Human Error

Nature of Error

Introduction

- Terrible cost of human error
  - Tenerife runway collision, 1977
  - Three Mile Island, 1979
  - Bhopal methyl isocyanate tragedy, 1984
  - Challenger, 1986
  - Chernobyl, 1986
  - Capsize of the Herald Free Enterprise, 1987
  - Cross tube station fire, 1987
  - Pipe Alpha oil platform explosion, 1988
  - Etc.

Introduction

- Injurious consequences used to be confined to immediate vicinity disaster
- Potentially hazardous technologies
- Consequences may adversely affect whole continents for several years

Study Errors

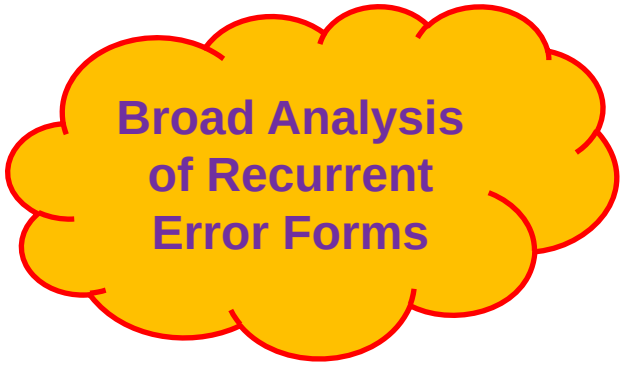
- Effectively predict & reduce
  - Better understand mental process
- Provide picture of cognitive control processes
  - Explain correct performance
  - Predictable varieties of human fallibility

"Knowledge and Error flow from the same mental sources, only success can tell the one from the other"

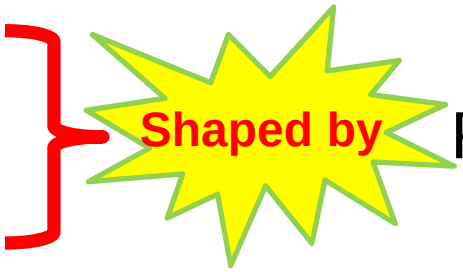
Ernst Mach, 1905

The Cognitive ‘Balance Sheet’

- Correct Performance and Systematic Error
- Resource limitation of conscious workspace
- Automaticity → Slips inevitable



Interpretation of Present & Anticipations of Future



Matching Regularities of the Past

Error Forms

- Limited number
- Neither abundant nor varied
- Similar across mental activities
- Demands formulation of global theories of cognitive control

Variable and Constant Errors

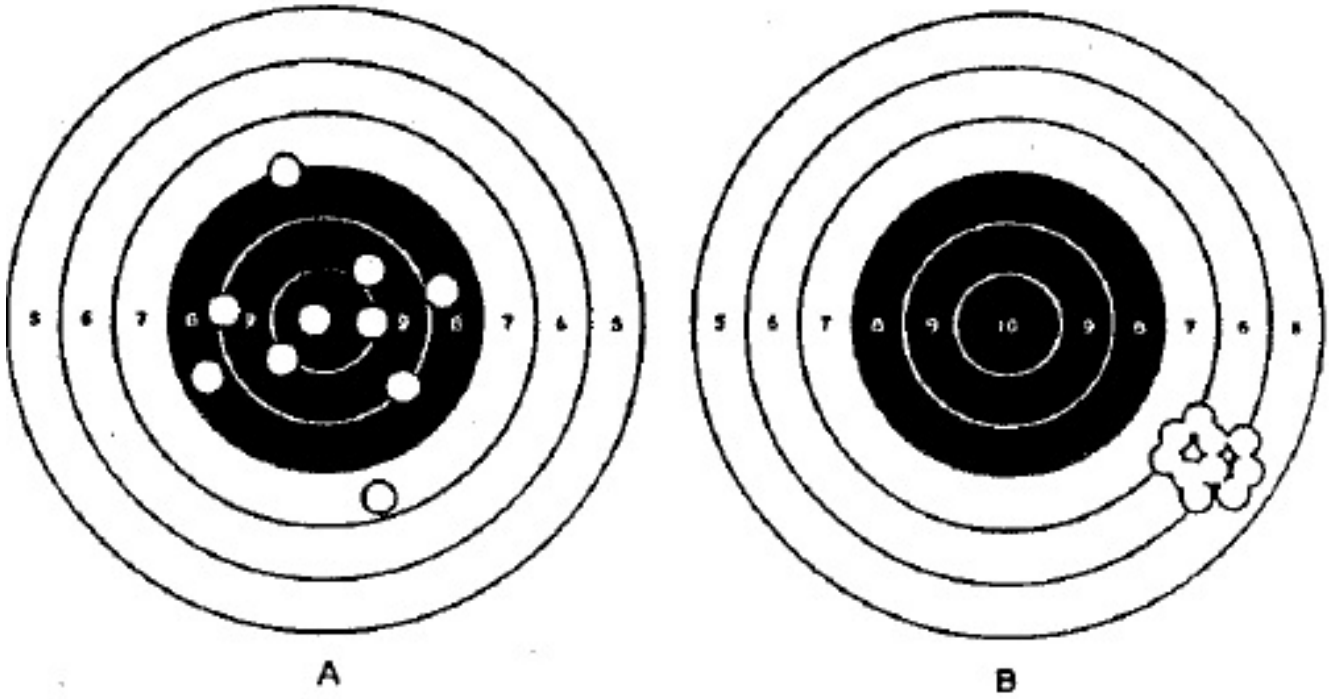


Figure 1.1. Target patterns of ten shots fired by two riflemen. *A*'s pattern exhibits no constant error, but rather large variable errors. *B*'s pattern shows a large constant error, but small variable errors (from Chapanis, 1951).

Accuracy of Predicting Errors

- Factors giving rise to errors understood

Require

- Theories relating the major elements in producing error:
  - Nature of task and its environmental circumstances
  - Mechanisms governing performance
  - Nature of individual

Accuracy of Predicting Errors

- Forecast conditions under which an error occurs
- Form of error
- Imperfect & incomplete
- Probabilistic

Intentions, Actions and Consequences

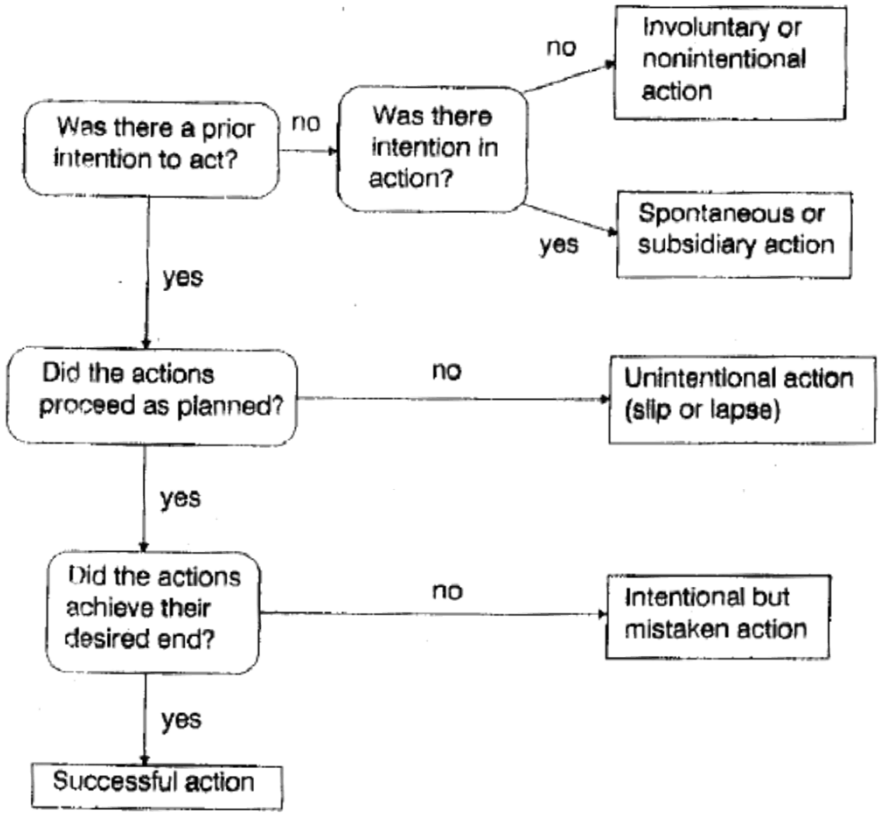
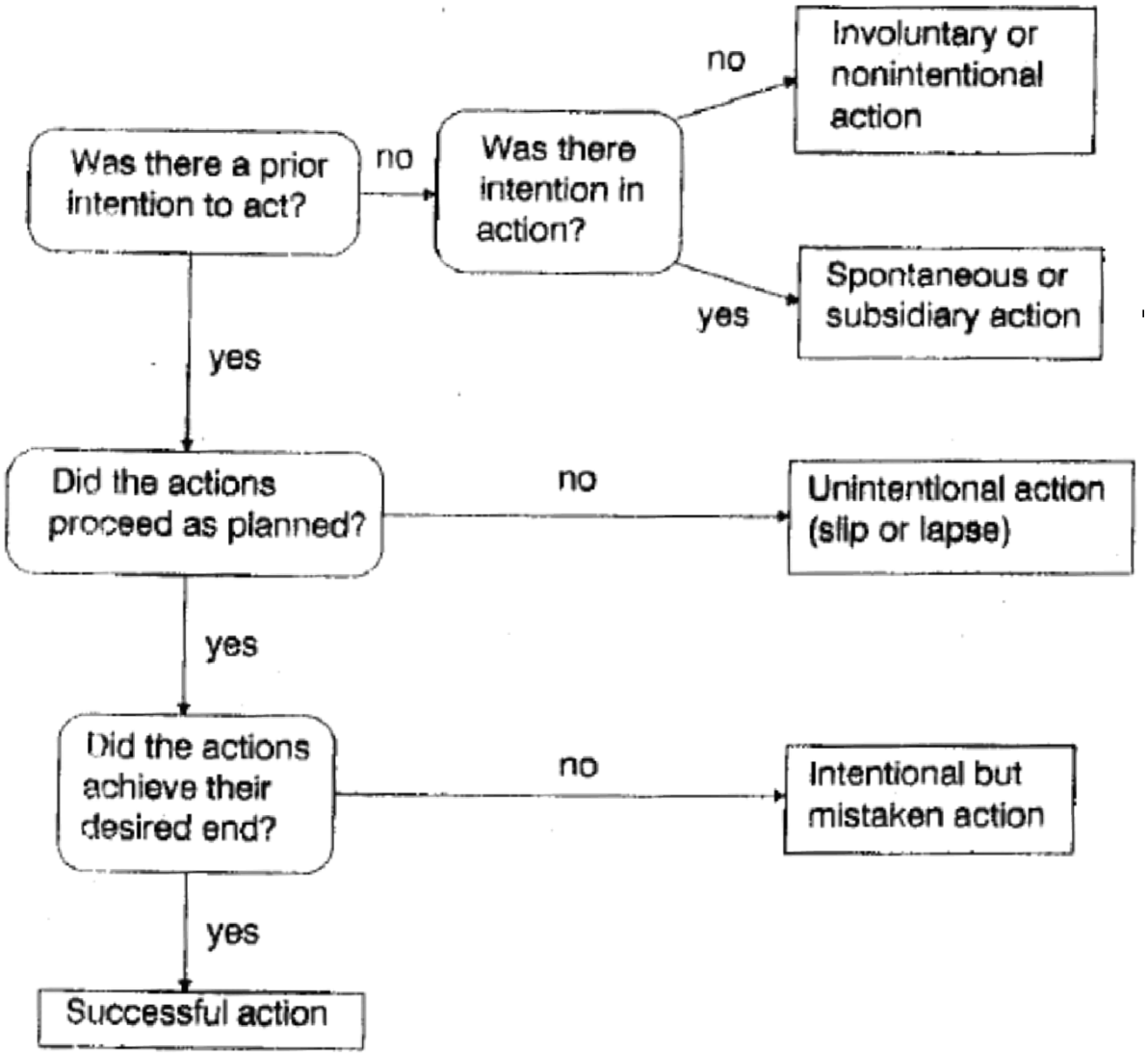


Figure 1.2. Algorithm for distinguishing the varieties of intentional behaviour. The three main categories are non-intentional behaviour, unintentional behaviour (slips and lapses) and intentional but mistaken behaviour.

Distinguishing Kinds of Intentional Behavior

- Were the actions directed by some prior intention?
- Did the actions proceed as planned?
- Did they achieve their desired end?



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Intention

- Expression of end-state to be attained
- Indication of the means to achieve it
- Routine Activity → low-level control statements
- Novel activities → conscious attention

Prior Intention and Intentional Action

"All intentional actions have intentions in action but not all intentional actions have prior intentions"

Searle, 1980

Actions w/o Prior Intention

- Intentional actions w/o prior intention
- Non-intentional or involuntary actions

Intentional Actions w/o Prior Intention

- Spontaneous
  - Intention resides in the action itself
  - Action and intention inseparable

- Subsidiary
  - Well-practiced action sequences
  - Major headings
  - Have an intention but no prior intentions

Non-intentional or Involuntary Actions

- Hits out in a spasm and hurts another
- Suddenly stung by a bee, in his agony drops and breaks a plate he is holding

Error and Action

- Error can only be applied to intentional actions
- Error types depend critically upon failure types:
  - Failure of actions to go as intended (slips and lapses)
  - Failure of intended actions to achieve their desired consequences (mistakes)

Intended and Unintended Actions

- Unintended actions
  1. Deviate from intention
  2. Achieve their intended goals (highly unlikely)
  3. Don’t

- Absent-mindedness (slips)
  - Automatic task in familiar surroundings
  - Attention captured by something other than the job in hand

Intended Actions and Mistakes

- Intended actions proceed as planned
- Fail to achieve intended outcomes
- Adequacy of the plan rather than
  - Conformity of its constituent actions to some prior intention

Intended Actions and Mistakes

"If the intention is not appropriate, this is a mistake. If the action is not what was intended, this is a slip"

Norman – 1983

Planning Failures ➔ Mistakes

Execution Failures ➔ Slips & Lapses

Working Definitions – Error

Generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency.

Working Definitions – Slips and Lapses

Errors which result from some failure in the execution and/or storage stage of an action sequence, regardless of whether or not the plan which guided them was adequate to achieve its objective.

Working Definitions – Mistakes

Deficiencies or failures in the judgmental and/or inferential processes involved in the selection of an objective or in the specification of the means to achieve it, irrespective of whether or not the actions directed by this decision-scheme run according to plan.

Mistakes

- More subtle, more complex, and less well understood than slips.
- Far greater danger
- Harder to detect.
  - Consciousness pick up departures of action from intention
  - Pass unnoticed for lengthy periods
  - Matter of debate when detected

Quality of Plan

- Open to a diversity of opinion
- Judged before and after implementation
- Prior to execution:
  - has sufficient contingencies,
  - displays soundness of judgment, imagination, flexibility, awareness of detail
- Once in action
  - How well it achieved its stated objectives

"Defective decisions based on misinformation and poor judgment sometimes lead to successful outcomes … we must acknowledge that chance and the stupidity of the enemy can sometimes give a silk-purse ending to a command decision worth less than a sow's ear"

Janis 1972

Classification of Error

- Behavioral level
- Contextual level
- Conceptual level
- "What?", "Where?", How?"

Behavioral Level

Superficial level, classification according to:

- Observable feature of the erroneous behavior:
  - formal characteristics of the error
    - omission-commission, repetition, misordering
  - immediate consequences
    - nature and extent of damage, injury
- Dealing with applied data at behavioral level:
  - Concerned with recoverability, human versus machine attribution, and operator versus design responsibility

Behavioral Level

- No simple and direct mapping of behavioral error types onto more theoretical categories of cognitive failure
- Members of the same behavioral error class can arise from different causal mechanisms
- Members of different behavioral categories can share common etiologies

Contextual Level

- Limited assumptions about causality
  - Do not stray far from the 'surface' data
  - Many slips of the tongue and pen taxonomies are constructed at this level

- Include reference to contextual triggering features as anticipations and perseverations.

Contextual Level

- Acknowledge relationship between error type and character of the situation
  - What prompts an error to appear at a particular point in the behavioral sequence
  - Stress the importance of recording as much information as possible regarding the surrounding circumstances
  - both internal and external to the perpetrator of the slip

Contextual Level – Limitations

- contextual factors cannot explain why the same or very similar circumstances do not always trigger the same error forms

Conceptual Level

- Predicated on assumptions about the cognitive mechanisms involved in error production
- Based more upon theoretical inferences than on the observable characteristics of the error or its context

Conceptual Level

- With each successive level of classification
  - move further from the immediate 'surface' data and deeper into the realm of assumption and conjecture.

- Classifications based upon conceptual considerations are potentially the most fruitful
  - because they seek to Identify underling causal mechanisms.

Error Types

Origin of an error within the cognitive stages

- Planning
  - identifying a goal and deciding upon the means to achieve it
- Storage
  - variable duration intervenes between formulating the intended actions and running them off
- Execution
  - Processes involved in actually implementing the stored plan

Error Types

Cognitive Stage	Primary Error Type
Planning	Mistakes
Storage	Lapses
Execution	Slips

Mistakes

- Failure of expertise
  - Rule-based level of performance
  - Pre-established plan or problem solution is applied inappropriately

- Lack of expertise
  - knowledge-based level of performance
  - Individual not having an appropriate 'off-the-shelf routine, is forced to work out a plan of action from first principles, relying upon whatever relevant knowledge they possess

Methods of Investigating Human Error

- Naturalistic methods
  - collecting, analyzing and .classifying naturally occurring slips and lapses

- Corpus gathering
  - Identification and description of naturally occurring phenomena
  - Portrays the richness and variety of real-world phenomena
  - Large enough corpus provides a reasonably comprehensive qualitative account of the available species of error.

Questionnaire Studies

- Present subjects with descriptions (and/or examples) of different slips and lapses

- Ask them to rate approximately how often they have experienced each one during some specified time period

Laboratory Studies

- Most powerful technique for studying underling mechanisms
- Deliberate elicitation of particular error types under controlled laboratory conditions

Laboratory Studies – Problems

- Precise control over possible determinants of error often forces investigators to focus upon rather trivial phenomena
  - Large number of studies on Stroop effect

- Usually the greater the measure of control achieved, the more artificial and unnatural are the conditions under which the error is elicited.

Simulator studies

- computer-based simulations
- Create dynamic features of real-life within laboratory
- complex decision-making tasks that were hitherto lacking in static, one-shot experimental studies
- Examine effects of complexity and feedback delay upon decision making in highly dynamic situations

Case Studies

- The primary sources of data are accident reports.
- Attributing blame & tell a story that may be inaccurate or incomplete
  - even when reports are prepared by experienced and relatively open-minded investigators

Case Studies

- Accident report contains less information than was potentially available
- A written account has the effect of 'digitizing' what in the original was a complex and continuous set of 'analogue' events
- Disasters are rarely the product of a single monumental mistake
- Several errors committed either by one person or, more often, by a number of people