A series of decisions required
The next decision depends on the outcome of the previous one(s)
Environments change
- as a function of the decision(s)
  and/or
- autonomously

Clock-driven (real-time) v.s. event-driven tasks
Interaction between players
What is dynamic decision behavior?
- Task performance
  * Single / aggregate, consistent / conflicting
- Learning (task knowledge)
  * Verbalizable / non-verbal, declarative / procedural
- Decision efforts
  * Time
  * Information use
- Decision quality
  * Decision scope
  * Reliability
- Decision making architecture
  * Networked / hierarchical
What can explain / predict dynamic decision behavior?
- Decision makers
- Task complexity
- Decision-making interfaces and environments

Four predictors related to decision makers:
- Computing skills
- Cognitive / learning style
- Task expertise
- Task experience / practice

Computing skills - Not found to be directly relevant

Cognitive / learning style
- Almost without relevance, except *Abstract* in Gregorc Style Delineator -- learning concepts first, then examples
- Test intelligence in the European literature
Task expertise
- Task performance affected by academic background / long-term expertise
  or by pre-task training on task domain knowledge?
- Task domain knowledge helps learning decision heuristics?

Task experience / practice
- Improves task performance, reduces decision time
- Task knowledge acquired? -- video game effect, dissociation between performance and learning
- Types of task knowledge

Practice, Performance, and Learning

Task experience / practice

Task structure (declarative, feedback loops, variables’ relationships: direct / indirect)

Heuristics (procedural)

Decision-outcome contingencies

Task performance
Predictors ↔ Independent Variables

What can explain / predict dynamic decision behavior?
- Decision makers
- Task complexity
- Decision-making interfaces and environments

Predictors related to complexity of task systems
- Real-time / event-driven simulation tasks
- Various task characteristics embedded in variables, e.g., treatment risk, types of software project, etc.
- Total number of variables
- Random variation
- Interaction of subsystems
- Positive feedback gains
- Lagged effects / time delays
- Decision effectiveness / task salience
- Frequency of oscillation
Real-time / event-driven simulation tasks
   - No effect on task performance and decision time found
   - Have to be replicated in simple tasks

Total number of variables: degrading task performance

Random variation: degrading task performance

Interaction between subsystems
   - Supposedly a negative effect on task performance, but
     a positive effect found
   - Types of subsystems (positive and negative loops)
   - Dominance of loops

Positive feedback gains
   - Enlarging trivial error, side effect
   - Task performance degraded
   - Decision time unchanged
   - Reduce decision scope (decision rules attempted)
   - Task knowledge?

Lagged effects (delays), decision effectiveness, and oscillation
   - Time lag ignored → over-aggressive action?
   - Task performance degraded
   - Information use and decision-architecture unchanged
   - Verbal knowledge impaired
   - Decision time unchanged?
What can explain / predict dynamic decision behavior?
- Decision makers
- Task complexity
- Decision-making interfaces and environments

Predictors related to decision-making interfaces and environments
- Decision-making architecture
- Heuristics built in task for Monte-Carlo simulation

**Direct Prescriptions**
- Heuristics-induced goal setting
- Verbal instructions on heuristics or task property

**Indirect Decision Aids**
- Concurrent verbalization (thinking-aloud)
- Degree of decision precision required
Predictors related to decision-making interfaces and environments (continued)

**Information Feedback**
- Contents of information feedback
- Forms of information feedback

**The Role of Task Complexity for Indirect Decision Aids**
- Learning modes induced by lagged effects
- Learning inducement
- Increasing task salience

Decision-making architecture (networked / hierarchical)
- The effect on task performance supported
- Decision time unaffected

Heuristics “hard-wired” in task systems
- Assumptions of the Monte-Carlo simulation:
  heuristics implemented with perfect consistency
- Heuristics demanding more information and more computation complexity do not always result in better task performance
Direct Prescriptions
- Heuristics-induced goal setting
  - Task performance improved
  - Decision time saved and information use affected
  - Task knowledge acquired

- Verbal instructions on heuristics or task property
  - Instructions on heuristics improves task performance, but task knowledge?
  - Instructions on task property → task performance?
  - Instructions on task property do not improve declarative knowledge -- direct / indirect relationships
  - Which is more helpful?
**Indirect Decision Aids**

- Concurrent verbalization (thinking-aloud)
  - Verbalization after pre-task instructions on performance and learning
  - Verbalization alone? Sufficient practice required? Redundancy with graphical representation?

- Require higher degree of decision precision - 1st decimal place
  - Force subjects to reason out the workings of variables’ relationships
  - The positive effect on performance and learning mixed supported
  - Task complexity as the “invisible hand” again?

**Information Feedback**

- Contents of information feedback
  - Available throughout task operations
  - Bayesian probability helps performance, but more time needed
  - Previous decisions and outcomes (outcome feedback) hinder performance and decision reliability → Completeness not relevant here
  - Cognitive feedback (task property) and feedforward (heuristics)?
Information Feedback
 Forms of information feedback
 - Graphical representation helpful
 - Equations with semantic meanings v.s. symbols only
 - Cue weights explicated v.s. cue weights plus decision rules

- Combination of contents and forms?

- Interaction of various decision aids?
  - Direct, indirect, and information feedback
  - Real-world learning environments

The Role of Task Complexity for Indirect Decision Aids
 Learning modes induced by lagged effects
 - Selective mode: explicit search for task structure
 - Unselective mode: decision-outcome contingencies
 - Adopting s-mode improves performance and declarative procedural knowledge
 - So what is good for u-mode learners? Transferring knowledge between tasks

- Increasing task salience
  - Informing subjects with lagged effects does not help
  - Providing task structure information improves performance and knowledge acquisition
The Role of Task Complexity for Indirect Decision Aids

- Learning inducement
  - Economic reward for search for task structure improves performance and decision scopes, though decision time not saved significantly
  - Another evidences find the explicit search instruction only helps those interacting with a salient task (no delays), but has a negative effect on performance for those interacting with a non-salient task (lagged effects)

What can explain / predict dynamic decision behavior?
- Decision makers
- Task complexity
- Decision-making interfaces and environments
Task Complexity as the Invisible Hand

- Lurking behind all empirical evidences
  - Providing task property information may be useful is a “simple” task, but not in a “difficult” task

- Are people dynamically deficient?
  - Appears “yes” from the literature
  - Task complexity as a ceiling for human performance on dynamic decision making

- An unified complexity metric?
  - Delay and positive feedback gains as individual indicators

<table>
<thead>
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<th>Delay</th>
<th>Score</th>
<th>Ceiling</th>
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<tr>
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<tr>
<td>4</td>
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</table>

Ceiling Score = 800 - Delay * 99
Components of Cognitive Feedback (Balzer et al., 1989)

Task information: Re, inter-cue correlation, and cue-criterion relation
Cognitive information: Rs and cue-judgment relation
Functional validity information: ra, G, and C

\[ r_a = GR_e R_s + C \sqrt{(1 - R_e^2)(1 - R_s^2)} \]

- The lens model equation above depicts the relationship between human performance (ra) and task predictability (Re).
  - If the nonlinear part can be ignored, i.e., Re and Rs large enough, ra is always less than Re since Rs (judgmental reliability) is always less than 1 even when we have a perfect knowledge (G = 1). That is, \( r_a \leq R_e \)

- Dynamic version of the lens model?
  - Independence of judgments (decisions in DDM)
  - A complex task model captured by a regression model
  - Human decisions in dynamic situations captured
Design of Information Feedback as an Effective Decision Aid
-- Cognitive Feedback?
  - What component of cognitive feedback helps dynamic decision making?
    - Task structure
    - Relevant cues with weights
  - Cognitive feedback (task property instructions) v.s. Feedforward (heuristics instructions)
  - Cognitive continuum theory as an alternative theoretical foundation for the design of information feedback

Design of Information Feedback as an Effective Decision Aid
-- Outcome Feedback?
  - For a judgment, such as weather prediction, the outcome of the judgment is the true status. For a dynamic decision task, we have a series of decisions leading to “outcomes.”
  - Outcome feedback in dynamic decision environments
    - In some DDM studies reviewed, outcomes of subjects’ decisions are regarded as outcome feedback
    - How about benchmark decisions and outcomes?
    - Plots over time as outcome feedback
**Task Expertise**
- What is task expertise?
  - Task domain knowledge, e.g., social welfare, economics
  - Between domain knowledge and task property and heuristics → capability to identify certain patterns, e.g., delays and fixes that fail, “systems architectures”
  - Systems thinking experts?

- How task expertise can be developed and helpful in DDM tasks
  - Formal academic training and/or long term experience
  - Pre-task training sessions
  - Group model building exposure?

**Methodological Issues**
- The current review collects the dynamic decision making research conducted by laboratory experiments with two possible limitations.

- Single case studies as theory construction and testing

- Dynamic feedback models as a theory of dynamic decision behavior