number of casualties as a consequence.² This has also been noticed by several other analysts,^{3,4} just as others have reported that increases in workers’ compensation payments for injuries may increase the rate of workplace accidents.⁵ Phrased in simple terms: to offer people protection against the consequences of risky behaviour encourages risky behaviour; to offer people better protection against the consequences of risky behaviour encourages riskier behaviour still.

A Dutch automobile insurance company advertised its services, quite honestly, by showing a picture of a collision of two cars in front of their office, with the slogan: “Our own driving isn’t always all that fantastic either. That’s why our insurance coverage is so complete.”⁶ In the circle of economists and insurance companies, this phenomenon is known as “moral hazard.”

Automobile insurance sells peace of mind, which is nice, but it is also a problem for that very reason. Not surprisingly, automobile insurance was, at one time, forbidden by law in some parts of the world. It was seen as encouraging imprudence. In short, “l’assurance pousse au crime”—insurance stimulates crime.⁷

¹Wilde, G.J.S. (1988). Incentives for safe driving and insurance management. In C.A. Osborne, *Report of inquiry into motor vehicle accident compensation in Ontario*, Vol. II. Toronto: Queen’s Printer for Ontario, pp. 464-511, p. 507.

²Cohen, A. and Dehejia, R. (2004). The Effect of Automobile Insurance and Accident Liability Laws on Traffic Fatalities. *Journal of Law and Economics*, 47, 357-393.

³Boyer, M. and Dionne, G. (1987). The economics of road safety. *Transportation Research-B*, 21B, 413-431.

⁴Chich, Y. (1991). L’Assurance automobile peut-elle et veut-elle investir dans l’action préventive? *Proceedings, OECD/ECMT Symposium on enforcement and rewarding: Strategies and effects*. Copenhagen, Sep. 19-21, 1990, pp. 150-153.

⁵Worrall, J.D. (1983). *Safety and the workforce: Incentives and disincentives in workers’ compensation*. ILR Press, New York State School of Industrial and Labor Relations, Cornell University.

⁶Zwolsche Algemeene Verzekeringen. (1986). Wij rijden zelf ook niet altijd even denderend. Daarom verzekeren we zo compleet. *De Telegraaf*, August 16.

⁷Ewald, F. (1992). Insurance and prevention: Conflict or convergence of reasoning? *Proceedings, OECD International Conference on Automobile Insurance and Road Accident Prevention*, Amsterdam, April 6-8.

Another example of the nefarious effect of “better protection” upon safety is the institution of no-fault insurance for drivers. No-fault insurance means that drivers who collide with one another are entitled to compensation for the damages incurred, regardless of who was responsible for the collision. Thus, the cost for being responsible for an accident is reduced. A law to this effect came into force in Québec in 1978, along with some other minor regulations. An economist working in that part of the world, and interested in establishing the effect of the law, calculated that accidents with property damage only increased by 11%, accidents with personal injury by 26%, and fatalities by 7%. The economist noted that, while the “centralized compensation system [...] generally increased the speed, frequency, and size of compensations, it also probably led to a condition that would lower the incentive to drive safely,” and that “lowered the average quality and motivation to safety of the stock of drivers because of the sudden subsidy given to relatively risky drivers and the suppression of the notion of fault for all drivers.”¹ An American study came to the conclusion that the introduction of no-fault insurance led to even higher increases in the rate of fatal accidents, i.e., 10-15%.²

So, the very existence of automobile insurance, as well as its specific operational rules, may have the effect of increasing the size of the problem it sells protection against. The opportunity for profit to the insurance industry also increases in this process.

Therefore, for the sake of safety, it is desirable that insurance practices are structured in a manner such that risk-taking tendencies of customers are being counteracted. One attempt in this direction is to offer premium discounts to young drivers who have had a particular type of driver training. Another is premium discounts for periods of accident-free driving.

In North America it is not uncommon for insurance companies to offer discounts for newly licensed drivers, provided they have taken a driver education course offered by high schools. There is no evidence whatsoever that such a course has a beneficial effect upon the accident rate of graduates (see Section 6.2). The fact that, nonetheless, they are offered an insurance discount, could either be explained by the insurers suffering a mistaken belief in the accident-reducing effectiveness of such courses, or their expectation that the discount will effectively subsidize driving by young people and thus enlarge the market of potential insurees and thus the potential for profit. The marked sensitivity of young people to subsidies that help them obtain a driver's licence and, thus, the ability to drive, has been clearly established (see Section 11.3). Where such subsidies were eliminated, there was a sharp decline in road accidents among the relevant age groups.

In the province of Ontario, Canada, it is common practice for insurance companies to give fee discounts that are greater as the number of claim-free years increases. But

¹Gaudry, M. (1991). Measuring the effects of the no-fault Québec Automobile Act with the DRAG model. In G. Dionne (Ed.), *Contributions to insurance economics*. Boston, Kluwer Academic Publishers, pp. 471-498.

²Landes, E.M. (1982). Insurance, Liability, and Accidents: A Theoretical and Empirical Investigation of the Effects of No-fault Accidents. *Journal of Law and Economics*, 25, 49-65.

this is only true for up to five years of accident-free driving, as if such discounts would have no accident-reducing effect beyond that period.¹ In passing, we note that Icelandic drivers receive free automobile insurance during the 10th year, if they are claim-free during the preceding nine years. And what may be worse from the point of view of accident prevention in Ontario, is that a driver with five or more fault-free years, who has an accident in which he or she is at fault, is not likely to incur an increase in insurance fees. The reason the insurance companies have this “forgiveness clause” would seem to be that the driver in question is seen as a relatively good risk whose business would be badly missed if it went to the competition. This practice, however, fails to bring the accident rate down to a level as low as it perhaps could have been otherwise. The same may be true for insurance that is offered in some countries—Great Britain, for instance—against losing one’s driver’s licence as the consequence of some behaviour such as driving while under the influence of alcohol.

One thing that’s clear from these considerations is that the optimal accident rate is different for different people. In the 1970s, this was emphasized by an author who, for reasons of social equity, proposed the notion of an “accident tax” to be levied on companies in order to compensate for the fact that only part of accidents costs are carried by the company in question, and the other part by society in general.² This accident tax would be expected to stimulate companies to make an additional effort at accident reduction. Because different social factions are interested in different levels of safety, and interested in different means for attaining it, safety is a bone of contention, a political issue. Safety is not as sweet and innocent as motherhood and apple pie. Rather, it is an apple of discord and it would be wise to be cognizant of this fact.

While, as individual persons or as corporate citizens, people in the private insurance industry may have a genuine interest in promoting safety, one cannot expect a business to act against its direct commercial interests. However, it is no less relevant to note that the absence of a strong concern for reducing the accident rate may also be reflected by many of the countermeasures taken by those governments that have no direct financial or political stake in actual accident reduction. This is because politicians may be tempted, for public relations reasons, to take measures whose main or exclusive merit consists of showing the electorate that something is being done about the safety problem. Surely, political expedience demands that safety is *seen* to be promoted; whether it actually *is* promoted is another matter.^{3,4}

¹Wilde, G.J.S. and Murdoch, P.A. (1982). Incentive systems for accident-free and violation-free driving in the general population. *Ergonomics*, 25, 879-890.

²Smith, R.S. (1973-1974). The feasibility of an injury tax approach to occupational safety. *Law and Contemporary Problems*, 38, 730-744.

³Hauer, E. (1991). The behaviour of public bodies and the delivery of road safety. *Proceedings, OECD/ECMT Symposium on enforcement and rewarding: Strategies and effects*. Copenhagen, Denmark, Sep. 19-21, 1990, pp. 134-138.

⁴Wilde, G.J.S. (1986). Beyond the concept of risk homeostasis: Suggestions for research and application towards the prevention of accidents and lifestyle-related disease. *Accident Analysis and Prevention*, 18, 377-401.

Unfortunately, when the recent history of road safety management in various countries or smaller jurisdictions is compared with other government concerns such as health care, it will be obvious that many governments have failed to develop coherent and vigorous strategies for traffic accident prevention. In part, this may be due to the fact that responsibility for safety is usually divided across various ministries, such as health, education, justice, transportation, and internal affairs. This very division of responsibility may reflect lack of governmental concern for the issue.

In this context it should be noted that general public pressure for greater safety is also lacking. Apart from occasional outcries by some citizen groups in some jurisdictions against the omnipresent infestation of automobiles, or against the safety threat posed by heavy trucks or by the young or drunk drivers, there seems to be no strong and persistent demand for greater safety throughout the general population.

If, in fact, such a demand existed, people would not wait for government action, but simply resort to their own capabilities to reduce the accident rate by voluntarily changing their amount and manner of road use. In other words, people in any jurisdiction have the accident rate they are collectively willing to accept, in return for the amount and manner of mobility they enjoy. Unless the desire for safety is somehow stimulated, people will exert only a little pressure on their government to reduce the accident rate, and in turn, the government is not likely to develop the political will that is necessary to take more than symbolic measures towards accident reduction. It would seem fair to conclude that there is little ongoing governmental, corporate or public interest in reducing the traffic accident rate. Whether this is irrational or not is another matter. So far in this report, we have made the tacit assumption that the accident rate should be reduced, but against the criterion of *net* social benefit maximization, this may not be so obvious.

Even if it were true that reduced speed limits save lives on the road, the increased travel time may produce greater costs to society than the benefits in casualties saved.¹ Data have been produced in Norway to support the following statement: "An objective of eliminating a certain cause of death, like traffic accidents, may be so expensive to realise that there are so many fewer resources available to control other causes of death that general mortality increases."² In other words, we are told that we are dealing here with a situation of risk versus risk: an increase in effort to reduce one risk may lead to an increase in another risk. It should be emphasized, however, that the author's reasoning may well be in error. This is because the estimates of lives saved due to measures such as banning motorcycles, mandating the use of helmets by bicyclists and the wearing of reflectors by pedestrians, are decidedly hypothetical and probably grossly exaggerated, if not plainly illusory, while remaining unsupported by empirical evidence in before/after studies. There are all of the "delta variety illusion" the illusion described in Chapter 1 above. The accident countermeasures cited are claimed to be able to reduce the overall accident rate by acting upon various

¹Kamerud, D.B. (1988). Evaluating the new 65 mph speed limit. In J.D. Graham (ed.), *Preventing automobile injury*. Dover, Massachusetts: Auburn House, pp. 231-256.

²Elvik, R. (1999). Can injury prevention go too far? Reflections on some possible implications of Vision Zero for road accident fatalities. *Accident Analysis and Prevention*, 31, 265-286.

immediate causes of accidents (as in the “delta illusion”), and do not consider the possible operation of accident migration, accident metamorphosis, or risk substitution or redistribution in general.

This is all the more astounding as the same author, in a different publication of his, discusses the operation of behavioural adaptations to technical safety measures in great length and acknowledges that these “may in part or in whole offset the effects of those measures on safety.”¹ This he illustrates by the finding that the provision of pedestrian and bicycling paths in Scandinavia has not been found to reduce the number of accidents involving pedestrians or cyclists.² He also notes that the installation of road lighting is followed by higher driving speeds at night, reduced driver alertness (as indicated by less careful lane-tracking), and by people who formerly did not drive at night subsequently beginning to do so.

Speaking of accident migration, it is worth noting that enforcement of speed limits – as one example of “delta illusion intervention” – may merely have the effect of “accident migration.” A German study reports a 21% reduction on an expressway following the introduction of a speed limit where formerly no limit had existed. A stretch of expressway running parallel to the one with the new speed limit experienced a 29% increase in accidents, apparently as the result of the fact that drivers who did not want to forgo speedy progress simply took an alternative route.³ So, according to the first paper lives can be saved by technical countermeasures; according to the second paper behavioural adaptation may cancel countermeasure effect. Can one have it both ways?

In order to break the vicious circle (vicious from the safety promotion point of view) between people’s complacency about the accident risk they seem to be willing to accept, and a lack of political will on the part of their elected representatives to reduce the accident rate, what can a government do?

Suppose we are dealing with a government that is fully aware of the tremendous costs of traffic accidents to its jurisdiction. Suppose, too, that we are dealing with a government that wishes to play a leadership role in reducing the traffic accident rate per head of population, rather than to remain a mere follower of existing public attitude and conduct. In that case, the answer to what a government could do in order to reduce the traffic accident rate is very simple: (a) assume public responsibility for automobile insurance, and (b) impose insurance fees that take account of each individual driver’s past accident record and of the requirements for effective incentive programming described above. In doing so, a government would be able to achieve two things: it would pull itself up by its own bootstraps in becoming more concerned

¹Elvik, R. (2002). To what extent can theory account for the findings of road safety evaluation studies? Paper presented at the conference of the International Cooperation in Theories and concepts in Traffic Safety (www.ictct.org), Brno, Czech Republic, Oct. 23-25.

² See also Section 7.3.

³Pfafferott, I. and Huguenin, R.D. (1991). Adaptation nach Einführung von Sicherheitsmassnahmen. *Zeitschrift für Verkehrssicherheit*, 37, 71-83.

about safety promotion than before, and it would enhance the general public's desire for safety and strengthen public support for government action toward that goal.

In addition, there is reason to expect that a government's commitment to road safety promotion will increase with time if it assumes responsibility for accident insurance. When claim costs rise from year to year as a consequence of continued inflation, there would seem to be three options for a government to cope with this:

- Impose higher insurance fees upon the electorate.
- Absorb the increased costs through other revenues, including taxes.
- Attempt to reduce the accident rate.

Since the first two alternatives are unlikely to be attractive to a government that wishes to stay in power, it will be more inclined to develop a stronger thrust in the pursuit of accident reduction.

11.9 *Recapitulation*

The argument developed in this chapter may be summarized as follows. Of all accident countermeasures that are currently available, those that affect people's motivation towards safety seem to be the most promising. Of all countermeasures that affect people's motivation towards safety, those that reward people for accident-free performance seem to be the most promising. Of all possible incentive schemes that reward people for accident-free performance, some promise to be more effective than others because they contain the elements that appear to enhance motivation towards safety.

Of the two major social establishments that can offer incentives—governments and automobile insurance—automobile insurance institutions would seem to be able to offer the most effective ones. Automobile insurance companies, however, when run by private enterprise, cannot be expected to implement incentive programmes with vigour and persistence, because a very low accident rate in the jurisdiction in which they operate is not in their business interest.

Governments, on the other hand, often are more interested in being seen by the citizenry to be doing something about the road safety problem, rather than actually doing something about it, while citizens seem to accept the road accident toll in return for the benefit of the amount and style of road use they enjoy. Citizens, however, can be made more interested in displaying self-protective behaviour if they are better rewarded for safety. Then they will put greater pressure on governments to pursue the goal of safety more vigorously.

Ergo, the merits of public, as opposed to private, ownership of automobile insurance deserve to be seriously debated.

Besides having the possible negative side effect of accident under-reporting, incentives also have *positive* side effects. For one thing, they are a money-making proposition in industry: savings in terms of accident reduction usually exceed by far

the costs of implementing a programme of this kind. For another, they lead to better company morale.¹ As is true for successful productivity gainsharing programmes,² safety incentive programmes can help improve the general organizational climate and, therefore, make a positive contribution to productivity over and above the gain due to accident reduction. Safety incentives give workers a common cause with each other as well as with management. Reinforcing safe acts “removes the unwanted side effects with discipline and the use of penalties; it increases employees’ job satisfaction; it enhances the relationship between supervisors and employees....”³ Is it unreasonable to expect that incentives for safety and health, applied to the general population, would not only promote safety and health, and the nation’s economic wealth, but also have the favourable side effect of improving the general social climate, including people’s respect for the authorities and the law of the land?

A leading literature review contains the following statement: “The major finding was that every study, without exception, concluded that incentives or feedback enhanced safety, and/or reduced accidents in the work place, at least in the short term. Few literature reviews find such consistent results.”⁴ So, if incentive programmes are found to be the most powerful tools for safety on the job and on the road, why are they not implemented much more frequently than is presently the case? One factor may be plain ignorance of their very existence, or lack of knowledge as to how they are best implemented. Another factor may be the fear that accident under-reporting will be the result. While there is some justification for this, it is also valid to say that, in industry, it may be possible to conceal a minor injury, but one cannot as easily hide a corpse. There may be resistance because of the attitudes of unions, of management or, more generally, because of company climate.

Particular incentives that appeal to operators in one cultural context may be viewed as mere “hoopla” in another. In addition to ignorance and opposition, there may be indifference to the notion of accident reduction because it would have little consequence for the company concerned. This may be the case if the company has proper insurance against accident consequences and if the insurance premium to be paid does not depend upon the safety record of the company in question. An official in one such company told me that there was more interest in having a good estimate of *how many* accidents were likely to happen in the future, rather than in having *fewer* accidents, because having that estimate would help in planning for equipment and personnel that would have to be replaced.

¹Fox, D.K., Hopkins, B.L. and Anger, W.K. (1987). The long-term effects of a token economy on safety performance in open pit mining. *Journal of Applied Behavior Analysis*, 20, 215-224.

²Doherty, E.M., Nord, W.R. and McAdams, J.L. (1989). Gainsharing and organization development: A productive synergy. *Journal of Applied Behavioral Science*, 25, 209-229.

³McAfee, R.B. and Winn, A.R. (1989). The use of incentives/feedback to enhance work place safety: A critique of the literature. *Journal of Safety Research*, 20, 7-19.

⁴Op. cit.

*L'espoir fait vivre.
While there is hope, there is life.*

12 Further perspectives

The preceding chapter contains ample evidence to show that the accident rate per person-hour, at work or on the road, can be greatly and durably reduced. This can be achieved by interventions that are specifically aimed at bringing down the level of risk people are willing to accept. The evidence supports the main tenet of this report—namely that the temporal accident rate depends on the level of risk of death, disease and damage that people accept in return for the expected benefits of risk taking. When the benefits of risk taking are reduced and the advantages of cautious action are enhanced, people will be *motivated* to take less risk. They will react accordingly and, consequently, society's accident losses will be reduced.

It also seems fair to conclude that major reductions in the traffic accident loss per person-hour or person-year, and thus per head of population, have *not* been achieved by interventions in the form of training, engineering or enforcement. This has been clearly documented in other chapters, notably Chapters 5 through 8. Although some of the interventions of this kind may have been capable of reducing the traffic accident rate per unit distance driven, or the number of accidents at a particular location, these interventions do not seem able to achieve a reduction in the accident rate per time-unit of participation in traffic, or per person-year in the population. Such measures may be useful in allowing people to drive more accident-free kilometres per hour of road use and per year of life, but they fail to add years to their lives. This failure, too, can be understood as being a consequence of the mechanisms postulated by Risk Homeostasis Theory.

The theory says that a nation's accident rate per head of population is the outcome of a closed-loop control process. In this process, fluctuations in the accident rate determine fluctuations in the degree of caution people subsequently apply in their behaviour. And fluctuations in the degree of caution are the cause of the ups and downs in the nation's per capita accident rate. We have also seen that potentially occurring fluctuations in the accident rate are greatly reduced by people's ability to anticipate the potential consequences of health and safety interventions of the technological—read “non-motivating”—kind. Feedback, together with anticipation, leads to adaptive behaviour, which has a stabilizing (not a reducing) effect on accident risk. The homeostatic nature of the “accident-production” process implies that a jurisdiction's ability to reduce the accident rate per head of population depends upon that jurisdiction's ability to reduce the amount of risk people choose, accept, prefer, tolerate—their target level of risk, in short.

As we have seen from the previous chapter, incentives for safe performance are able to reduce the accident rate per person-hour of participation in the risky activity. Effective treatment of the problem is directed at its cause, not at its symptoms, while treatment of symptoms provokes symptom substitution. It is not difficult to conceive of effective measures for safety and health insofar as these are dependent on human behaviour, once we have liberated our reasoning from the tyranny of the delta illusion

first mentioned in Chapter 1. By obstructing the channels, one cannot prevent the water that flows through a river delta from reaching the ocean. The solution has to be found upstream. One cannot reduce the accident rate and the lifestyle-dependent damage to health by piecemeal measures that fail to affect the superordinate cause.

Sometimes the delta illusion is obvious and displayed in simple terms, for instance, in the belief that clearer edge-markings will reduce the highway accident rate in a population. At other times, the fallacy is shrouded in a more complicated argument that has at least the appearance of sophistication.

As an example, consider the type of reasoning that has been put forward to demonstrate the life-saving benefit of seatbelt legislation. Accident analysis in the USA has shown that, in years prior to mandatory seatbelt use, about half as many front-seat passenger-vehicle occupants, who had their seatbelts buckled, were killed in their collisions as compared with front-seat occupants, involved in collisions of similar impact, but who were not wearing their seatbelt. Thus, assume that seatbelts, when worn, are about 50% effective in preventing a fatality. Now compare the numbers of front-seat occupants killed in collisions before and after seatbelt wearing became compulsory. On the basis of the numbers killed who had their seatbelt on, an estimate is made of how many front-seat occupants must have survived their collisions due to using their belts (i.e., about the same number). Finally, show that there has been an increase in seatbelt wearing as a result of the legislation, and the number of people “saved by the seatbelt legislation” can be calculated.¹

In one study, this type of reasoning led to an estimate of some 7,000 lives saved in the USA during the five-year period between 1983 and 1987.² Here, the delta illusion is reflected in the tacit, but faulty, *assumption* that seatbelt legislation only influences the seatbelt-wearing rate, while no other aspect of driver behaviour is affected. On the basis of *factual* data, it may be further noted that the number of fatally injured seatbelt-wearing front-seat occupants in passenger vehicles increased more than six-fold, from 714 in 1983 to 4,709 in 1987. The percentage of fatally injured front-seat occupants of passenger vehicles relative to all traffic fatalities rose slightly, from 63.7 to 65.1%. In the same period, the total number of traffic deaths per annum rose from 41,609 to 45,406, which is equivalent to an increase of about 9%, or about 2% per year (and about twice as fast as the population growth). Note that the data are presented in the very same US government report that claims that thousands of lives were saved!

So, where is the evidence for the thousands of lives that were supposedly saved by the seatbelt legislation? When we rid ourselves of the delta illusion (see Chapter 1), what we see instead is an *increase in lives lost*. This increase may be related to the drop in the unemployment rate that occurred in that period (see Section 5.4 and Figure 5.1). Another possible explanation is that we are dealing here with yet another case of seatbelt legislation leading to an increase in accident frequency. This is what seems to

¹Evans, L. (1991). *Traffic safety and the driver*. New York: Van Nostrand Reinhold (Chapter 10).

²Partyka, S.C. (1988). *Lives saved by seat belts from 1983 through 1987*. Report No. DOT HS 807 324. Washington, DC: US Department of Transportation, National Highway Traffic Safety Administration.

have taken place in various other countries. Evidence has been presented in Section 8.2 which also suggests why this may have been so.

Certain, however, is that the delta illusion shows a marked immunity against the type of thinking developed in the present report. The reasoning error committed in the two American studies cited above echoed again in a Canadian government report that claimed that seatbelts and airbags had saved as many as 11,690 lives from 1990 to 2000 in light-duty vehicles (such as pick-up trucks, vans, and sport-utility vehicles) alone!¹

Here comes another example of insensitivity to the possibility that people might have a response of their own to a technological change that an American government agency considers as a possible “safety intervention.” The idea is to glaze automobile windows with a substance that will reduce the likelihood of car occupants who do not use their seatbelts being ejected from their vehicle when a crash occurs. On the basis of the historical observation that the likelihood of death is much greater in a crash when occupants are ejected, “large benefits of ejection prevention” are being claimed,² just as once was done for mandatory seatbelt wearing, the installation of airbags, anti-lock brakes, and other safety gadgetry. The common safety misconception of being “thrown clear” in a crash is here receiving competition from the opposite, but equally questionable, assumption, namely that safety can be enhanced by “containment.” A further example of this type of thinking is a 1998 Swedish study according to which “fixed roadside objects cause 100 fatalities each year;” the authors suggest that these could be saved by removal of these objects.³

Trees don’t kill, or do they? If the reasoning developed in this report is correct, removal of the trees may reduce the accident rate per km driven, but it won’t save lives. Have another look at Section 5.2, and Figure 5.2 in Section 5.1. Those who fail to learn from history are doomed to repeat it. So are those who feel that “the evidence from the past that adaptive or compensatory processes are seriously reducing or even negating the effectiveness of safety measures [note: no denominator for calculating the accident rate provided!] is slender and far from conclusive, and poses little threat to current road safety practice.”⁴ Is the evidence really so slim, or is perhaps the threat to conventional and uncritical thinking so great that the evidence, for comfort’s sake, has to be belittled? “Faced with the choice between changing one’s mind and proving

¹Transport Canada, Road Safety Directorate (2001). Evaluation of the effectiveness of air bags and seat belts: estimates of lives saved among front seat occupants of light-duty vehicles involved in collisions attributable to the use of seat belts and air bags in Canada. A follow up. Report TP#13187 E, Fact Sheet RS 2001-03E, Ottawa, Canada.

²Winnicki, J. (1996). *Estimating the injury-reducing benefits of ejection-mitigating glazing*. Washington, DC: Mathematical Division; National Center for Statistics and Analysis; Research and Development, National Highway Traffic Safety Administration, US Department of Transportation, Report DOT HS 808 369.

³Nilsson, G. and Wenäll, J. (1998), *Fixed roadside objects cause 100 fatalities each year*. (In Swedish). Nordic Road and Transport Research, 10, No. 1, 13-15.

⁴Grayson, G.B. (1996). *Behavioural adaptation: A review of the literature*. Report 254. Crowthorne, U.K.: Transport Research Laboratory, p. 22.

that there is no need to do so, almost everyone gets busy on the proof," according to economist John Kenneth Galbraith.

The traffic safety issue described above has its analogue in the area of health. In discussions of deaths in relation to unhealthy habits and lifestyles, it is not uncommon to read statements to the effect that, in a given country, so many thousands of people per year die as a consequence of being overweight, contracting sexually-transmitted disease, or smoking cigarettes. Obviously, if we take an estimate that 10,000 people per year die as the result of smoking-related illness, it cannot logically be inferred that the country would count 10,000 more citizens at the end of the year if these 10,000 people had never smoked.

Although risk homeostasis theory is not only concerned with accidents, but lifestyle-dependent disease and death as well, this text has included comparatively little evidence for its validity in the latter area. This is because of a dearth of definitive data. The number of people who die in accidents can be assessed with a relatively high degree of accuracy. It is, however, much more difficult to determine with a similar degree of certainty how many people die prematurely as a result of smoking, sunbathing, consuming too much alcohol, being overweight or underweight, being sexually promiscuous, having too little or too much physical exercise, and so on. There are simply too many other factors at work at the same time, factors of unknown degrees of importance and over which the individual has no direct control. These factors include genetic predisposition, environmental conditions (including pollution as well as threats posed by nature itself), and bacteria and viruses.

12.1 *Expectationism*

In connection with incentives for safe performance, it is of interest to note that incentives may be viewed as *just one example* of a wider class of interventions that hold the promise of doing much more than the fatal accident rate per capita. Incentives also hold promise for reducing lifestyle-dependent disease and death rates, as well as diminishing the level of violence in society.

Offering a person a reward for not having an accident in the future implies offering that person a reason for looking forward to the future with increased expectations. Therefore, it also amounts to motivating that person to be more careful with life and limb and to take the measures necessary to be alive and well when that future comes.

Hence, a *motivational* approach is offered as an alternative to the traditional "Triple E" (Engineering, Education and Enforcement) ideology for increasing safety—an ideology that we have seen to be rather ineffective in reducing the accident rate per head of population. A "Single E" approach is being suggested here for the purpose of reducing the accident rate per head of population: "Expectationism."

Expectationism is the name of the preventative strategy for reducing the accident rate and lifestyle-dependent disease and death rate per head of population by

enhancing people's perceived value of the future.¹ Expectationism is the art of offering greater expectations. Two varieties may be distinguished: "specific" and "general." A *specific* expectationist strategy demands that a person fulfill a particular requirement at some future point in time, such as not having been at fault in a road accident or not suffering from alcohol-related cirrhosis of the liver, not suffering from smoking-related respiratory disease, or some other specific criterion of health. The "general" variety sets no detailed criteria; all a person has to do to receive the reward is to be alive at that future date at which the incentive has been promised to materialize.

Consider, as a very simple example of general expectationism, a society in which every citizen is promised, upon reaching the age of retirement, a sum of money that equals five or ten times the average annual wage, in addition to current pensions and old-age benefits. This prize would stimulate people to use and develop their survival skills in such a way that more people than presently is the case will reach that age and be fit enough to enjoy the bonus.

The amount of money to be paid out in this example may appear large, but the benefit to the nation's economy may well be found to be larger still, if one considers the amount of money that could be saved. The savings would take the form of reduced costs of medical care, physical damage and disability compensation, as well as a reduction in the current economic loss due to forgone wages and a person's contribution to the gross national product. Consider, too, the savings that would accrue to a nation if governments no longer relied on safety legislation, engineering technology, law enforcement practices, and educational measures of various kinds. These represent large expenditures, but fail to reduce the accident rate per capita to a significant degree, as we have seen from the available evidence.

Additional benefit would come from a reduction in the social cost of *violence*. To be violent is to run a major risk to one's life or health, because of the damage that the perpetrator may incur in attacking another person. Hence, expectationism also holds the promise of reducing violence, not just accidents and lifestyle-dependent diseases.

Basic to expectationism, and thus to people's efforts to be cautious, is the distinction between the perceived value of present time and expected value of the future. When the first of these two values is high, that is, when every minute counts and money can be made by rushing and cutting corners on the use of safety equipment and precautions, people will be oriented toward the immediate gratification of their desires. They will thus sacrifice safety for the sake of need fulfillment here and now.²

When, however, the perceived value of the future is high, people will sacrifice immediate pleasures for the sake of richer gratifications in the future, and they will

¹Wilde, G.J.S. (1986). Beyond the concept of risk homeostasis: Suggestions for research and application towards the prevention of accidents and lifestyle-related disease. *Accident Analysis and Prevention*, 18, 377-401.

²We are, of course, dealing with a deadly serious issue here, but readers who wish to read a more irreverent account of examples of such behaviour are referred to www.darwinawards.com.

make efforts to safeguard that future. They will thus be more prudent in their actions. They will save, rather than spend.

As a consequence, the tendency to be cautious and safety-oriented will depend on the *balance* between the values of the future and the present.

In an effort to obtain some insight as to whether this balance may or may not have changed over historical time, we consulted international statistics on the frequency of violent death. The notion of violent death includes three categories: fatal accidents of all kinds (not just in traffic or in industry), homicide and suicide. Data from 31 different industrialized countries around the globe—in Europe, the Americas and around the Pacific—have been collected¹ and may be compared across the first 75 years of the 20th century.

Such comparisons should be made with care because countries' populations differ from one another in their gender and age-group proportions, and these proportions may change over time within any given country. The greater the proportion of young males to the total population, the higher the violent death rate one might expect, other things being equal. Therefore, in order to insure fairness of comparisons between countries at any point in time and within the same country across different time periods, it is necessary to take account of any variations in the gender and age contingents in the populations. This is achieved by "correcting" the mortality statistics for variations in the gender-by-age distributions, and obtaining what are called *standardized mortality ratios*.

What is remarkable about these standardized ratios of mortality due to violence is their pattern from roughly 1900 to 1975 (unfortunately, no comparative tabulations have been published since that time). This pattern shows that, if periods of war are disregarded, the ratios have changed remarkably little in the great majority of countries—the ratios in the first decade of the 20th century and in 1975 are virtually the same!² The violent death rate appears to have been largely impervious to the massive advances made since the early 1900s in the design of roads and vehicles, in education, in safety legislation, in medicine and so forth. Note that the human-made environment over this time period has changed dramatically, almost beyond recognition. We can look at old photographs or motion pictures for evidence of this. The massive environmental changes might well have influenced specific forms of risk taking, but would not be expected to modify its overall level. These measures are not motivational in nature and thus fail to influence the target level of risk. In other words, they fail to enhance the desire for health, safety, and a longer life.

And note, in particular, that there were very few automobiles around in the first decade of the 20th century while, in the 1970s, traffic deaths were responsible for about one-half of all accidental deaths. The data presented in Section 5.3 suggest that the introduction of the automobile has not even had much influence on the violent

¹Alderson, M.R. (1981). *International mortality statistics*. New York: Facts on File.

²Wilde, G.J.S. (1986). Beyond the concept of risk homeostasis: Suggestions for research and application towards the prevention of accidents and lifestyle-related disease. *Accident Analysis and Prevention*, 18, 377-401.

death rate as far as traffic is concerned. So, neither the appearance of the automobile, nor the various road and vehicle engineering improvements ever since, seem to have had a major impact on the violent death rate. As far as road fatalities are concerned, Figures 5.2, 5.3 and 5.4 also fail to show a downward trend.

Yet, there is an element of surprise in the stability of the standardized mortality ratios in connection with violence. It conflicts not only with a general belief in progress (a belief that may be cherished rather than founded in fact), but, more specifically, with a perception that the value of the future improved over the first 75 years of the 20th century. Pensions have improved; so has housing and health care for the elderly, the poor, and the disabled; and many other forms of social legislation have been introduced in both “leftist” and “rightist” countries. These measures should have given citizens in these countries reason to look forward to the future with greater confidence and expectations, with an increased sense of control over their lives, with more hope, and thus a stronger desire to stay alive and be healthy. Life expectancy has significantly increased; thus, there is more future indeed.

So, there *is* reason to believe that the perceived value of the future has increased. That, nevertheless, the violent death ratios have not dropped may be due to the fact that another factor has been at work, a factor that favours the taking of physical risk and that also became more prominent during the course of the 20th century. It can be argued that the other factor is the perceived value of present time, time here and now. If present time is highly valued, that is, if every minute counts, people will be likely to speed, to cut corners and take short cuts, to jump lights, to rush to their destination. They will focus on performance and productivity, disregarding safety precautions that would slow them down or otherwise interfere with earning immediate benefit. Higher wages for greater productivity, piecework, and generous overtime pay, economic booms (see Section 5.4), and so on, are all reasons for accepting greater accident risk. The target level of accident risk in the population would thus be expected to rise with increases in the value of present time. The 20th century saw major increases in wages, commissions, and salaries. Although the perceived value of the future may have increased, so did the perceived value of the present. If both factors increased by the same degree, no change in the violent death rate would be expected. It might be of interest to search for other time-series data that might shed a light on the issue.

On a more immediate level, several studies have attempted to relate inter-individual differences in safe and unsafe behaviours to measures of future and present-time orientation of the individuals concerned. A study of Québec motorists that used this conceptualization found that individuals who were characterized by a comparatively high valuation of the future had more favourable attitudes to automobile safety, fewer demerit points, and fewer road accidents.¹ American

¹Chebat, J.C and Chandon, J.L. (1986). Predicting attitudes toward road safety from present and future orientations: An economic approach. *Journal of Economic Psychology*, 7, 477-499.

university students with a stronger future orientation have been found to refrain more often from smoking cigarettes,¹ and from risky sexual activities.^{2,3}

Research at our own university in Canada asked more than 600 students to report on their compliance with eight health and safety related behaviours: safe driving, regular seatbelt use, moderate drinking, healthy diet, not smoking, regular exercise, few sexual partners, and condom use. We also developed a self-report instrument for three different aspects of a person's time horizon: future-time value, present-time value, and future planning. With the exception of few sexual partners and condom use⁴, the health and safety related behaviours could be predicted from scores on the time-horizon questionnaire, with future planning having the strongest association with health and safety.^{5,6} Using their translation of our time horizon questionnaire, Iranian researchers found strong positive correlations between the perceived value an planning for the future and the compliance with recommended self-care behaviours in diabetic patients, while high scores on the perceived value of the present was associated with poorer self-care.⁷ American researchers studied the "last meals" offered to 247 prisoners awaiting their execution in that country. These meals were found to be extremely high in caloric value and the researchers commented that "this offers a window into one's true consumption desires when one's value of the future is discounted close to zero."⁸

These studies support the notion that habits beneficial to health and safety are more common among people who hold the future in high regard. There is also firm evidence, as discussed in Section 11.2, that the implementation of incentives for accident-free task performance does, in fact, reduce the accident rate per person. What has not yet been established is that incentives for safety have their beneficial effect on safety *because* these incentives increase the perceived value of the future and strengthen the inclination to plan for it, although that would seem plausible indeed.

¹Strathman, D., Gleicher, F., Boninger, D.S., and Edwards, C.S. (1994). The consideration of future consequences: Weighing outcomes of behavior. *Journal of Personality and Social Psychology*, 66, 742-752.

²Rothspan, S. and Read, S.J. (1996). Present versus future time perspective and HIV risk among heterosexual college students. *Health Psychology*, 15, 131-134.

⁴Kelli, A., Keogh, K.A., Zimbardo, P.G., and Boyd, J. (1999). Who's smoking, drinking, and using drugs? Time perspective as a predictor of substance use. *Basic and Applied Social Psychology*, 21, 149-164.

⁴ which, unlike the other behaviours, showed little consistency over time.

⁵Björqvinnsson, T. and Wilde, G.J.S. (1996). Risky health and safety habits related to perceived value of the future. *Safety Science*, 22, 27-33.

⁶Björqvinnsson, T. (1998). *Health and safety habits as a function of the perceived value of the future*. Doctoral dissertation, Department of Psychology, Queen's University, Kingston, Ontario, Canada.

⁷Ghasemi, N., Namdari, K., Ghorehshian, M. and Amini, M. (2010). The Relationship between "Expectationism" and "Loyalty to Self-Care Behaviors" in Type II Diabetes Patients. *Scientific-Research Journal of Shahed University*, 43, 1-10.

⁸Wansink, B., Kniffin, K.M. and Shimizu, M. (2012). Death Row Nutrition: Curious Observations of Last Meals. *Appetite*, 59, 837-843.

It is not surprising that some industries in recent years have embarked on incentive programmes for better health status of their employees. Industry seems quicker than government to adopt an intervention that effectively enhances health and safety, possibly because health costs and savings are so patently clear from one and the same balance sheet. Within one and the same corporation, interests are not so rigidly divided, as is true for various agencies and government bureaucracies¹ that are concerned with road safety. Be that as it may, improvements in blood pressure and blood-cholesterol levels were achieved by a company in Kansas with the help of monetary incentives for employee health and wellness.² Other companies have used the incentive approach to weight control,³ while variations in the incentive approach to weight control have been compared in other settings.⁴

Interestingly, having greater hope for the future not only appears to stimulate people to adopt a safer and healthier way of life, but it also seems to increase people's resistance to physical diseases that may or may not be dependent on lifestyle. Numerous studies have already established that people with an optimistic view of the future also have a better-functioning immune system.⁵ Moreover, there is experimental evidence to suggest that an intervention that is capable of making people more optimistically minded, can also improve their immune function.⁶ Recent investigations have shown that optimism, be it realistic or not, may offer protection from conditions such as HIV and AIDS.⁷ This leads to the striking affirmation that hope helps people live longer, not just because it motivates them to make decisions that are conducive to health and safety, but also because it stimulates the effectiveness of their physiology in fending off physical disease!

Thus, it would seem worthwhile to consider what modifications could be made to our society so that citizens would have more reason to look forward to their next birthday, their next decade, and their later years, than currently is the case. How can helplessness be reduced and a sense of learned hopefulness be instilled in the minds of

¹Some time ago, the author was involved in the planning by a government department of a province in Canada of an incentive program for road safety in which drivers would be rewarded by free drivers' licence renewal. Despite original enthusiasm, the plan was eventually cancelled because of the unwillingness of one government agency to forego some revenue from drivers' relicensing fees.

²Stevens, M.M., Paine-Andrews, A. and Francisco, V.T. (1996). Improving employee health and wellness: A pilot study of the employee-driven Perfect Health Program. *American Journal of Health Promotion*, 11, 12-14.

³Hennrikus, D.J. and Jefferey, R.W. (1996). Worksite intervention for weight control: A review of the literature. *American Journal of Health Promotion*, 10, 471-498.

⁴Mavis, B.E. and Stöffelmayr, B.E. (1994). Multidimensional evaluation of monetary incentive strategies for weight control. *Psychological Record*, 44, 239-252.

⁵Ader, R. Felten, D. and Cohen, S. (Eds.). (1991). *Psychoneuroimmunology*. San Diego, California: Academic Press.

⁶Strauman, T.J., Lemieux, A.M. and Coe, C.L. (1993) Self-discrepancy and natural killer cell activity: Immunological consequences of negative self-evaluation. *Journal of Personality and Social Psychology*, 64, 1042-1052.

⁷Taylor, S.E., Kemeny, M.E., Reed, G.M., Bower, J.E. and Gruenewald, T.L. (2000). Psychological resources, positive illusions, and health. *American Psychologist*, 55, 99-109.

the nation? What steps might be undertaken towards the establishment of a “safety culture“ or, rather, a “health and safety culture”? One of the simplest, crudest, and most effective instruments of incentive is money. Here are some simple suggestions. For children and teens, increase the weekly allowance at every birthday. Reduce tuition fees for college and university students for subsequent years of study. Increase the legal minimum wage for people as they become older. Provide longer annual holidays as employees become older. Make wages and salaries, as well as job security, more dependent on years on the job. Provide greater tax advantages and insurance discounts for people as they grow older. Offer incentives for saving money and retirement plans, so that people are stimulated to contribute to the monetary value of their future. Take measures that reduce people’s fear of becoming a burden upon others, or of being neglected, abused, or lonely in their sunset years. Offer older people more opportunity to live in their familiar surroundings. Make euthanasia more widely available to those who want it; for many people, this alternative diminishes the dread of a dolorous and undignified death, and thus enhances confidence in the future and the desire to live. So, paradoxically, then, life may be lengthened by the availability of a hastened yet merciful death.

Expectationism is “green.” The focus is on preservation, not on exploitation. With respect to life, the focus is on caution, not on daring. With respect to finance, the focus is on saving, not on spending. In short, the recurring theme of expectationism is “saving for later.” One corollary of saving for later is a livable environment: a clean and green ecology and the availability of natural resources. With a sharpened focus on the future, a society is more likely to protect the environment against misuse for short-term profits at the expense of what is left for our children.

Expectationism, however, not unlike the ideological “isms” in the political arena that range from “radical socialism” to “savage capitalism,” may also bring its own problems. We may, thus, speculate about possible negative side effects of the benefits of expectationism. For instance, in an expectationist utopia, the older segments in the population will be more numerous, more prosperous, more powerful, and thus more influential. This entails the dangers of a “gerontocracy,” a “rule by seniors,” with increased conservatism, a stronger desire to maintain the status quo, and a weaker tendency to explore novel approaches to solving social problems. If there exists a genetic propensity towards risk taking, this will become more widespread throughout the population. This is because people with “risk-taking genes” will be more likely to survive to the age of parenthood, and thus more likely have offspring than currently is the case. The proportion of “risk-taking genes” in the human gene pool would increase as a consequence, and people would by nature become more inclined to take physical risks. Thus, society would become increasingly dependent upon expectationist measures for the maintenance of health and safety, just as the health and fitness of more recent generations have become increasingly dependent upon medical know-how and intervention to offset genetically determined ill health.

12.2 *Epilogue*

According to the views presented in this report, the accident rate and the incidence of unhealthy habits ultimately depend on people's orientation towards their future. The more they expect from it, the more they are willing to prepare for it, and the more careful they will be with life and limb. If their expectations are low, they will try to find more immediate gratification of their desires, and do so at a greater risk of jeopardizing their lives. The extent of risk taking with respect to safety and health in a given society, therefore, essentially depends on values that prevail in that society, and not on the available technology.

As we have argued, values can be altered through change towards a social order that we have called expectationist. Such a social order would offer people reason to look forward to the future with a stronger sense of control, with greater confidence, and more hope. Bringing about such a social order engenders benefits, but it also involves the costs of sacrificing immediate satisfactions. The desire to bring about a human condition that favours cautious health and safety habits depends on human values. The willingness to take action towards the creation of such a condition depends further on the perceived effectiveness of the available means toward that end.

This text has been written in an effort to explain why traditional interventions are not effective and why some innovative ones are. Wider realization that the traditional ways do not work may stimulate willingness to innovate. It has been said that "in matters of occupational safety, all countries are underdeveloped countries."¹ The same can be said about safety in traffic and lifestyles when what is being done is compared with what could be done.

Wider awareness of the effectiveness of alternative approaches to health and safety may increase willingness to debate the merits of limited or even society-wide implementation of expectationist measures against lifestyle-dependent death and disease, as well as against violence and abuse of the environment. We may decide to wait for Godot no longer and cease to expect that some technological panacea will liberate us from our social ills. Safety is not in material things. Safety is either in ourselves, or it is nowhere.

¹Le Serve, A., as quoted by López-Mena, L. and Veloz, J. (1990). Aplicaciones del refuerzo positivo a la reducción de accidentes en el trabajo. *Revista Latinoamericana de Psicología*, 22, 357-371.

- abdominal belts, 66
- ABS (anti-lock brakes), 109–12
- abstinence (from alcohol), 23, 178
- Abtahi, A., 135
- accelerometer, 110
- accident liability, 161, 173
- accident metamorphosis, 127, 203
- accident migration, 203
- accident rate, 178
 - bicycle, 116
 - denominator, 66, 121, 209
 - fatal, 127, 133, 137
 - industrial/occupational, 75, 82
 - optimal, 155, 201
 - per capita, 203
 - per capita, 30, 53, 63, 65, 71, 82, 87, 93, 98, 113, 119, 137, 162, 177, 198
 - per capita, 42
 - per capita, 207
 - per capita, 207
 - per capita, 207
 - per capita, 210
 - per capita, 210
 - per capita, 211
 - per capita, 214
 - spatial, 59, 60, 62, 63, 66, 78, 85, 93, 113, 117, 118, 119, 120, 121, 122, 138, 185, 207, 209
 - temporal, 60, 63, 66, 79, 121, 122, 129, 207
- accident repeater, 162
- accident reporting, mass media, 45, 55
- accident risk
 - comparative, 48
 - objective, 12, 24, 26, 47, 48
 - spatial, 24, 26, 147
 - subjective, 28, 38, 39, 43
 - temporal, 26, 51, 63
- accident tax, 201
- accidents
 - hit-and-run, 194
 - industrial/occupational, 75, 82, 186, 187, 188
 - recreational, 75
 - under-reporting, 187, 191, 193, 204, 205
- Ackersviller, M.J., 81, 104
- Adams, J.G.U., 9, 29, 70, 80, 100, 133, 134
- Addiction Research Foundation, 100
- Ader, R., 215
- adventure seeking, 168
- advertising, 97, 183
 - alcohol, 100, 103
 - cigarettes, 103
 - legal but also responsible?, 123
- aesthetics, 86
- age (as population subgroup), 75
- age of car, 122
- AIDS, 99, 100, 105, 215
- airbags, 113, 209
- air-traffic control, 82
- Ajzen, I., 98
- Al-, 70
- Al-Adawi, S.
 - ., 70
- Albers, W.A., 11, 12
- alcohol advertisements. *See*
 - advertising, alcohol
- alcohol, legal limit, 125, 127, 179, 181
- Alderson, M.R., 11, 212
- alertness, 49, 51, 160, 165, 203
- Alexander, J., 105
- Allen, D.N., 183
- Al-Maniri, A., 70
- Al-Reesi, H., 70
- Alsop, J., 29
- Amini, M., 214
- amplitude, 19, 20
- Amsterdam, 130
- Anger, W.K., 186, 187, 193, 205

- anticipation, 207
- anticipator, 19, 51
- anti-lock brakes. *See* ABS
- appeal procedure, 192
- A-Reesi, H., 72
- ARIMA analysis, 74
- Arnold, H.J., 180
- Aronoff, C.J., 166
- Arwidson, P., 115
- Ås, B., 106
- Aschenbrenner, M., 109
- Asplund, P., 169
- Assum, T., 120
- attitude, 97, 98, 99, 101, 103, 104, 106
- attribution error, fundamental, 163
- Australia, 66, 67, 102, 119, 122
- Austria, 85, 102
- aviation, 188
- aviation accidents, 51, 188
- BAC (blood alcohol concentration),
125, 126, 127, 128, 129, 131, 179
- Bach, H., 164
- Bacher, K., 192
- back injury, 66
- Baggeley, J.P., 105
- Baldes, J.J., 193
- Ball, D.J., 114
- Ball, I.L., 176
- Ball, K., 174
- Bargh, J.A., 163
- Barmack, J.E., 188
- Baron, R.A., 187
- Bartels, K., 75, 192, 194
- Barton, R., 192
- Barwick, K.D., 193
- Baudelaire, C., 57
- Beach, L.R., 49
- beauty, 86
- Beckett, S., 109
- Begon, M., 15
- behavioural adaptation, 111, 112, 120,
139, 178
- Beilinson, L., 114
- Beirness, D.J., 128, 167
- Belgrade, 163
- Beltramini, R.F., 99
- Ben-David, G., 43
- benefit/cost ratio, 179, 186, 187, 194
- Bensley, L.S., 183
- Beral, V., 9
- Bergeron, J., 192
- Bernard, C., 41
- Berry, C., 105
- Bertalanffy, 178
- Bhalla, S.K., 102
- Bickel, H., 164
- bicycle paths, 203
- bicycles, 67, 79, 89, 115, 116, 117
- Biehl, B., 87, 90, 102, 109, 164
- Bilderdijk, J.W., 188
- Björgvinsson, T., 214
- Bjørnskau, T., 120
- Bjurulf, P., 91
- Black, D., 91
- Blackman, R., 82
- Bliss, J.P., 188
- Blomquist, G.C., 29, 122
- blood alcohol concentration. *See* BAC
- blood cholesterol, 215
- blood pressure, 9, 15, 41, 42, 215
- blood sugar level, 15
- body temperature, 15, 41, 42, 43
- body weight, 25
- Boninger, D.S., 214
- Bonnie, R.J., 178
- boomerang effect, 101, 182, 184
- boredom, 35, 37, 143
- Bos, M.W., **36**
- Bouladon, G., 37
- Bouter, L.M., 159
- Bower, J.E., 50, 215
- Box, P.C., 117
- Boyce, T.E., 193
- Boyce, W., 183
- Boyd, J., 214
- Boyd, J.N., 186

- Boyer, M., 199
 Bragg, B.W.E., 89
 braking force, 110
 Branas, C.C., 135
 Brauer, R., **36**
 Braun, C.C., 115
 Braver, E., 112
 Brehmer, B., 191
 Bridger, R.S., 66
 Brinkmann, B., 57, 73
 Brinkmanship, 143, 144, 147, 148, 157
 Britain, 9
 British Columbia, 70, 129
 Brock, J., 91
 Brodsky, H., 80
 Brown, I.D., 87, 90
 Brown, J.D., 50
 Brown, J.W., 105
 Bruening, J.C., 187, 191, 194
 Bruni, J.R., 174
 Buliung, R., 94
 Burns, N., 103
 Burns, P.C., 159
 bus drivers, 160, 163
 Butler, R.J., 196
 California, 92, 93, 113, 115, 123, 162, 185, 189, 191, 192, 195, 196
 Camden, A., 94
 Campbell, B.J., 161
 Campbell, D.T., 136
 Canada, 2, 27, 65, 66, 71, 74, 81, 86, 104, 111, 119, 120, 127, 128, 129, 167, 181, 183, 190, 192, 200, 209, 214, 215
 Cannon, W.B., 41
Care on the Road, 68
 car-following, 131
 Carr, A.F., 136
 Carrere, S., 160
 Carson, J., 96
causa causans, 53, 129
 causation
 circular, 21
 linear, 21
 Champagne, F., 88
 chance effects, 165, 192
 Chandon, J.L., 75, 213
 Chang, C.J., 117
 Chapanis, A., 139, 140
 Chapman, S., 66
 Chebat, J.C., 75, 213
 Chen, G., 71
 Cheng, B., 131
 Chicago Crackdown, 179
 chicanes, 119
 Chich, Y., 198, 199
 child-proof, 94
 children, 89, 94, 106, 176, 216
 Cho, H.J., 169
 cholesterol, 9
 Christ, R., 55
 Christensen, P., 91, 123
 cigarette smoking, 8, 9, 13, 65, 67, 99, 103, 121, 168, 184, 210, 214
 Clark, W.C., 11, 12
 Claxton-Oldfield, S.P., 141
 Clement, R., 159
 climate, social, 181, 185, 196, 205
 Clinton, K., 91, 179
 Club of Rome, 31
 Coe, C.L., 215
 cognitive dissonance reduction, 191
 Cohen, J., 23
 Cohen, S., 215
 Colwell, L., 9
 commercial drivers, 92
 comparator, 17, 43
 computer games, 143, 146, 147
 computer virus, 142
 Comrey, A.L., 165
 condoms, 93, 95, 99, 100
 Congleton, J.J., 66
 Conley, J.A., 91
 Conlon, D.E., 142
 Connecticut, 136, 189, 196
 consumer products, 95, 123

- control
 - closed loop, 12, 18, 21, 47, 87
 - feed-forward, 51
 - open loop, 21
- control theory, 21, 27, 87
- Conybeare, J.A.C., 122
- Coppin, R.S., 162
- Corbett, M., 158
- counterevidence, 78
- court action, 179
- crack-down action, 136
- Cramton, A.C., 181
- crash helmets, 82, 135
- crashworthy cars, 9, 63, 65, 82, 119
- Crooks, L.E., 112
- cross-sectional comparisons, 58, 59, 63, 79, 118, 119
- crying wolf, 95
- Cullen, J..
- curiosity, 37, 155
- cutting and mowing, 120
- cybernetics, 27, 31
- D'Arcy St. Pierre, M., 181
- da Vinci, L., 46, 87
- danger money, 32
- Dawson, N.E., 89
- daytime running lights, 120, 140
- de Bruin, R.A., 29, 57, 85, 87, 90, 143
- defective design, liability for, 123
- defensive avoidance, 102
- defensive driving courses, 90
- Dehejia, R., 199
- DeJoy, D.M., 49
- DeKalb County, 89, 146
- delta illusion, 13, 53, 128, 129, 132, 163, 178, 203, 207, 208
- demand for safety, 137, 201, 202
- demographic characteristics, 167, 169
- Denmark, 92
- Derrig, R.A., 135
- design defects, liability for, 123
- Desmond, P.A., 82
- deterrence, 179, 180
- Detroit, 60
- deviation from optimality, 145, 149, 155, 157
- Dewar, R.E., 90, 180
- DFO. *See* deviation from optimality
- diabetic patients, 214
- Dickenson, R.A.V., 157
- diet, 104, 168, 214
- Dijksterhuis, A., 36
- Dionne, G., 199, 200
- disease, lifestyle-dependent. *See* lifestyle
- disincentive, 188, 192, 196, 197
- divorce, 23, 164
- Doherty, E.M., 194, 205
- Donatsch, P., 31
- Dorn, L., 82
- Dostoevsky, F.M., 182
- Dowse, G., 50
- drinking, 11, 52, 75, 98, 99, 100, 102, 125, 126, 127, 141, 167, 179, 183, 214
- drinking and driving, 13, 99, 125, 129, 159, 178, 184
- driver training, 53, 55, 88, 89, 90, 196, 200
- driver training in high school, 88, 89, 90
- driver's licence, 63, 79, 88, 89, 137, 166, 167, 185, 189, 196, 197, 200, 201
- driver's licence renewal, 185, 196
 - free, 177, 191
- driver's licence suspension, 138, 181
- driver's licensing test, 91, 95, 137
 - written, 91
- driving experience, 159, 169
- driving simulation, 82
- driving style, 110, 130, 132, 176, 184
- Drottenborg, H., 86
- Duffy, J., 158
- Durbin, D.L., 196
- Ebbesen, E.B., 41

- Echterhoff, W., 165
 ecology, environment, 216
 economic factors, 36, 37, 59, 69, 70, 71, 73, 74, 75, 76, 77, 78, 88, 133, 154, 189, 211, 213
 economic success, 86
 Edman, B., 89
 education. *See* training/education
 educational accident journalism, 104
 Edwards, C.S., 214
 effectiveness evaluation, 105, 106
 effectiveness yardsticks, 97, 99
 ejection-mitigating glazing, 209
 Elander, J., 161, 164, 176
 elderly drivers, 120, 170
 Elliot, B.J., 101
 Elvik, R., 31, 202
 energy crisis, 63, 137
 enforcement, 11, 13, 53, 85, 125, 128, 129, 130, 136, 138, 178, 179, 203, 207, 210
 selective, 178
 engineering, 11, 13, 26, 29, 35, 54, 63, 66, 85, 95, 96, 97, 109, 115, 116, 117, 118, 119, 121, 137, 186, 207, 210, 211
 England, 27, 67, 68, 163
 Engs, R., 184
 environment, ecology, 216
 equifinality, 178
 equilibrium, 15, 51, 87, 137
 ergonomics, 32, 54
 error rate, 53
 Ettema, J.S., 105
 euthanasia, 216
 Evans, G.W., 160
 Evans, L., 29, 30, 42, 67, 79, 80, 134, 137, 141, 208
 Ewald, F., 199
 exercise, 11, 14, 15, 23, 168, 186, 214
 expectationism, 210, 211, 216
 general, 211
 specific, 211
 experience mix, 175
 Fabiano, B., 75
 Faedda, S., 183
 false sense of security, 93, 123
 Farmer, C.M., 112, 120
 Farnill, D., 176
 Farquhar, J.W., 105
 feedback, 21, 23, 31, 32, 51, 55, 144, 205, 207
 feedback, negative, 21
 Feij, J.A., 159
 Felten, D., 215
 female drivers, 120, 170
 Ferraiolo, A., 75
 fever, 15, 37, 41
 Feyer, A.M., 190
 Finland, 74, 92, 96, 113, 120, 165, 169
 fire shelters, 115
 Fischhoff, B., 29
 Fishbein, M., 98
 Fitch, H.G., 186
 fitting the operator to the task, 47
 fitting the task to the operator, 32, 47
 flexitime, 177
 floods, 11, 12, 53
 fog, 80
 following distance, 44, 114, 174
 Forbes, T.W., 162
 forbidden fruit effects, 182
 Forst, B., 179
 Fosser, S., 111, 114, 120, 123
 Fouts, J., 115
 Fox, D.K., 186, 187, 193, 205
 France, 31, 80, 104, 181
 Francisco, V.T., 215
 Freidberg, S.S., 66
 French, D., 161, 164, 176
 French, M.T., 71
 Friedland, M.L., 180
 Frith, W.J., 126
 Fuller, C.A., 42
 fundamental attribution error, 163
 gainsharing, 205

- Galbraith, J.K., 210
 Galvani, L., 24
 Galvanic Skin Response (GSR), 24, 26, 174
 gambling, 53, 158, 159, 184
 Ganguly, S.S., 70
 Ganton, N., 27, 174
 Garder, P., 110
 Garland, H., 142
 Gaudry, M., 200
 Gelau, C., 82
 Geller, E.S., 130, 180, 191, 193
 Georgia, 89, 146
 Germany, 74, 109, 163, 185
 Gerondeau, C., 155
 gerontocracy, 216
 Gerszke, D., 154
 Ghasemi, N., 214
 Ghoresbian, M., 214
 Giannakopoulos, E., 183
 Gibson, J.J., 112
 Gilbert, D.T., 163
 Glad, A., 91
 Gleicher, F., 214
 Glendon, A.I., 82
 Glonek, G., 103
 Godot, 109, 112, 217
 Goethe, J.W., 37
 go-kart, 130
 Goldberg, D.L., 137, 179
 Goldblatt, R.B., 117
 Goodenough, D.R., 10
 Gordon, K., 49
 Gordon, R.A., 183
 Graham, J.D., 30, 202
 Grand Rapids, Michigan, 125
 Grant, B.A., 111
 Gray, M., 198
 Grayson, G.B., 33, 67, 78, 174, 209
 Great Britain, 70, 80, 91, 106, 131, 134, 160, 201
 Green Cross Code, 106
 Greenberg, J., 187
 Gregersen, N.P., 91, 92, 191
 Groeger, J.A., 87, 90
 Gros, J., 186
 Gruenewald, T.L., 50, 215
 GSR. *See* Galvanic Skin Response
 Guastello, S.J., 91, 179, 186
 Guessmanship, 143, 149, 150, 152, 157
 Gumus, T., 71
 Haddad, S., 66
 Hagge, R. A., 92
 Haight, F.A., 30
 Haigney, D.E., 82
 Hakama, M., 9
 Hakkert, A.S., 29, 57, 80
 Häkkinen, S., 166
 Haliva, Y., 43
 Hamilton, P.J.S., 9
 Haney, M., 41
 Hansen, J., 184
 Hanson, D.J., 184
 Harano, R.M., 75, 185, 189, 191
 Hardy, R.N., 15
 Harper, J.L., 15
 Harper, S., 169
 Harrington, D.M., 197
 Harte, D., 126
 Hasselberg, M., 70
 Hatakka, M., 92
 Hatfield, H., 86
 Hauer, E., 29, 57, 105, 110, 128, 201
 Hawke, D.C.L., 81
 Haynes, R.S., 186
 health, immune system efficiency, 215
 health, lifestyle-dependent. *See* lifestyle
 heart rate, 15, 43
 heavy vehicles, 92, 188, 202
 Hedlund, J., 37, 55, 79, 122
 Heijer, T., 55
 Heino, A., 157, 159
 Heino, A.H., 187
 Heiskanen, M., 158

- Helsinki, 163, 166
 Helvacian, N.M., 196
 Hennrikus, D.J., 215
 Henry, J.P., 91
 Herms, B., 93
 Hilakivi, I., 169
 Hilton, B.W., 188
 historical data, 67
 HIV, 215
 Hoban, P., 56
 Hobbs, G.E., 157
 Hoffer, G., 113
 Hofmann, D.A., 83
 Hofstätter, P., 48, 49
 homeostasis, 15, 16, 18, 21, 28, 30, 33, 35, 41, 42, 43, 50, 51, 57
 homicide, 11, 75, 212
 Hong, S.M., 183
 hopefulness, 215
 Hopkins, B.L., 186, 187, 193, 205
 Horace, 125
 horses, 67
 Horvath, P., 50, 159
 Hourany, L., 158
 Howard, A., 94
 Howarth, C.I., 54
 Hoyes, T.W., 82
 Hoyos, C.G., 79
 Hoyt, D.W., 120
 Hubert, D.E., 185, 189, 191
 Huguenin, R.D., 30, 54, 203
 Huntzinger, D.L., 188
 Hurst, P.M., 125, 126
 Hutchinson, T.P., 57, 73, 163
 ice, 80, 96
 Iceland, 44, 51, 114
 ICTCT, 203
 Illinois, 91
 illusion of safety, 92, 130
 immediacy principle, 103
 immune system efficiency, 215
 incentive for risk taking, 184
 incentive programme requirements, 185, 186, 187, 189, 190, 192, 193, 194, 196, 204, 205, 215
 incentives for production, 188
 incentives for safety, 40, 82, 180, 185, 186, 187, 189, 190, 191, 192, 193, 195, 196, 197, 200, 204, 205, 207, 210, 211, 214
 incentives versus rewards, 195
 income tax, 197
 index of industrial production, 74
 India, 147, 160
 industrial workers, 52, 195
 industrial/occupational accidents, 75, 82, 186, 187, 188
 insurance
 automobile, 203
 automobile, 197, 199, 200
 automobile, 204
 automobile, 204
 companies, 88, 162, 195, 197, 199, 200, 201, 204
 discounts, 36, 88, 177, 195, 197, 200, 216
 forgiveness clause, 201
 medical, 177, 197
 no-fault, 200
 premiums, 177, 187, 200, 205
 private/public, 196
 insurance discounts, 188
 International Labour Office, 71
 invisible safety measures, 55
 Israel, 163
 Israelstam, S., 181
 Italy, 75
 Jackson, D.N., 158
 Jackson, J.S.H., 82
 Jakus, P.M., 31
 Janssen, W.H., 42, 131
 Japan, 82, 137, 138
 Jefferey, R.W., 215
 Jerrim, A., 92
 Jiang, C., 54, 66

- JND (just noticeable difference), 20, 44
- Johnson, H.M., 162
- Johnson, M.S., 115
- Johnson, W.L., 66
- Joly, R., 144
- Jonah, B.A., 89, 158, 159
- Joubert, P., 29
- judgement, individual versus pooled, 48, 49
- Jurik, N.C., 115
- just noticeable difference. *See* JND
- Kallberg, V.P., 120
- Kamerud, D.B., 202
- Kapferer, J.N., 98, 99, 103
- Karasina, N.I., 190
- Katila, A., 92
- Kelli, A., 214
- Kemeny, M.E., 50, 215
- Keogh, K.A., 214
- Kernan, M.C., 142
- Keskinen, A., 92
- Khang, Y.H., 169
- King, A., 183
- King, G.F., 117
- King, M., 183
- Kingston, Ontario, 27, 174
- Kirchner, R.E., 136
- Kitchener, Ontario, 118
- Klette, H., 179, 181
- Kniffin, K.M., 214
- Knipschild, P.G., 159
- Knott, J.W., 67
- Knudson, M.M., 135
- Køltzow, K., 196
- Komaki, J., 193
- Koshi, M., 137, 138
- Koskenvuo, K., 169
- Krause, T.R., 186
- Kreb, A.R., 115
- Kunkel, E., 77
- Kvernlund, J.K., 81
- L'Hoste, J., 104, 184
- Labadie, M.J., 104
- labelling effects, 180
- Laberge-Nadeau, C., 88
- laboratory, 51, 83, 98, 139, 140, 141, 143, 147, 155, 164, 177
- Laflamme, I., 70
- Laing, D., 183
- Laitinen, L., 169
- Lambert, M.I., 66
- Lambert, S., 181
- Lamble, R.W., 91, 179
- Landes, E., 31
- Landes, E.M., 200
- Landes, M., 31
- lane width, 119
- lane-tracking, 203
- Langley, J., 29
- Langley, L.L., 15, 41
- Lasenby, J., 115
- Lasenby-Lessard, J., 158
- late adopters, 104
- Latham, G.P., 193
- latitude of acceptability, 101, 102
- Laurie, I., 91
- Lave, L.B., 12
- Lave, T.R., 12
- Le Serve, A., 217
- learned hopefulness, 215
- Lec, S.J., 8, 23, 31
- legal liability, 96
- Lehto, M.R., 95
- Lemieux, A.M., 215
- Lessne, G.J., 183
- Lester, J., 160, 176
- Lewin, I., 43
- Lichtenberg, G.C., 86
- lifestyle, 8, 12, 13, 24, 52, 65, 75, 98, 99, 107, 157, 168, 176, 178, 208, 210, 211, 215, 217
- Limits to Growth, 31, 32
- Lin, Q., 131
- litigation, 96, 123
- Liu, L.L., 135

- Lloyd's List, 198
 London, England, 24
 Lonero, P.L., 91, 179, 190
 longitudinal comparisons, 59, 62, 119, 138
 López-Mena, L., 217
 lotteries, 190, 192
 Lu, G., 131
 Ludborzs, B., 192
 Luepker, R.V., 105
 lulling effect, 92
 Lund, A.K., 90, 112
 Lynch, J.W., 169
 Macarthur, C., 94
 Maccoby, N., 105
 Mackay, M., 137
 Mackie, A.M., 91
 MacLean, H., 91, 179
 MacNeil, S., 90
 Mahalel, D., 93
 Mäkinen, T., 55
 Mäkinen, T., 114
 Mannering, F., 96
 Mannheim, 163
 Markus, T., 192
 Martin, S.E., 179
 Maslach, C., 182
 mass communication
 opinion leadership, 103
 personal influence, 104
 two-step flow, 103
 mass media communications
 boomerang effect, 184
 fear appeals, 102, 183
 motivating appeals, 102
 mass media messages, 97, 103, 104
 mass media, accident reporting, 45, 55, 104
 Matalon, B., 38
 Mautner, F., 86
 Mavis, B.E., 215
 May, A.D., 61
 Mayhew, D.R., 90, 128
 McAdams, J.L., 194, 205
 McAfee, R.B., 187, 190, 205
 McBride, R.S., 75, 162
 McClure, J., 50
 McCoy, M.A., 66
 McDougall, J.L., 65
 McGuire, F.L., 164
 McGuire, W.J., 101, 184
 McKenna, F.P., 30, 42, 54, 80
 McKnight, A.J., 91, 179
 McMurray, L., 164
 Meadows, D., 31
 medicine cabinets, 93
 Menahem, G., 52
 mental health, 50
 Mercer, G.W., 70
 Metzner, G., 57, 73
 Michon, J.A., 29, 42, 54
 military personnel, 169, 188
 Miller, J.G., 123
 Miller, P., 158
 Millner, E., 113
 mining safety, 188
 Minnesota, 179
 Minor, S.W., 183
 Mitchell, A., 132
 Moatti, J.-P., 115
 mobility, per capita, 44, 59, 63, 65, 67, 77, 80
 Montag, I., 165
 Montréal, 88, 181
 Moore-Ede, M.C., 42
 moral hazard, 196
 moral judgement, 85
 Moran, A., 27
 Morén, B., 191
 Morisey, M., 193
 Morris, J.P., 107
 Morrongiello, B., 115, 158
 mortality ratio, standardized, 212
 motivating appeals in mass media, 103

- motivating towards safety, 177, 178, 188, 190, 192, 193, 194, 195, 200, 204, 210
- motor vehicle manufacturing standards, 113, 121, 122
- motor vehicles per capita, 79
- motorcyclists, 71, 82, 89, 135
- mountain climbing, 31
- MRFIT, 9
- Munden, M., 58
- Munich, 109, 111, 116
- Murdoch, P.A., 192, 201
- Murray, A., 169
- Musk, L.F., 80
- Naisbitt, J., 102
- Namdari, K., 214
- Napier, V., 114
- Narrow Escape (game), 148, 149
- Nashville, Tennessee, 135, 136
- National Cooperative Highway Research Program, 81
- National Highway Traffic Safety Administration, 89, 208, 209
- National Safety Council, 62, 71, 76
- NATO, 181
- Nehru, J., 40
- Netherlands, the, 72, 130, 147, 179, 181
- Netherlands, The, 74
- New South Wales, 67, 119
- New York, 148, 179
- New Zealand, 29
- Ng, W-J., 100
- Nilsson, G., 209
- Nilsson, L., 55
- Noordzij, P., 174
- Nord, W.R., 194, 205
- Nordgren, L.F.. *See*
- North Carolina, 161
- Northern Ireland, 163
- Norway, 88, 91, 92, 106, 111, 112, 118, 120, 122, 179, 202
- Notarantonio, E.M., 183
- Nova Scotia, 46, 188
- novice drivers, 88, 91, 92, 170, 175
- O'Neill, B., 31, 92
- Obadia, Y., 115
- occupational accidents, 195
- occupational health legislation, 82
- OECD, 33, 70, 80, 97, 111, 112, 119, 121
- oil crisis. *See* energy crisis
- Olson, P.L., 90
- Ontario, 63, 64, 80, 89, 104, 118, 119, 169, 200, 201
- Ontario Ministry of Health, 100
- Oppe, S., 29, 42
- optimism
 - realistic, 215
 - unrealistic, 50, 154
- Oregon, 114
- Osborne, C.A., 186, 190, 195, 199
- Oslo, 80, 111, 118
- Ottawa, 129, 167
- overconfidence, 49, 90, 92, 95, 149, 173
- Owsley, C., 174
- oxen, 46
- Paine-Andrews, A., 215
- Palsane, M.N., 160
- Palutikof, J.P., 80
- Papastravrou, J.D., 95
- parachute jumping, 114
- Parentini, I., 75
- Parkin, M., 9
- Partyka, S.C., 70, 208
- Pastorino, R., 75
- Paulozza, L., 154
- pavement condition, 80, 96, 113
- pavement friction, 55
- pavement undulation, 119
- Payne, P.E., 188
- Peck, R.C., 75, 162
- pedestrian countdown signals, 93
- pedestrians, 41, 75, 81, 93, 95, 113, 116, 117, 121, 202, 203

- peer pressure, 193, 195
- Peltzman, S., 121
- penalty, 128, 144, 146, 147, 149, 178, 180, 192, 196
- perceived value of future time, 211, 213, 214
- perceived value of present time, 213
- Peretti-Watel, P., 115
- Perl, A., 105
- Perry, A.H., 80
- personality
 - authoritarian, 160
 - extraversion, 154, 158
 - field dependence, 160
 - impulsivity, 160
 - introversion, 154
 - locus of control, 159, 165
 - sensation seeking, 154, 158
 - traits, 40, 101, 139, 154, 158, 159, 163, 164, 165, 168, 169
 - Type A, 160
- personnel selection, 186
- personnel, military, 169, 188
- perspiration, 24
- Peters, R.H., 194
- Peterson, C.R., 49
- Peterson, S., 113
- Pettinger, C.B., 193
- Pfafferott, I., 203
- physical exercise, 53, 210
- Piccolino, E.B., 99
- Pine, A.R.C., 186
- Plant, M., 158
- Platenius, P.H., 141
- playgrounds, 114
- Plowden, W., 67
- Poffenberger, A.T., 48
- poisonings, 94
- police surveillance, 135, 178
- politics
 - political will, 202
 - public relations, 201
- Porter, L.W., 185
- Potvin, L., 88
- pre-attentive awareness, 43
- Preston, B., 23
- professional drivers, 163
- prospective studies, 167
- Prothero, J.C., 85
- psychological distance, 101
- psychotherapy, 85
- public transportation, 177
- punishment, 82, 178
- punishment, swift, certain, severe, 127, 128, 180
- Putnam, T., 115
- Pyrrhus, 129
- Québec, 88, 111, 200, 213
- Rabinowitz, D., 66
- racing drivers, 92
- railway crossing, 95, 120, 121
- rain, 41, 80
- Rain, 81
- Rajalin, S., 165
- Rämä, P., 97
- Rathmayer, R., 114
- Ratz, M., 197
- reactance, 181, 182, 183, 184
- Read, S.J., 214
- Reagan, I.J., 188
- recession, 69, 74, 76
- recidivism, 179
- Reed, G.M., 50, 215
- reflector posts, 120
- regression to the mean, 118
- repeated offenders, 85
- retrospective studies, 166
- rewards and penalties, 192
- rewards for safe conduct, 86, 177, 193
- rewards versus incentives, 195
- Richard, K.P., 188
- Richmond, S.A., 94
- Richter, I.A., 46, 87
- Riemersma, J., 120
- Ringold, D. J., 183
- ripcord, 114

risk

- intrinsic, 33, 51, 109
- objective, 26
- optimal, 87, 150, 151, 158
- subjective, 26
- surrogate, 178
- verbal ratings of, 27, 175
- zero, 28, 40, 87, 142, 145
- risk acceptance (see also Target level of risk), 53, 81, 112, 173, 174
- risk compensation, 32, 132
- risk estimation, 48, 87, 90, 173, 174
- risk neutrality, 145
- risk perception, 28, 48, 50, 55, 87, 90, 173, 176
- risk recognition, 173
- risk redistribution, 67, 203
- risk tolerance, 81
- risk versus risk, 202
- risk-averse, 145, 154
- risk-loving, 145, 146
- risk-seeking, 145, 151, 154, 157
- risk-taking competency, 90, 146
- risk-taking strategy, 150, 154
- risk-tolerant genes, 216
- Roach, K., 91, 179
- road lighting, 120
- road markings, 82
- road tax, 196
- Roberts, D.F., 104
- Robertson, L.S., 79
- Robertson, S., 189
- Robertson, S.A., 82
- robot, 53
- Rockerbie, R.A., 129
- Rodgers, G.B., 95
- Roenker, D.L., 174
- Roer, P.O., 96, 118
- Romanowicz, P.A., 92
- Rose, G., 9
- Rose, T.L., 115
- Rosenthal, R., 140
- Ross, H. L., 179
- Ross, H.L., 128, 136, 180
- Rothengatter, T., 29, 57, 85, 87, 90, 143
- Rothman, L., 94
- Rothspan, S., 214
- rule breaking*, 188
- Rumar, K., 42
- Rundmo, T., 163
- Russia, 188
- Russo, M., 36
- Rutherford, G.S., 80
- Ryan, J.M., 52
- Saccomanno, F.F., 190
- Sætermo, I.A.F., 111
- Safe Performance Curriculum, 89, 92, 146
- safety caps, 94, 95
- safety culture, 216
- Safety first (slogan), 102
- safety margin, 148
- Sagberg, F., 88, 111, 120
- Salminen, S., 158
- Sampson, A., 179
- Sandell, R., 101
- Santa Barbara, California, 115, 117
- Saskatchewan Plan, 193
- Sävenhed, H., 120
- Sawyer, J.E., 142
- Scandinavia, 86, 203
- Schachter, S., 65
- Schmidt, L., 85, 86
- Schmidt, W.F., 82
- Schnelle, J.F., 136
- Schofer, J.L., 80
- Schoppert, D.W., 120
- Schramm, W., 104
- Schulz, U., 91
- Schulze, H., 55
- Schwing, R.C., 11, 12, 29, 80, 134, 137, 141
- Scott, L.R., 193
- search and rescue, 31

- seatbelts, 9, 95, 104, 119, 121, 130, 132, 133, 168, 208, 209
- Seddiki, E., 81
- Segui-Gomez, M., 135
- Select Committee on Highway Safety, 170
- self-fulfilling effects, 180
- Seneca, 178
- sensation seeking, 159, 168
- set-point variable, 16, 21, 41
- sexual partners, 100, 214
- Seymour, K.J., 186
- Shakespeare, W., 85, 92
- Shannon, H.S., 79
- Shaw, W.D., 31
- Sheppard, D., 91, 184
- Shinar, D., 166, 174
- Shinizu, M., 214
- Shipley, M.J., 9
- Short, M.S., 117
- Shortreed, J. H., 190
- side effects, negative, 14, 180, 181, 187, 193, 204, 205
- side effects, positive, 185, 204, 205
- sight distance, 110, 120, 121
- signs
 - warning, 95, 96, 121
 - yield, 93, 96, 117, 118, 175
- Sigthorsson, H., 114
- Silver, N.C., 115
- Simonet, S.L., 74
- Simpson, H.M., 128, 167
- simulation, 141
- Sindhusake, D, 66
- Sindhusake, D., 66
- Sinivuo, J., 169
- Sivak, M., 66
- Skelly, G.B., 88
- skid training, 92
- skiing, 132, 159
- skill, 29, 43, 45, 46, 47, 49, 85, 87, 89, 90, 91, 92, 97, 112, 141, 143, 145, 146, 149, 150, 158, 166, 173, 174, 211
- decision-making, 46
- perceptual, 46
- psychomotor, 46
- risk perception, 48, 50, 87, 90, 176
- skydiving, 114
- Slade, J., 66
- slippery pavement, 91, 93
- Sloane, M.E., 174
- Sloat, K.C.M., 186
- slogans, 95, 102
- Slovic, P., 29
- slowdown action, 136
- Smart, R.G., 100
- Smiley, A., 111
- Smiley, R., 91
- Smith, R.M., 184
- Smith, R.S., 201
- snow, 80
- sobriety, 99, 126, 178
- social climate, 185, 196, 205
- social legislation, 213
- social recognition, 143, 155, 157, 177, 196
- socio-economic status, 40, 75, 89, 154, 169
- Socrates, 10
- speed, 25, 28, 38, 39, 43, 44, 49, 51, 58, 59, 60, 63, 79, 80, 81, 82, 86, 95, 96, 102, 109, 110, 111, 113, 114, 116, 119, 120, 130, 136, 138, 142, 143, 159, 174, 175, 176, 177, 178, 180, 181, 184, 190, 200, 202, 203, 213
- speed limit, 102, 120, 180, 203
- speeds, 203
- sport, 114
- Sprenkel, D.G., 183
- standardized mortality ratio, 212
- Stanton, N.A., 82
- Starr, C., 191
- Statistics Canada, 71

- Steers, R.M., 185
 Steg, L., 188
 Stellman, Jeanne M., 190
 Stetzer, A., 83
 Stevens, M.M., 215
 Stockman, T., 31
 Stöffelmayr, B.E., 215
 Strathman, D., 214
 Strauman, T.J., 215
 streetcar drivers, 163, 166
 Streff, F.M., 130
 Struik, H., 31
 studded tires, 82, 113
 subject recruitment, 144
 suicide, 11, 75, 212
 Sulzman, F.M., 42
 Summala, H., 165
 summing point, 17, 43
 sunbathing, 210
 Svenson, O., 49
 Sweden, 44, 45, 51, 74, 86, 92, 93, 120, 179
 Swinehart, J.W. and Grimm, 184
 Switzerland, 74
 syllogisms, 10, 160
 Symons, L.J., 80
 Szternfeld, Z., 93
 Takala, J., 195
 Tardif, L.P., 192
 target level, 15
 target level of risk, 28, 35, 36, 37, 42, 43, 44, 45, 47, 48, 51, 54, 57, 59, 63, 68, 85, 87, 109, 110, 129, 137, 177, 197, 207, 212
 variations, 40, 41
 taxi, 109, 110, 111, 163, 177
 Taylor, D.H., 23, 24, 25, 26, 27, 31, 174
 Taylor, R.G., 82
 Taylor, S.E., 50, 215
 team awards, 193
 technological fix, 26, 112
 television, 103
 Tel-Nir, L., 43
 Tenkink, R., 42
 terrorism, 53
 Tetzlaff, J., 53
 Texas, 119, 188
 Theeuwes, J., 120
 thermostat, 16, 17, 18, 19, 20, 35, 36, 41, 47
 Thulin, H., 93
 Tillmann, W.A., 157
 tires, 82, 113, 197
 Topolinski, S., 184
 Toronto, 100, 129
 Toronto Star, 130
 Toronto, Canada, 81
 Townsend, C.R., 15
 traffic calming, 119
 traffic change, from left to right hand, 39
 traffic conflicts, 43, 110, 175
 traffic lights, 10, 93, 117, 118
 traffic signs, 180
 permissive, 180
 prohibitive, 180
 stop/yield, 96
 traffic violations, 136, 177
 train travel, 65
 training, motorcyclists, 89
 training/education, 47, 48, 53, 85, 87, 89, 194, 207
 Tränkle, U., 82
 transit bus operators, 186
 Transport Canada, 209
 travel time, 39, 60, 61, 202
 Traynor, T.L., 113
 Trempel, R.E., 112
 Trepass, D., 31
 Trimpop, R.M., 69, 76, 109, 141, 143, 144, 157, 159
 Triple E, 85, 210
 trucks and vans, 185, 189
 Tschernitschek, E., 194
 Uleman, J.S., 163

- Ulleberg, P., 163
 uncertainty of consequence, 142, 143
 uncertainty of performance, 142
 underconfidence, 49, 149, 154
 under-reporting, 29
 Underwood, G., 54
 unemployment, 32, 70, 71, 72, 73, 74, 75, 76, 78, 137, 208
 United Kingdom, 74, 114
 United States, 74
 Unrau, D.D., 81
 US Department of Labor, 76
 US Food and Drug Administration, 94
 USA, 9, 12, 55, 62, 68, 69, 71, 72, 76, 78, 79, 89, 92, 94, 96, 121, 125, 127, 130, 131, 135, 160, 161, 162, 183, 208
 Usher, M., 36
 utility factors, 35, 68
 Vaaje, T., 191, 198
 van Baaren, R.B., 36
 van der Molen, H.H., 157, 159
 van Houten, R., 188
 variety seeking, 37
 Vaupel, J.W., 65
 vehicle manufacturing standards, 113, 121, 122
 vehicle repair costs, 177
 Veilahti, J., 169
 Veling, I.H., 42
 Veloz, J., 217
 verbal ratings of risk, 27, 175
 Vidmar, N.J., 158
 Vienna, 102, 149
 vigilance, 44
 violations, 85, 91, 135, 136, 157, 159, 161, 166, 169, 179, 185
 violence, 136, 210, 211, 212, 217
 violent death rate, 11, 68, 212, 213
 Virginia, 113
 Viscusi, W.K., 94
 Vitale, P.A., 183
 Vogel, C.B., 193
 Volovics, A., 159
 volunteers, 140
 Volvo owners, 103
 Wagenaar, W.A., 78
 Wales, 67, 68
 Walker, J., 103
 Walker, M.B., 159
 Walpole, B., 115
 Wang, Y., 131
 Wangeman, J.F., 176
 Wansink, B., 214
 Ward, N.J., 121
 Warner, K.E., 66
 warning signs, 95
 warnings, 31, 95, 182, 183
 Washington State, 96
 Webster, John, 178
 weight control, 9, 215
 weight lifting, 66
 Weinstein, N.D., 50
 Wenäll, J., 209
 West, R., 161, 164, 176
Westray coal mine, 188
 Weyers, M., 36
 White, M., 103
 Wiener, J.B., 30
 Wiener, N., 27
 Wilde, G.J.S., 9, 11, 16, 19, 27, 32, 37, 39, 45, 51, 62, 64, 66, 69, 74, 76, 77, 78, 79, 80, 81, 82, 85, 91, 97, 101, 103, 104, 109, 112, 119, 121, 127, 128, 137, 138, 141, 143, 144, 154, 157, 159, 174, 176, 179, 181, 184, 185, 186, 188, 190, 192, 193, 195, 198, 199, 201, 211, 212, 214
 Wilkinson, B., 168
 Willan, A.R.. *See*
 Williams, A.F., 31, 90, 92
 Williams, N.A., 183
 Williamson, A., 190
 Wind, G., 184
 Windsor, England, 24, 27
 Winn, A.R., 187, 190, 205

- Winnicki, J., 209
Winzeler, S., 184
Witkin, H.A., 10
Woelfl, G.A., 117
Wood, P.D., 105
workers' compensation, 187, 196, 199
workplace accidents, 66, 75, 196, 199
Worrall, J.D., 196, 199
Wretling, P., 120
Wright, G., 50
Wu, R., 183
Wuolijoki, A., 114
Yagar, S., 9, 51, 64
Yang, S., 169
Yashin, A.I., 65
Yates, J.F., 78
youth, 23, 70, 73, 74, 88, 167, 170,
176, 184, 185, 189, 196, 200, 202,
212
Zador, P., 90
Zahavi, Y., 52
Zakay, D., **36**
zero risk, 28, 40, 87, 142, 145
Zimbardo, P.G., 182, 186, 214
Zlatoper, T.J., 67, 69, 122
Zohar, D., 194
Zuckerman, M., 50, 158, 159
Zwolsche Algemeene Verzekeringen,
199

