

Research in progress: The influence of presentation formats on information processing

With the developments within information technology, managers have increased possibilities to base their decisions on huge amounts of data from various sources. However, the search for and use of these data increase the load on the managers' information processing capacity. To help managers make sense of data, there is a heavy focus on computer-supported graphic presentation formats. In line with this focus, there is a call for research to enhance the understanding of how presentations of data should be designed to support managers (Luo, 2019; Kopp, Riekert & Utz, 2018; Kelton, Pennington & Tuttle, 2010). In line with this call, our study focuses on enhancing the understanding of whether – and possibly how – the initial presentation formats in information systems influence the subjects' information processes.

Numerous studies have been conducted investigating the relationship between data presentation formats and decision-making performance. The earliest studies were mostly atheoretical and gave inconsistent results. Later, Vessey (1991) developed the cognitive fit theory based on Paivio's dual-code theory (Paivio, 1971) to enhance the understanding of such relationships. According to the theory, for most effective and efficient problem solving to occur, data presentation formats should match the task to be accomplished. The theory distinguishes between two basic task types: spatial tasks and symbolic tasks. Graphs are the appropriate data presentation format for spatial tasks, whereas tables support symbolic tasks. The argument is that when the data presentation format and the task type match, the decision maker can formulate a mental representation and use information processes that fit the external presentation of the data. When the data presentation format does not match the task, similar processes cannot be used both to act on the data and handle the task, which will increase the cognitive effort.

Most research on cognitive fit has focused on tables and graphs as mutually exclusive presentation formats, and on how data presentation formats may affect decision-making performance in rather simple information acquisition tasks. In her extension of the theory, Speier (2006) increased the number of information cues and required calculations. However, Speier (2006) maintained the distinction between spatial and symbolic tasks, and the presentation formats were treated as mutually exclusive. Furthermore, the task Speier (2006) termed a complex spatial task required accuracy (find the lowest cost production plan). This task is, in our opinion, a task with spatial and analytic subtasks that is not possible to solve without the use of tools, such as a spreadsheet. Managers usually have such tools available. Thus, the cognitive fit theory has not been applied in studies attempting to reflect a real-life decision situation.

The present study extends the cognitive fit theory to complex tasks that involve both spatial and symbolic subtasks. We developed two tasks that involved the management of a summer restaurant for 17 weeks. The complexity of the tasks in our study is primarily related to the relationships among the variables. Thus, our tasks do not only require the subjects to extract data from the presentation formats and perform calculations, but also to integrate variables to attain an optimal solution. The main difference between our two tasks is that the more complex task requires the integration of an additional decision variable. The initial presentation formats were only graphs, only tables or both graphs and tables. Furthermore, we allowed the subjects to use decision aids, such as spreadsheets, calculators and pen and paper. With these extensions of present research on cognitive fit theory, we believe that our study reflects the use of presentation formats in a decision situation that is closer to real-life decision situations.

The independent variables of our study are task type and presentation format. The dependent variable is profit from managing the restaurant, and the goal is to maximise profit. Thus, the problems presented to the students required accuracy. There was no time pressure. 42 MBA students from a business school were asked to handle the task.

To assess differences in mental problem representation and processing related to the various data presentation formats, we collected data using concurrent verbal protocols. Our theoretical lens for assessing the subjects' level of information processing was cognitive complexity theory (Schroder, Driver & Streufert, 1967). Paivio's dual-code theory (1971) motivated the design of our study.

Our results indicate that the initial presentation format influences the students' mental representation of the decision problem and their information processing. This was particularly the case for subjects solving the complex version in our study. Subjects that were given the graphic format, mainly used spatial processes, while subjects with the table format mainly used analytic processes. Subjects that used analytic processes attained higher profits ($p < 0,001$).

Our results also show that subjects who knew how to handle the spreadsheet could generate the graphs needed when they had access to the data in a table format. Furthermore, the subjects with the best performance needed the details of the data in their calculations. Thus, our study illustrates that even though line, bar and XY graphs may support managers identifying patterns in data and indicating relationships among variables, designers should also provide easy access to the underlying data values to support calculations and statistical analyses.

A limitation of our study is that the subjects often became silent when they attempted to use the graphs for analytic purposes, and when they performed comprehensive calculations. Even though we saved the results of such efforts, we were not able to analyse the *processes*. The use of eye tracking would have facilitated the analysis of such silent periods. Complementing the verbal protocols with eye-tracking data would also have enhanced the understanding of how our subjects used the combined presentation formats. Another limitation is that the tasks in our study do not demonstrate the comparative strengths of graphics when the managers are presented with huge amounts of data. In future studies, verbal protocols should be combined with eye-tracking, and experiments should be designed that present the subjects with more "historic data" than our study.