Behavioral and Cognitive Methods

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Perceptual Cycle (Neisser, 1976)

- Argued that knowledge of how the world works (e.g., mental models) leads to the anticipation of certain kinds of information, which in turn directs behavior to seek out certain kinds of information and provide a ready means of interpretation.
- As the environment is sampled, the information serves to update and modify the internal, cognitive schema of the world, which will again direct further search.
- Action is directed by schema
- Faulty schemas or faulty activation of schemas will lead to erroneous performance in at least three ways:
  - We can select the wrong schema due to misinterpretation of the situation.
  - We can activate the wrong schema because of similarities in the trigger conditions.
  - We can activate schemas too early or too late.

Model of Action (Norman, 1986)

- Human activity divided into two distinct phases:
  - Execution (human action produces changes in the world)
  - Evaluation (changes in the world are evaluated).
- Both of these phases are linked by goals, which define the purpose of the activity.
- In a seven-stage model, a goal is translated into intention, which is in turn translated into a sequence of actions, which are finally executed.
- Feedback on the effects of the action are perceived by the sensory systems, those perceptions are then interpreted, and interpretations evaluated and related to the goal.

Multiple Attentional Resources (Wickens, 1992)

- Extends the standard stage-based process model (i.e., where information is perceived via the sensory systems, to a decision-making system that draws on memory, from which actions are decided upon and executed) to propose a theory of multiple pools of attentional resources in relation to different information-processing demands:
  - Speech and text utilize a verbal information-processing code and draw upon a different pool of attentional resources than tones and pictures, which utilize a spatial processing code.
- Demands and resources can come from the task, the device, and the user.

Cognitive Task Analysis Methods

- CTA methods developed for tasks involving significant cognitive components (such as monitoring, anticipating, predicting, and decision making).
- CTA methods often describe a system in terms of goals and subgoals, with feedback loops in a nested hierarchy.
- CTA methods are inherently flexible and can describe any system involving decisions.
- CTA methods are versatile and can be used for person specification, training requirements, error prediction, team performance assessment, and system design.

Cognitive Task Analysis Methods

- Hierarchical task analysis (HTA)
- Cognitive allocation of function (extension of HTA)
- Critical decision method (CDM) (an update and extension of the critical incident technique)
- Applied cognitive work analysis (ACWA)

Error Analysis Methods

- Can we predict human error?
  - Systematic human error reduction and prediction approach (SHERPA) – partly based on HTA as a description of normative, error-free behavior to consider what may go wrong in task performance. At the core of SHERPA is a task and error taxonomy.
  - Task analysis for error identification (TAFEI) - based on the idea of rewritable routines. TAFEI can be used for predicting, representing, and analyzing the dialogue between people and products. TAFEI has two forms of output.
    - Predicted errors from human interaction with a device, based on the analysis of transition matrices.
    - Task flow model based on mapping human action onto state–space diagram.

Workload and Situational Analysis Methods

- Can we measure mental workload?
- Mental workload is a multidimensional concept incorporating task and performance demands together with operator skill and attention.
- Both mental overload and mental underload are associated with performance decrements
- Task design must keep workload within an optimal performance zone, where workload is neither too high nor too low.
- Measures of mental workload include measures of primary and secondary task performance, and physiological, psychophysiological, and subjective measures.

Workload and Situational Analysis Methods

- Multiple resources time-sharing model (MRTSM) - developed from Wickens's (1992)multiple resources theory into a practical approach for predicting workload in situations where multiple tasks are performed concurrently.
  - MRTSM distinguishes between perceptual modalities, processing stages, processing codes, and responses. The methodology can predict multiple task performance and overload but it cannot predict mental underload on tasks.
- Multimodal critical path analysis (mmCPA) method has its roots in:
  - CPA - based in project management literature
  - Multimodality of people is based in a human factors literature.

Workload and Situational Analysis Methods

- Keystroke-level model (KLM) - a simple additive method for calculating response times in computing tasks. Does not take account tasks performed in parallel (i.e. when they use different modalities and draw upon different resources).
- Situational awareness global assessment technique (SAGAT) measures three levels of awareness (i.e., perception of elements, comprehension of the situation, and prediction of future status) by presentation of recall-probe

questions when the task is interrupted. The recall probes are developed using an HTA-type technique so that operator goals can be elicited. From this, questions at each of the three levels of awareness can be developed.

Conclusions

- Selection of the appropriate set of CTA methods requires that the analyst ergonomist careful define the purpose of the analysis.
- Most studies are likely to involve a combination of CTA methods.
- A pilot study should be used to determine the methods most likely to yield the kind, and form, of data required.