VERBAL PROTOCOLS IN REAL-TIME DYNAMIC DECISION-MAKING

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This study presents the results from the analyses of verbal protocols elicited from inexperienced and experienced participants of a real-time, Dynamic Decision-Making (DDM) task. This research intends to complement a series of studies performed in DDM environments analyzing the cognitive structures and processes involved in learning in DDM. Results show that inexperienced and experienced participants differ in several ways: in the way they distribute attention to different parts of the system, in their awareness of the relationship of the attributes involved in the decision making process, and in their coordination to make decisions in real time. These results have been used to support the refinement of a cognitive model developed to explain how people learn in DDM tasks.

INTRODUCTION

Real-time, Dynamic Decision Making (DDM) has three main characteristics: a) multiple and interdependent decisions; b) the environment changes because of exogenous events and because of prior decisions; and c) the pacing of decisions is dictated by the task rather than by the decision maker (Brehmer, 1990). Verbalizations of the thought process are often used to study expertise and decision making in real-world complex tasks (Hoffman, Shadbolt, Burton, & Klein, 1995). These methodologies are also frequently used as the basis to build cognitive models. Development of cognitive models often requires detailed information regarding attention and cognitive processes in the task. In particular, it is necessary to know how and why participants select alternatives, in which order, and how they evaluate and judge them. One way towards understanding these detailed cognitive processes is the collection of verbal protocols.

Our research investigates learning in dynamic decision making situations and we have developed cognitive models of the learning process (Gonzalez, Lerch, & Lebiere, 2003). Often, protocols are elicited from experts, and only rarely research looks at verbalizations from people with different experience. The work initiated by Herbert Simon ic(7c)-6( )-ss

Water Production Plant (WPP) simulation is an abstraction of a resource management task occurring in a real-world organization. WPP simulates a water distribution system with multiple deadlines for alternative tanks in the system. Decision makers have to decide when to activate or deactivate pumps associated with different tanks, given a restriction in the number of pumps working at any given time. Figure 1 shows a screenshot of the simulation, and a detailed description of the task can be found in other publications (Gonzalez et al., 2003).

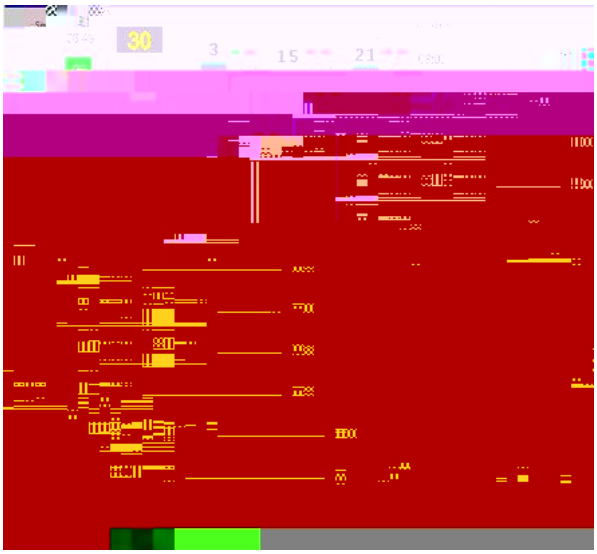
WPP is highly dynamic because water may arrive into a tank at any time, and the level of water in each tank depends on prior decisions (i.e., the pumps that were activated or deactivated by thprior

participated in this study. Each participant was paid $10 per hour. Participants ran the WPP simulation at a rate of 8 minutes per trial, simulating 8 hours of water processing.

Experimental design

A heterogeneous pair of individuals was selected to participate in the inexperienced condition and two other

individuals participated in the experienced condition. Figure 2 presents the activities of both inexperienced and experienced participants. In the first hour, all participants completed a training session in the WPP simulation.



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PROTOCOL:
---------- <1> ----------
1     Tank      pumps
Activate        C         2
---------- <1> ----------
2     Tank      pumps
Activate        B         1
---------- <1> ----------
3     What
Start Simulation
      Tank      pumps
Activate        B1.1      2
---------- <1> ----------
4     Tank      pumps
Activate        C1.5      1
---------- <1> ----------
5     Tank      Ref       Order
Explain         C1.5      £4        First deadline
---------- <1> ----------
6     Tank      pumps
Activate        C1.3      1
---------- <1> ----------
```

Figure 3. A segment of the PAW protocol

Figure 4 presents the process model for inexperienced and experienced participants shown as a network. To construct the networks, we used the transition matrix produced by PAW,

Wait->Explain->Deactivate->Explain->Deactivate->Activate->Deactivate->Activate->Explain->Activate->Explain->Activate->Explain->Wait

While a participant in the experienced condition performed the following cycle:

Wait->Activate->Explain->Activate->Wait

These cycles suggest that inexperienced participants performed many actions before waiting again, while experienced participants performed fewer actions. Among the actions performed by participants in the inexperienced group, there are several Activate and Deactivate actions that, as correctly noted, cause "switching costs".

CONCLUSIONS

Results show that the behavior of people with and without experience in a dynamic task differs in several ways. First, experienced people are more aware of where to attend and how to give prognosis of a situation than inexperienced participants. Second, experienced participants learned to wait to make decisions and try to analyze and explain their actions more than did inexperienced participants. This is important in DDM environments, where many decisions may imply additional costs and therefore affect performance. Third, experienced people seem to divide their attention equally throughout the system compared to inexperienced participants that concentrated only on some parts of the system. In DDM tasks it is very important to evaluate and be aware of all the activities at any moment of time. Fourth, people with more experience seem to be more aware of the relationship of the different variables involved in making a decision, while less experienced people seem to focus on one aspect at a time while making decisions. Finally, experienced individuals know when to wait, it appears that they know when to act at the right time.

DDM tasks present several challenges for the collection and analysis of verbal protocols. The dynamic and highly complex nature of these tasks inhibits concurrent verbalization of cognitive processes. The collection of protocols with replay is helpful to recall all the actions while verbalizing, without the need of executing the task at the same time. However, as expressed and observed from the subjects reported in this study, replaying the simulation made them evaluate their previous decisions rather than just recall what they thought in the past.

Results from these verbal protocols helped us refine the processes implemented in a cognitive model of learning in dynamic decision making. A theory of how people use their past experience to make decisions is in development, and it helps explain how inexperienced people differ and acquire the processing experience found with these protocols (Gonzalez, Lerch, & Lebiere, 2003).

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