Laws of accident causation

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Multiple theories of accident causation

1. Accidents as random events
2. Accident proneness theory
3. Causal theory (in-depth approach)
4. Systems theory
5. Behavioural theory

No synthesis of these theories has emerged
The nature of causal relationships

• Laws of nature (can be approximated as deterministic relationships – usually stated in mathematical terms)
• Agency relationships (acts of man and their precursors and consequences)
• Random (or chaotic) processes (can be modelled statistically)
The complexity of accident causation

• All types of relationships are involved
• There is no general theory that specifies in what ways or mixtures the different types of relationships contribute
• Causal relationships are deeply random and cannot be reduced to sets of conditions that are necessary or sufficient
Taxonomies ≠ theories

• Several taxonomies of factors contributing to accidents have been developed
• A taxonomy is basically only a classification of something
• A taxonomy is not a theory
• Theories are systems of testable hypotheses
A plea for reductionism

- It is possible, but not very informative, to provide endless lists of risk factors that are associated with accidents.
- It is also possible form fairly abstract and general groups of these factors.
- Does this provide an explanation of accidents?
Good explanations are general

- Ideally speaking, an explanation is a statement of a scientific law
- The possibility of giving law-like explanations in social science has long been denied or treated with considerable scepticism
- Are we forever confined to statements that are, at best, accidental generalisations?
A basic postulate of accident theory

• If road users were always:
  – Perfectly rational, and
  – In perfect control of all hazards

• Then:
  – There would be very few serious accidents

• Therefore:
  – Accidents can always be modelled as a failure of rationality of hazard control
Laws of physics or laws of psychology?

• Both
• I will concentrate on laws of psychology

• These laws summarise in general terms factors that limit human rationality
Laws of accident causation

- The law of learning
- The law of the unpredictable
- The law of complexity
- The law of limited human capacity
- Laws of motion (physical laws)
- Laws of energy dissipation (physical laws)
The logical structure of accident causes

| Accident | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | C(A) |
| 1        | X | X | Y | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 5 |
| 2        | X | Y | Y |   | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 5 |
| 3        | X | X | Y | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 5 |
| 4        | X | X | X |   | Y | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |
| 5        | X | X | X | Y |   | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |
| 6        | X | X | X | Y | Y |   |   |   |   |   |   |   |   | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 7        | X | X | X | Y |   | Y |   |   |   |   |   |   | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 8        | X | X | X | Y | Y |   |   |   |   |   |   | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 9        | X | X | X | Y | Y |   |   |   |   |   |   | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 10       | X | X | X | Y |   | Y |   |   |   |   |   | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 11       | X | X | X | Y |   | Y |   |   |   |   |   | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 12       | X | X | X | Y | Y |   | Y |   |   |   |   | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 13       | X | X | Y | Y | Y |   |   |   |   |   |   | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 14       | X | X | Y | Y | Y |   |   |   |   |   |   | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 15       | X | X | X | Y | Y |   | Y |   |   |   |   | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |

| N(A) | 13 | 14 | 12 | 6 | 5 | 5 | 4 | 4 | 4 | 3 | 3 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 84 |
| P(E)  | 12 | 15 | 12 | 4 | 4 | 3 | 2 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
Rearranging the factors contributing to accidents

| Accident | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | C(A) |
| 2        | X | Y | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 5 |
| 13       | X | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |
| 5        | X | X | X | Y | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |
| 6        | X | X | X | Y | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |
| 7        | X | X | X | Y | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |
| 14       | X | X | Y | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 5 |
| 1        | X | X | Y | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 5 |
| 3        | X | X | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 5 |
| 8        | X | X | X | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |
| 9        | X | X | X | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |
| 10       | X | X | X | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 5 |
| 11       | X | X | X | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 5 |
| 12       | X | X | X | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |
| 15       | X | X | X | Y | Y |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |
| 4        | X | X | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 6 |

N (A) 13 14 12 6 5 5 4 4 4 3 3 1 2 2 1 1 1 1 2 1 8 4
P (E) 12 15 12 4 4 3 2 1 2 1 1 0 0 0 0 0 0 0 0 0
The universal law of learning

- The rate of accidents per unit of exposure drops as exposure increases
- This holds both at the individual and the societal level
- Effects of risk factors tends to vanish
Some instances of the universal law of learning

- Individual driver accident rates drop as annual driving distance increases
- The overall accident rate of a country drops over time

- Both instances can be interpreted as the result of an ongoing process of learning
Injury accidents per million vehicle kilometres - Norway 1973-2003
Relationship between annual driving distance and accident rate. Source: Forsyth, Maycock and Sexton 1995

Mean for men: 0.345 at 8,350 miles per year

Mean for women: 0.389 at 4,766 miles per year
The law of the unpredictable

- The more rarely a risk factor is encountered, the larger is its effect on accident rate

- Applies to risk factors that everybody may, in principle, encounter

- Rare encounters provide few opportunities for learning
Some instances of the law of the unpredictable

- The effect of snow or ice on accident rates
- The effect of rainfall on accident rates
- The effect of horizontal curves on accident rates
- Driver expectations are violated
Relative accident risk on snow- or ice-covered roads in Sweden
Accident rate in curves depending on the length of the straight section before the curve

![Graph showing the relationship between the length of the straight section before the curve and the accident rate for sharp and gentle curves.](image-url)
The law of complexity

• The more elements a road user has to observe per unit of time, the higher the accident rate

• Complexity is a measure of the richness of information

• Human information processing capacity is limited
Some instances of the law of complexity

- The effect of the number of conflict points on junction accident rates
- The effect of the number of access points on overall accident rate
- The effect of highly mixed traffic on accident rates
Injury accident rates in junctions

- Roundabouts 6: 0.05
- Roundabouts 9: 0.06
- Junctions 8: 0.10
- Junctions 32: 0.20

Junction type and number of conflict points
Effect of access point density on injury accident rate
The law of limited human capacity

- Human rationality is limited by the structure of the environment, by information processing capacity, and by factors influencing skills and judgement

- Information processing capacity is limited
- Mental or physical impairments may further reduce capacity
Some instances of limited capacity

- Errors made by novice drivers
- Effects of disease and chronic medical conditions
- Effects of alcohol and other drugs
- Effects of fatigue
- Effects of other temporary conditions
Effect of medical conditions etc on accident rate

- Sleep apnoea: 3.71
- Severe mental illness: 2.01
- Any drug presumably abused: 1.96
- Any visual impairment: 1.09
- Any hearing impairment: 1.19
- Any locomotor disability: 1.17
Laws of motion

• Physical laws of motion set absolute limits to evasive actions road users can take

• Speed determines stopping distance
• Friction determines stopping distance and manoeuvrability
• Mass determines stopping distance
Laws of energy dissipation

- Kinetic energy is dissipated in the form of:
  - Braking
  - Structural deformation
  - Rotation
  - Heat
  - Biomechanical impacts

- Within the duration of accident (< 1 second)