Sticking to plans: capacity limitation or decision-making bias?

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Summary

The purpose of the present thesis was to find an explanation for cognitive lockup: the tendency to focus on a subpart of a system and ignore the rest of it. The first chapter of the thesis started with the example of flight 401 of Eastern Air Lines. In this example the pilot continued with a problem on the landing gear while there was a more urgent problem of the descending altitude. The dramatic result was a plane crash which, in hindsight, could be ascribed to cognitive lockup. The crash could have been prevented if the pilot had reassessed the situation and had dealt with the problem of the descending altitude first. Two specific experimental reports on cognitive lockup were discussed (Moray and Rotenberg, 1989 and Kerstholt, Passenier, Houttuin and Schuffel, 1996). However, neither of these studies provided a theoretical explanation for the lockup phenomenon and for that reason the present thesis aimed at finding a plausible explanation for cognitive lockup.

In order to identify possible explanations for cognitive lockup we discussed research of three paradigms that examined phenomena similar to cognitive lockup: planning, task-switching and decision making. Recent definitions of planning have incorporated the notion that efficient planning requires a revision of plans when the environment has changed. From a planning point of view there were three different explanations for cognitive lockup: (1) people commit themselves too early to a detailed plan, (2) people refrain from monitoring the environment, and (3) people generate future scenarios that are too optimistic. Task-switching studies could be subdivided into two categories: successive task-switching, where the second task is presented in close succession to the first task, and concurrent task-switching, where the second task is presented before the first one is completed. In the last category we also incorporated interruption studies. In these studies, the second task also starts before the first task is completed, but the tasks are
more complex than in the simple reaction times experiments in the traditional task-switching paradigm. Overall, the task switching literature provided two explanations for cognitive lockup: (1) limited information-processing capacity and (2) perception of high switching costs.

**Decision making** literature contains a number of phenomena that also reflect people's tendency to continue with an ongoing task. Three possible explanations were provided: (1) the sunk cost effect: people are inclined to continue with a course of action because investments such as time, money or effort are made; (2) task completion: people continue with a course of action because they want to complete the task, and (3) loss aversion: the tendency to weigh potential losses larger than potential gains.

In the second chapter we related the explanations provided in the first chapter to the main characteristic(s) of the tasks that are used in each paradigm. As we were mainly interested in supervisory control tasks, such as flying an airplane, we also identified its relevance to supervisory control. For the planning paradigm we identified the reaction to an environmental change as a main characteristic. A main characteristic of the task-switching paradigm is that participants have to deal with multiple problems at the same time. Decision-making studies indicated the importance of prior and future investments in the first task the moment a second task is introduced. All these factors are of importance in supervisory control tasks.

All task characteristics that we identified as relevant to supervisory control were implemented in the experimental task, which we used in five experiments. This task was a simulation of a shipping control task. Globally, there were two modes of control: monitoring the system and fault diagnosis. The system was in a steady state until a fire breaks out. At that moment, participants had to detect the fire and start diagnosing the cause of the fire in order to select the appropriate treatment. When there were two fires at the
same time, the situation had to be (re)assessed in order to find out which fire was the most urgent and had to be dealt with first.

In the first experiment we compared a sequential presentation of fires (a second fire starts while the participant is working on the first fire) with a simultaneous presentation (both fires start at the same time). In the sequential scenarios there was an environmental change of the situation during fault handling which was absent in the simultaneous condition. Results of this study showed that the performance level was equal for both conditions, but that cognitive lockup (operationalized as completing the first fire before detecting the second fire) was stronger in sequential scenarios. So, participants were less inclined to assess priorities when they were already involved in fire fighting.

In the third chapter we examined the explanations from the task-switching paradigm. Is cognitive lockup due to limited information-processing capacity or to a deliberate decision? We investigated the explanation of limited human information-processing capacity in the second experiment of this thesis. By varying the complexity of the diagnosis process we tried to manipulate the claim on the human information-processing system. It was assumed that a more complex diagnosis process would claim the system to a higher degree. As a consequence, in case of additional fires, participants would be less inclined to reassess the situation in scenarios in which the diagnosis process of the first fire was more complex. Results showed, however, that task complexity did not have an effect on participants’ tendency to continue with the first fire. So, participants’ tendency to solve the first fire first and to refrain from reassessing the situation is independent of the task load of the first fire.

In the third experiment we tested the notion that cognitive lockup is a deliberate decision, resulting from an explicit trade-off between costs and
benefits of making a reassessment. Participants may decide to continue with the first fire because they anticipate that the costs of making a reassessment are too high relative to the benefits. We therefore varied the costs of making a reassessment, that is, assessing the priorities of both fires. There were three different conditions of priority assessment, in order of declining costs: (1) asking questions; (2) clicking a button, and (3) reading priority information from a separate window. Results showed that cognitive lockup decreased when the costs of making a reassessment were lower. In all, cognitive lockup seems to be due to a trade-off between costs and benefits of making a reassessment rather than limitations in human information processing. However, when the costs are evidently lower than the benefits, participants still decided to continue with the ongoing task. Apparently, participants are biased in their decision to continue.

In the decision making paradigm people’s tendency to continue an ongoing task is referred to as behavioral entrapment. In the fourth chapter we examined two explanations from this paradigm that may account for cognitive lockup in supervisory control: the sunk cost bias and task completion. Apart them the purpose of finding a plausible explanation for cognitive lockup, the present task environment provided the opportunity to test the validity of sunk costs and task completion in a dynamic task setting, instead of a static setting as used in previous studies. Hitherto, sunk cost and task completion effects have always been found in a static task setting in which an environmental change had to be imagined. In the present task setting of a fire control task, the environmental change is actually experienced.

In both experiments, the level of sunk costs and task completion was manipulated by respectively the number of questions that had already been answered and the number of questions that still had to be answered, at the moment a second fire was introduced. Results showed that there was a sunk
cost effect in a dynamic task setting as well, but opposite to what was found in static tasks when investments in the first fire increased participants detected the second fire more rather than less often. This effect could be explained by the presence of time pressure in a dynamic task. We reasoned that participants might experience more time pressure when relative more by investments were done.

A closer look at the data indicated that in many cases participants did detect the second fire before they had completed the first fire, but still continued with solving the first fire. For that reason, an additional experiment was conducted in which it was recorded whether the second fire was solved before or after completion of the first fire. Furthermore, to identify the effect of a real time component we added a static condition in which participants were presented with snapshots of the dynamic condition. The results of this experiment showed that behavioral entrapment was stronger in the static environment. This effect may be explained by the presence of feedback concerning the consequences of the decision, which was only present in the dynamic task condition. This feedback enabled participants in the dynamic scenarios to adjust their strategy. As in the previous experiment there was a reversed sunk cost effect, but this effect was only present when the task was not near completion. When the task was near completion, this effect was not present.

In the fifth and final chapter of this thesis, we returned to the explanations that we identified in the second chapter and we discussed them in the light of the present findings. The present task environment was not designed with the purpose to examine planning explanations, but mainly to examine individuals’ reaction to an environmental change. The first planning explanation was an overall indication for cognitive lockup. The first experiment of this thesis clearly demonstrated that when participants were engaged in fire fighting and when an additional fire was introduced, they
often did not deal with fires in the correct order. This in contrast with scenarios in which participants had to deal with two fires from the start. In that case participants nearly always dealt with fires in the correct order. This effect was replicated in the second and third experiment of the thesis.

A second explanation from the planning literature was that people neglect the monitoring task. The fourth experiment of this thesis demonstrated that participants were able to interrupt the diagnosis process of the first fire to detect the second fire, but nevertheless chose to solve the first fire first. This finding does therefore not support the explanation that cognitive lockup is due to a neglect of monitoring the environment. Another explanation - people overestimate the available time - was refuted in the fifth experiment. In that experiment a time index exactly indicated how much time was still available. The finding that participants still continued with the first fire makes it implausible that they overestimated the time they had at their disposal.

For the task-switching paradigm, no support was found for the explanation of a bottleneck in the human information-processing system. We did find support for the second ‘task-switching’ explanation, namely that people consider the costs of making a switch - in this case a reassessing the situation – as too high. Even in cases where the costs of a reassessment were clearly lower than the benefits, participants decided to continue with the first fire. With respect to the explanations derived from decision making literature we found a reversed sunk-cost effect in a dynamic environment: participants were less inclined to continue with the ongoing task when more investments had been made. This effect was found on both the level of detection and on the level of problem solving. However, on the level of problem solving, the reversed sunk-cost effect was mediated by the degree of task completion. There was a reversed sunk-cost effect but only in case the ongoing task was not near completion.
Compared to the static environment we found that in the dynamic environment people's tendency to continue with the ongoing task was less strong. This effect may be explained by the fact that the dynamic task provided participants with feedback on their decision that enabled them to adjust their overall strategy. This feedback was absent in the static environment.

We ended this chapter with the example of flight 401. We tried to apply the findings of this thesis to this example and provided some suggestions for future design of system support tools.