A sequence analysis of actions in complex systems comprehension

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Introduction

- Modern life implies to take decisions in complex situations (Sterman, 2000).
- Complex systems are composed of numerous interacting elements, which evolve across time (Illachinski, 1996).
- Human beings are limited in situations involving such systems (Karakul & Qudrat-Ullah, 2008).
- In these situations, individuals may be greatly helped by external supports, as those based on visual analytics techniques (Thomas & Cook, 2005).
- The **IMAGE** computer tool (Lizotte, Bernier, Mokhtari, Boivin, DuCharme, & Poussart, 2008; Lafond, Gagnon, Tremblay, & Lizotte, 2009) aims at augmenting the comprehension of complex systems by analysts through an interative process involving (1) representation, (2) scenarisation, (3) simulation and (4) exploration (see Figure 1).

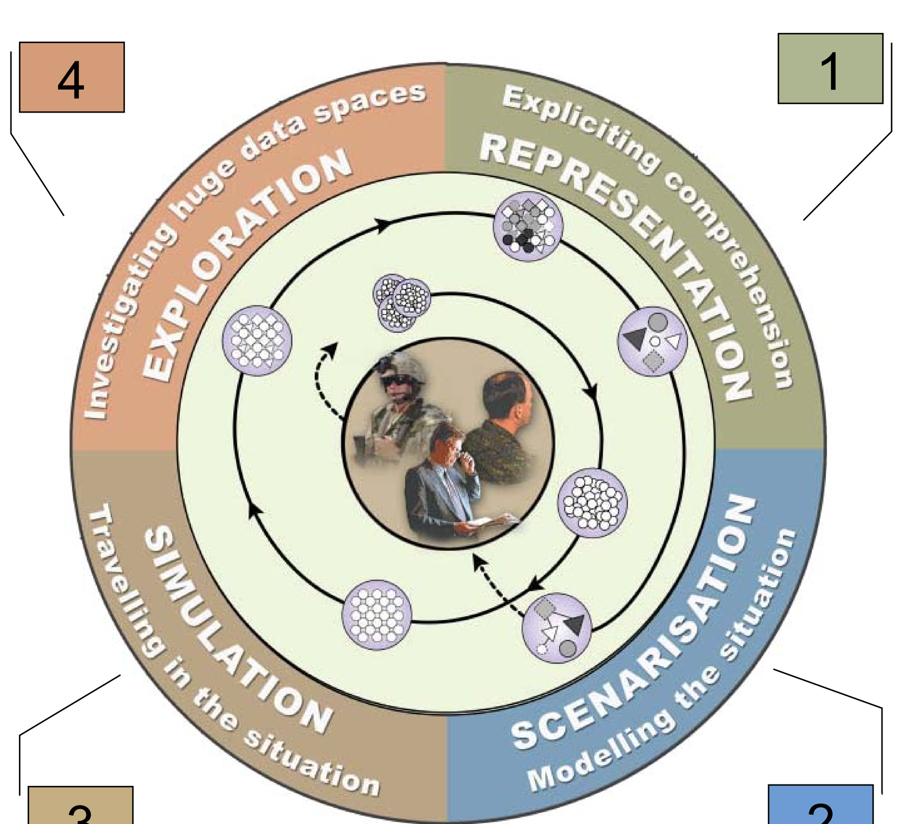

Figure 1. The concept underlying the **IMAGE** system, with its four modules: (1) representation, (2) scenarisation, (3) simulation and (4) exploration.

Research questions

- Is comprehension augmented by the **IMAGE** tool?
- If yes, when, and why?

Method

Participants

- 24 students with formal knowledge (e.g., mathematics).

Procedure and Design

- Two groups (n = 2 x 12) : **Baseline** and **IMAGE**.
  - **Baseline** : tools with reduced functionalities.

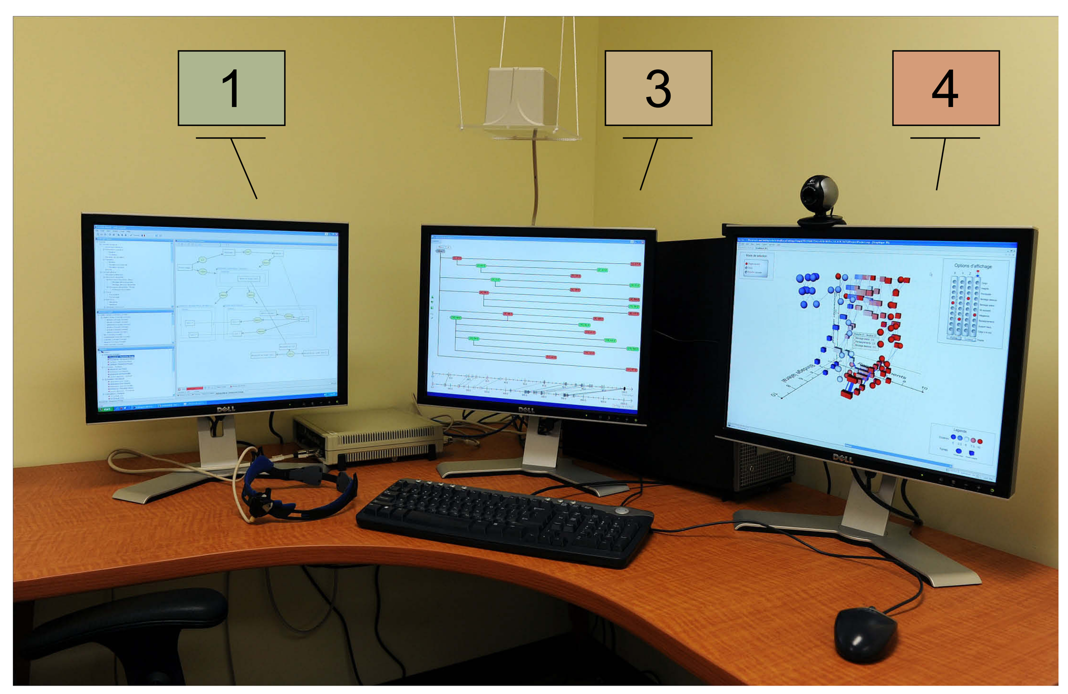

Figure 2. The experimental interface with its three modules: (1) representation, (3) simulation and (4) exploration.

- Task: (I) understand a system and answer questions about how to optimize variables; (II) represent one's knowledge of the system.
- Scenario: a military convoy crosses a field and defends itself against insurgents (Bernier & Rioux, 2008). Two levels of complexity:
  - Tactical : 1 mission.
  - Procedural: 100 missions + co-evolution.
- 2 tutorial sessions
  - Tools + Complex systems.
- 4 sessions over 2 cycles :
  - Cycle 1 : (A) Tactical, (B) Procedural.
  - Cycle 2 : (C) Tactical, (D) Procedural.
- Duration of a session: 1h15-2h00.
- Dependent variable : comprehension index based on variables to optimize.
- Independent variables :
  - Group, Complexity, Cycle, Actions.
- Analysis of actions
  - Hierarchical Task Analysis (Annett, 2003).
  - Sequential analysis (Gabadinho, Ritschard, Studer & Müller, 2008).

Results

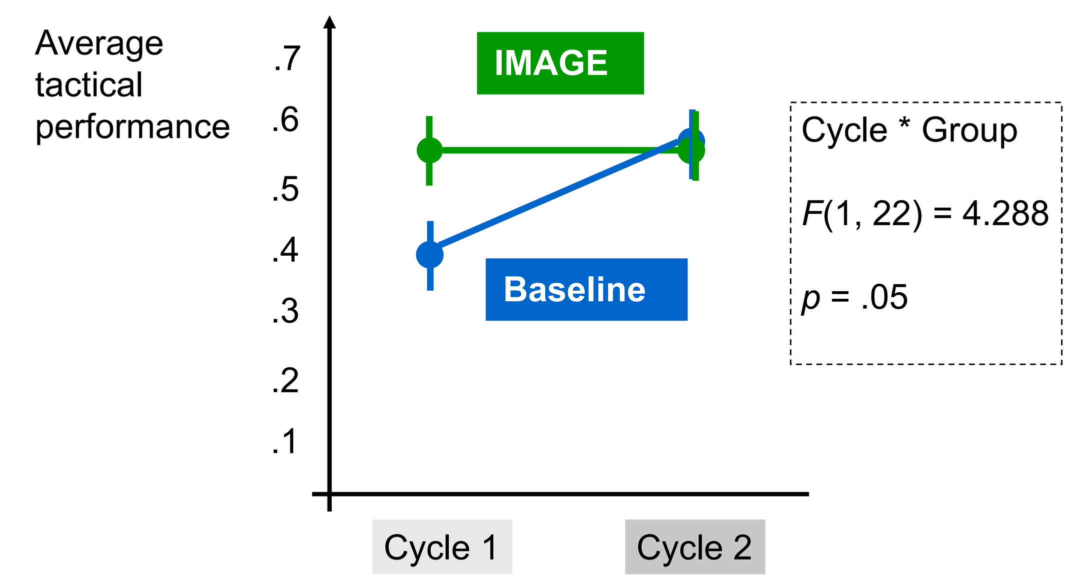

Figure 3. Tactical performance per Group and Cycle.

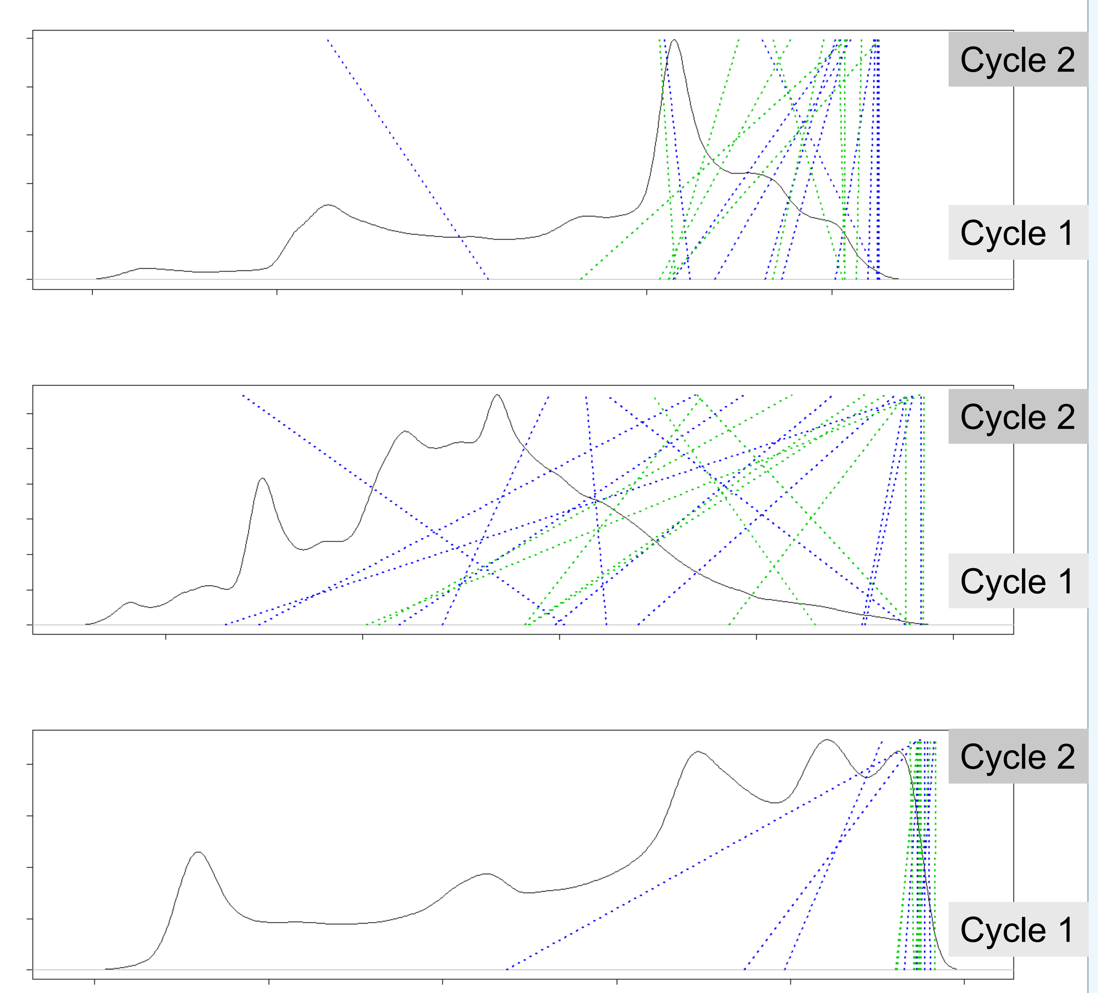

Figure 4. Density of performance of procedural simulation (**black line**) and individual performance in **Baseline** (**blue lines**) and **IMAGE** (**green lines**), in both cycles.

P Define the Problem.
E Explore the results.
S Launch a Simulation.
A Answer.
D Disseminate.

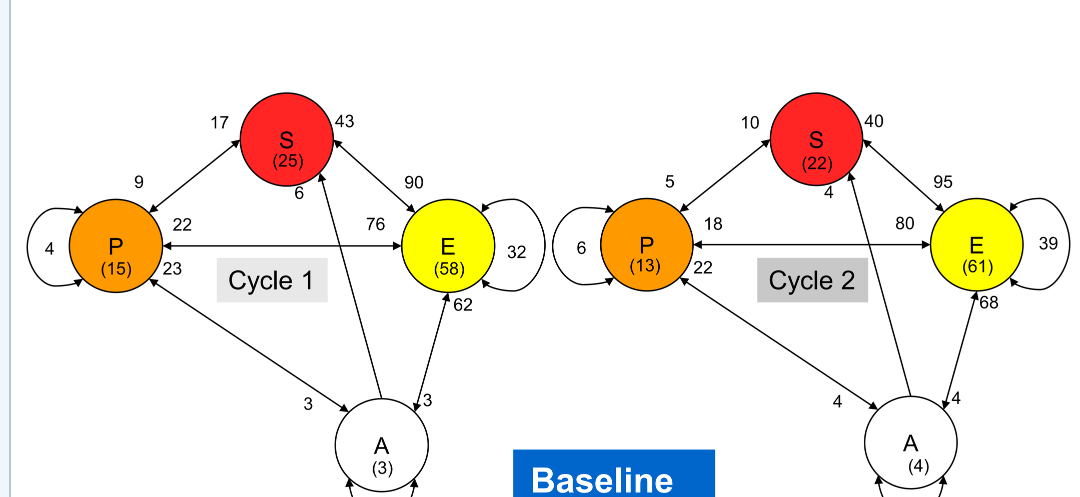

Figure 5. Matrices of transition for the **Baseline** group, per cycle.

Discussion

- Both **Baseline** et **IMAGE** tools allow the participants to explore the parameters space in an efficient way.
- The **IMAGE** group obtains a tactical performance superior at cycle 1 but that advantage disappears at cycle 2 (see Figure 3). This result suggests that the **IMAGE** tools allow to reach a ceiling score faster than the **Baseline** tools.
- Groups do not differ from each other at the procedural level (see Figure 4).
- Participants increase their performance from Cycle 1 to Cycle 2 (Figure 4).
- This increase per cycle could be explained by a greater tendency to explore results of simulations (process tracing; Gabadinho et al, 2008; Figures 5-6).
- The development of a better measure of comprehension (e.g., mental models; Cooke & Gorman, 2009) would perhaps allow to appreciate clearer differences between groups.

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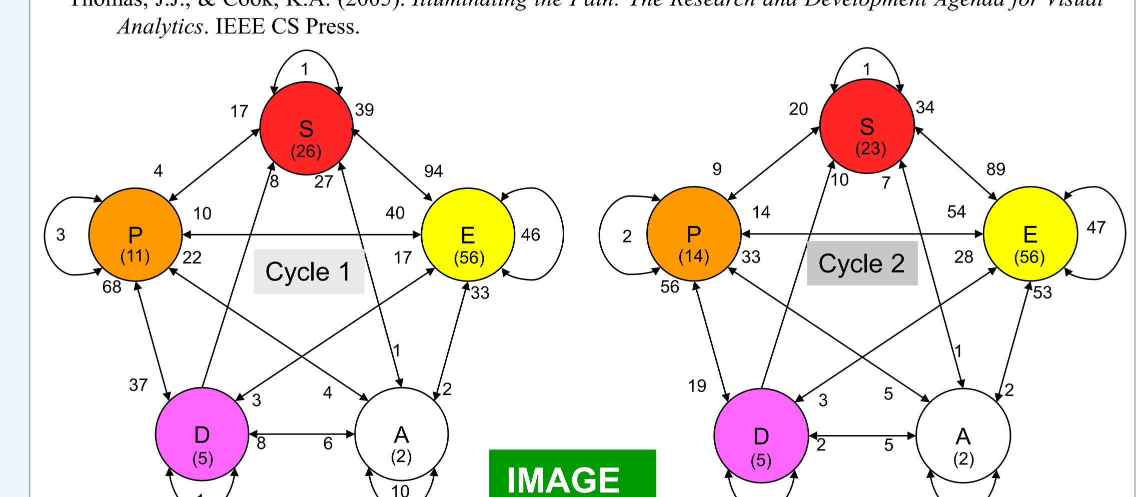

Figure 6. Matrices of transition for the **IMAGE** group, per cycle.

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