Errors

Norman

- "Freud believed that slips resulted from competition among underlying mechanisms, often working in parallel with one another and almost always beneath the consciousness of the owner. The resulting notions were of mental operations controlled by a quasi-hierarchical control structure, with parallel activation of thoughts and memories and with conscious access to only a limited amount of this activity" p. 2.
- Gee -- was Freud really a Cognitive Scientist?

Perspectives on Errors

- Gray & Fu on postcompletion errors

Outline of an Activation-Trigger-Schema System

- Combines elements of theory from control of cognition in his day. A nice blending of things without getting overly precise in the mechanisms. The result could easily fit within several of our contemporary systems, including ACT-R.
**Schemas**

- A knowledge-structure
  - Think of data-structures in the head
  - In particular, one specialized for sensori-motor knowledge

- Activation
  - Like DMEs in ACT-R -- different schemas have different activation values

- Trigger
  - Could be implemented in the left-hand side of a production rule

**ATS Applied to Errors**

- In this paper, Norman is attempting to use a generic control structure (for control of cognition) to explain slips

- Parent -- child
  - Think of this very generically
  - goal -- subgoal
  - Objects as in object-oriented programming, specialized forms, etc

**Essence of Control Structure**

- "The essential assumptions are that any given action sequence is controlled by an ensemble of child schemas, that at any one time numerous schemas for a number of different sequences may be active. Schemas only invoke actions when they have been triggered, and this requires satisfaction of trigger conditions plus a sufficiently high level of activation." p. 5.

**Norman’s Three Categories of Slips**

- formation of the intention
- activation
- triggering
**Formation of Intention**

- Will ignore errors that result from “intention formation” problems as a result of decision-making or problem-solving issues.
- Two classes of errors in intention:
  - Errors in classifying the situation — mode errors
  - Errors that result from ambiguous or incompletely specified intentions

**Errors in Classifying the Situation**

- **Mode Errors**
  - “The intentions, the act specification, and the carrying out of the acts are done properly; the fault lies in specification of the situation” p. 6.
  - “they share the characteristic that an action entirely appropriate for a situation is being performed, except that this is not the current situation” p. 7.
- **Description Errors: Insufficient Specificity**

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**Slips from faulty activation of schemas**

- Two ways to be faulty
  - A schema may be unintentionally activated
  - May lose its activation before its appropriate time to control behavior has occurred (leading to an omission)

**Unintentional activation**

- **Capture Slips**
  - Familiar habit substitutes itself for the intended action sequence. Stimulus generalization as the traditional mechanism
  - “particularly when the central processor is occupied with some parallel mental activity” p. 8 — Norman quoting Reason 1979.
- **External Activation (data driven)**
  - E.g., Stroop effect
- **Associative Activation**
**Example of Stroop Test**

- Two lists will follow
- For first list, say the “name” of the word as fast as you can, ignore the color it is printed in (i.e., read the word)
- For the second list, say the “color” of the word as fast as you can, ignore the name of the word.

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**Stroop Effect**

- Interference -- both the physical shape of the letters and the color are activating semantic memory
- Problem is that they are activating different semantic memories, though closely related (color names)
- Example of external activation interfering with performance of a task and leading to errors (data driven)
- Hence, Norman would say that the wrong schema has been activated
**Loss of Activation**
- Second class of activation errors stem from loss of activation
- Step skipping
  - A major concern to the aviation community
- Post-completion errors (Byrne & Bovair)

**Faulty Triggering**
- Schema properly selected and activated but triggered at the wrong time or not at all
- Spoonerisms
- Confusing intention with action (thought with deed)
- “Slips that result from failure to perform some action are more difficult to detect than errors that result from falsely executed action” p. 11

**Detecting Slips**
- The need for feedback mechanisms in cognitive behavior
  - A feedback mechanism with some monitoring function that compares what is expected with what has occurred;
  - A discrepancy between expectations and occurrences
- Notion that need to know the intention, not just the outcome (act could be executed brilliantly, but could be the wrong act!)
- See table 3

**Levels of Feedback**
- “To compare intentions and actions, the two must be at the same level of specification” p. 13.
- His car key example from the Psychology of Everyday Things book
- Data from Gray & Anderson on Lisp programming
Naturalistic Methods

- Hard, very hard!!
- See Friday’s lecture for one solution
- “If the goal is to determine relative frequency, then only a complete record will do.” p. 14
- If goal is to truly study their origin and detection then only a complete record will do. Retrospective records just will not yield a complete understanding of human error!!

Norman’s Summary of Norman

- Theory allows for multiple sources of activation – external world, internal processing, or well-learned familiar habits.
- Slips occur for only three reasons
  - the formation of the intention is in error
  - there is faulty activation of schemas
  - there is a failure in satisfying the conditions for triggering
- The performance of an action, from initial conceptualization through realization, is then the process of
  - decomposing the original intention into a sequence of physically performable acts
  - with multiple levels of feedback analysis accompanying the acts

Berry

- Three takes on errors
  - Naturalistic
  - Lab studies with simulated task environments
  - Case studies

Slips versus Mistakes

- Slips – failures in the execution phase of an action sequence.
- Mistakes – originate in the planning (or intention) phase
### Reason's Reasonable Expansion
- Skill-based slips and lapses
- Rule-based mistakes
- Knowledge-based mistakes

### Naturalistic Studies
- Norman's (1981) categorization of action slips
  - Slips in the formation of intention
  - Faulty activation of schemata
  - Faulty triggering

### Problems with Naturalistic Studies
- Numerous methodological problems with observing and recording one's own slips and those of others
- Difficulties in classifying particular slips

### Laboratory studies of mistakes in the control of simulated systems
- Simulated task environments
  - Lohhausen & Moro (Dörner), Fire-fighting (Brehmer)
## Primary Mistakes

- Insufficient consideration of processes that extended in time. Ss tended to focus on time NOW. Ignore trends.
- Trouble dealing with non-linear trends (exponential).
- Thought in terms of "causal series" not "causal net." Ignored side effects or delayed effects.

## Mistakes Made by Poor Ss

- Thematic vagabonding – frequent changes of topic, failure to follow through a line of thinking from beginning to end
- Encystment – Stick to a single point and focus attention on it, ignoring other aspects of what was going on.
- Blaming others (including the system) for one’s failures
- Delegating responsibility that should not be delegated
- Refusing to make any decisions

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## Case studies

- **Active errors**
  - have consequences that are immediately apparent and tend to be associated with front line operators of a system.
- **Passive or latent errors**
  - have consequences that may lie dormant within a system for some time. Tend to be associated with people who are not front line operators (designers, managers, and maintenance personnel).

## Impossible Accidents!

- Can accidents such as 3-mile island and Bhopal have been predicted and prevented?
- Most accidents are result of highly complex coincidences that could rarely be foreseen by the people involved.
**Error Detection**

- Role of Memory in Error Detection
  - A feedback mechanism with some monitoring function that compares expected to found
  - Discrepancy between expect and occurrence
  - Errors will only be detected and remedied if the comparison of intention and action is done at the same level of specification

- Straight from Norman

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**Error Reduction**

- People oriented approaches
- System oriented approaches

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**Additional Data on Postcompletion Error**

- VCR Study (Gray & Fu, in prep)
- Effect in programming varied across three groups: gray-box > control group > memory-assurance
- Expected that errors would vary as well -- data supported this

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**Postcompletion Error in the VCR Task**
**Additional Data**

- Looked at postcompletion error for gray-box group as function of # checks of show information per trial
  - 1.26 checks on error free trials
  - 1.66 checks on error trials (when postcompletion error are excluded)
  - 3.92 checks on postcompletion error trials

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**Summary**

- Working memory capacity is key variable in understanding performance differences as function of workload
- Also key to understanding individual differences in performance
- Requires well developed theory to understand how working memory affects performance
- Requires a rigorous computational approach to predict performance

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**Larson & Perry**


**Contributions**

- Focus on errors that “stem from the environmental capture of our actions”
- Consider that the tendency for attention to be captured by the environment may be central limit of the human information processing system
- Hence, error proneness (for a certain class of errors) may be reflect individual difference on limits of the control of attention

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**Measures**

- Cognitive Failures Questionnaire (CFQ)
- Mental Counters Test
- Saccade Test
Results

- Capture errors
  - Failure to inhibit a reflexive saccade to the cue in the antisaccade condition
  - Occurred on 40% of antisaccade trials

Results -- Over all Subjects

- Eye Movement Latencies
  - Saccade RT
    - Approximately 250 msec -- same for pro & anti trials
  - Fixation RT
    - 159 msec slower for anti than for pro
  - Anti is hard to do

Results -- Individual differences

- Prosaccade
  - Neither CFG or MC correlate with either saccade RT or fixation RT

- Antisaccade
  - MC does not correlate with anything
  - CFG sign correlation with saccade RT
  - CFG sign correlation with capture errors

Results

- Capture errors
  - Failure to inhibit a reflexive saccade to the cue in the antisaccade condition
  - Occurred on 40% of antisaccade trials
**What does it mean?**

- Some human errors inadvertently triggered by environmental cues
- These cues take momentary precedence over internal goals
- Error prone individuals find it harder to suppress this response than non-error prone people

**Human Error**

- Working memory failures
- Visual capture errors
- Individual differences
- What else?
- Can we design for error?