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2. Supporting Decision Makers with Knowledge Management Systems

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Abstract

This study compared the effectiveness of two knowledge management system designs in supporting individual decision makers in a predictive judgement task. The black-box versus white-box system design was varied to allow for automating versus informing support in cue weighting and combination stages of the judgement process. The main findings indicate that only the white-box system design was effective in improving decision makers' performance through enhancing their knowledge and debiasing their judgement strategies. However, the study reveals room for further improvement and provides directions for future research.

Keywords: Decision Maker, Knowledge Management System, Debiasing, Decision Performance

Introduction

There is a considerable body of evidence indicating that people systematically deviate from rational decision making. Such deviations are termed “decision biases” and are described as cognitions or mental behaviours that prejudice decision quality (Arnott 2002). The variety of biases documented in behavioural decision literature include: memory, statistical, confidence, adjustment, presentation and situation related biases. Most decision biases tend to cause poor decision outcomes. Therefore they are of concern to designers of information systems that aim to facilitate and improve decision makers' task performance.

Of particular interest to this study are biases that people experience in combining multiple cues into single judgmental responses. The problem of combination could be due to misperception and/or misaggregation (Lim and O'Connor 1996). With respect of misperception, the literature shows that people are lacking the ability of correctly assigning the weights to the cues. Both tendencies to overestimate unimportant and underestimate important cues have been identified. With respect to misaggregation, the literature indicates that people have difficulties in performing mental calculations when combining multiple cues due to cognitive overload.

Knowledge management (KM) offers a promising new approach to reducing or eliminating biases from the cognitive strategies of a decision maker. Assuming that the decision maker is the primary source of the biased judgement (Fischhoff 1982), our attention is focused on how to better manage the decision maker's knowledge. Two main trends are distinguishable in terms of this support. One is to focus on the use of information and communication technology (ICT) as tools to facilitate management of knowledge processes (Handzic 2004). The other trend is the proposition of a set of prescribed social and structural mechanisms to create an enabling environment for knowledge development, transfer and application (Holsapple 2003).

While there is considerable theoretical support for suggesting efficiency and effectiveness benefits of different socio-technical KM initiatives for decision making, there is little

empirical evidence regarding the actual impact of these initiatives on decision makers' working knowledge and performance (Alavi and Leidner 2001). The main objective of this paper is to address the existing gap between theory and practice by providing some empirical evidence regarding the potential and limitations of specific technology-based KM initiatives for supporting individual decision makers in the context of judgemental time series forecasting.

For the purpose of this study, we selected two knowledge management system (KMS) designs that differ in how they attempt to "debias" decision makers' judgment strategies. One, termed "black-box", focuses on the automating knowledge integration process in the attempt to reduce decision makers' cognitive overload and thus eliminate misaggregation bias. The other, termed "white box", focuses on organising and representing knowledge for human consumption in a way that would reduce misperception. It is implicitly assumed that the availability of such systems should lead to better decision performance. This study intends to empirically test this assumption.

Prior Related Research

Various knowledge management systems (KMS) implementations provide differing levels of support in locating, extracting and utilizing knowledge and impose differing burdens to their users. In this section, we discuss two approaches to KMS development that may help to overcome some of the negative influence of decision biases.

Automating

The Artificial Intelligence (AI) approach to knowledge management systems focuses on "automating" knowledge processes. It involves the use of "smart" systems that apply knowledge to solve problems for, and instead of, humans. Typically, such systems can reason in a narrow domain and in a relatively mechanistic way (Becerra-Fernandez et al. 2004). Examples of popular systems in this category include those that can facilitate activities of direction and routines. Other well known examples are knowledge based systems in the form of intelligent decision support and expert systems. These were devised as problem solving systems long before the term KM became popular (Hasan 2003). Neural networks are another significant development by AI researchers. The most important feature of neural networks is their ability to learn from noisy, distorted or incomplete data (Glorfeld 1996).

Of special interest to this study is an automated knowledge aggregation tool that mechanically combines multiple cues into a single judgemental response. It is argued that the provision of such a tool may help alleviate or even completely eliminate negative effects of misaggregation bias. In general, computers are considered to be better than people in making complex calculations, and making calculations rapidly and accurately (Stair and Reynolds 2003). However, despite benefits offered by these systems they are not free from criticism. Some scholars warn that replacing people with machines may have important ethical implications. Most AI systems are of the "black-box" kind. This means that the tool produces conclusions without any explanation and justification of the reasons behind such conclusions. Consequently, it may have a detrimental effect on decision makers' working knowledge. Past empirical studies report general preference for heads over models in judgment (Darlymple 1987).

Informating

The above discussion suggests that an alternative approach to KMS focusing on “informating” and guiding rather than “automating” knowledge work may be more useful to decision makers. Essentially, this approach involves organising and presenting knowledge to users in ways that would enhance their interpretation of the available knowledge and thus enable them to apply it more effectively in solving problems (O’Leary 2003). Such an approach can be considered as a “white box” kind of approach to managing knowledge. A stream of related research on system explanations strongly suggests the usefulness of providing explicit terminological, tracing, control and/or justification support for the knowledge offered (Gregor and Benbasat 1999). In general, suitably designed system explanations that conformed to Toulmin’s model of argumentation and provided to users in an unobtrusive way resulted in improved performance, learning and positive perceptions of a system. Similarly, recent empirical studies on knowledge mapping reported beneficial effects of initiatives such as competency and procedural knowledge maps (Handzic 2004).

The focus of this study is on another potentially useful white-box type of KMS, a knowledge weighting tool that provides users with a graphical image of task relevant cues and their relative importance weights. It is argued that the provision of such a tool may help alleviate/eliminate negative effects of misperception bias. In addition, the white box approach to KMS may help increase people’s “trust” and reliance on helpful decision aids. Empirical evidence from recent knowledge tagging and content rating studies (Shanks 2001; Poston et al. 2005) also hints that such a tool may enhance users’ working knowledge and performance.

Study Objectives

In view of the prior findings and concerns expressed, the main objective of the current study is to determine the nature of assistance, the extent of assistance and the limitations of the above two approaches to KMS in supporting managerial decision making. In particular, the study examines whether and how KMS of varying knowledge weighting and knowledge aggregation support may assist individual decision makers in enhancing their working knowledge and improve the quality of their subsequent decisions in a specific judgemental decision making task.

Research Method

Experimental task

The experimental task for the current study was a simple production planning activity in which subjects assumed the role of Production Manager for an imaginary firm and made decisions regarding daily production of a perishable product. The company incurred equally costly losses if production was set too low (due to loss of market to the competition) or too high (by spoilage of unsold product). The participants' goal was to minimise the costs incurred by incorrect production decisions. During the experiment, participants were asked at the end of each day to set production quotas for the product to be sold the following day. Subjects were required to make ten production decisions over a period of ten consecutive simulated days.

To aid their decision making all participants were provided with decision relevant contextual cues. Subjects were free to use the available knowledge as much or as little as they wished to. Contextual time series were artificially generated with cue weights set to 0.53, 0.30 and 0.17 to provide varying predictive power. The optimal decision strategy was derived by using a

weighted additive model with three contextual cues as independent, and product demand as dependent, variables in the equation. The optimal cue weights yielded minimal expected decision errors.

The task differed with respect to the type of KMS received. One half of the subjects received a “black-box” system that automatically combined contextual cues into a single production decision without giving users any explicit analysis of the quality of the available contextual cues, or the rule applied to translate them into specific decisions. The other half received a “white-box” model with both the explicit analysis of the quality of the available contextual cues, and the rule applied to translate them into specific decisions. Both systems gave recommendations that led to equally accurate optimal decisions.

At the beginning of the experiment, task descriptions were provided to inform subjects about the task scenario and requirements. The given text differed with respect to the model provided. Performance feedback was omitted in order to increase subjects’ reliance on helpful tools as suggested by Arkes et al. (1986).

Experimental design and variables

A laboratory experiment with random assignment to treatment groups was used for the study. This made it possible to draw stronger inferences about causal relationships between variables due to high controllability. The experimental design was a single factor design, with the knowledge management system type (black-box versus white-box) as the only independent variable.

The manipulation of different knowledge management system types was achieved by changing the amount of explicit knowledge provided to the participants. The black-box version of KMS provided participants with a recommended decision only. The white-box version provided participants with additional explicit knowledge about the decision relevant cues (in the form of relative importance weights) and the rule (in the form of weighted additive model) applied to integrate them into final decisions.

Subjects’ performance was evaluated in terms of *decision accuracy* operationalised by absolute percentage error (APE) as suggested by Makridakis (1993). APE is obtained by computing the subjects’ absolute error (ie. difference between units of sales produced and demanded), then dividing the absolute error by the corresponding actual value (ie. units demanded) and multiplying by 100%. In addition, the corresponding errors of their control and nominal optimal counterparts were calculated. These were actual subjects who produced their decisions without any KMS support and imaginary decision makers who made their decisions by using optimal decision strategies respectively. These scores were used to assess how much of the available KMS support was used by the experimental subjects in making their decisions.

Subjects and procedure

Twenty-seven graduate students enrolled in the Master of Commerce course at the University of New South Wales, Sydney, participated in the study on a voluntary basis. They had no prior knowledge of the task and received no monetary incentives for their performance. Generally, graduate students are considered to be appropriate subjects for this type of research (Ashton and Kramer 1980; Remus 1996; Whitecotton 1996). The experiment was conducted as part of a guest lecture on knowledge management systems and technology. Nine subjects were assigned randomly to one of the treatment or control groups by picking up an

appropriate version of the research instrument to be used. Subjects were briefed about the purpose of the study, read the case descriptions and then performed ten decision tasks each. Thus, 90 decisions per group were collected for the analysis purposes. The session lasted about half an hour.

Results

The collected data were analysed statistically using a series of t-tests to examine the effect of two different types of knowledge management systems on subjects' decision accuracy, and to compare it with that of their nominal optimal and control (unsupported) counterparts. Since all experimental groups were equal in size there was no need to perform any normality test on data (Huck et al. 1974). The summary results of t-tests performed on a decision accuracy measure are presented in Figure 1, while the respective means by experimental groups are shown in Table 1.

Table 1: Means of APE (in %) by experimental groups

Groups	N	APE
Control (unaided)	90	9.82
Black-box	90	10.76
White-box C	90	7.70
Optimal (nominal)	90	5.81

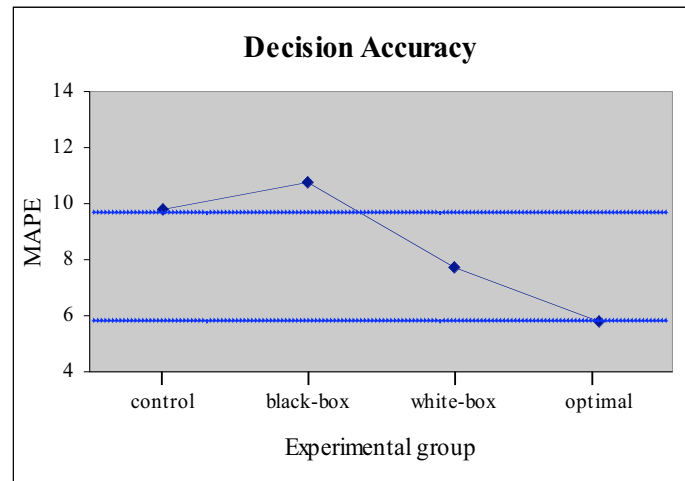


Figure 1: Results of t-tests for decision accuracy (APE)

The results of the analysis shown in Figure 1 indicate no significant change in decision accuracy due to the black-box type of KMS. The subjects provided with the black-box system made similarly high decision errors as those without any such support (10.76 versus 9.82, $p=ns$). Similar errors indicated low (if any) reliance and use of the available system support.

In contrast, Figure 1 shows a significant difference in decision accuracy between the two KMS types. The mean error of the subjects supported with the white-box system was significantly smaller than that of the subjects with the black-box one (7.70 versus 10.76, $p=0.019$). Smaller errors indicated that the “opening” of the black box had a significant positive effect on decision makers' reliance and use of the system support provided.

Finally, the results in Figure 1 show that subjects failed to reach optimal decision performance irrespective of the KMS type provided. The mean error of the subjects supported by the white-box system was significantly higher than that of their nominal optimal counterparts (7.70 versus 5.81, $p=0.017$). In real terms, these subjects managed to utilise only about one half (53%) of the system's maximum potential. This indicates a lot of room for further improvement.

Discussion

Main Findings

The main findings of the present study indicate that the opening of the black-box KMS was useful in improving decision making; however performance gains were less than theoretically possible. This was demonstrated by significantly smaller decision errors found among white-box subjects than their black-box counterparts, but greater decision errors compared to notional optimal counterparts.

The fact that the participants with the white-box system support performed better than those with the black-box one indicates that they were able to better understand and use the knowledge available from their system. The analysis found that these subjects tended to rely at least to some extent on explicit cues provided when making their decisions. As a result, they tended to achieve substantial improvement in their subsequent performance. In real terms, decision errors dropped by 28%. Such findings seem to contradict the overly pessimistic picture of human ability to utilise explicit knowledge painted by earlier laboratory research in judgement and decision making (e.g. Andreassen 1991; Harvey et al. 1994).

One potential explanation for the finding may be attributed to the "white-box" nature of the system support. Participants in the current study were given a small number of relevant contextual variables in a meaningful task context, graphical presentation of their relative importance weights to provide clues to causal relationships, and forecast values to suggest future behaviour. It is also possible that a graphical form of knowledge presentation facilitated interpretation and enabled the subjects to better judge the right size of future changes.

Despite this, the results indicate a lot of room for further improvement. The white-box subjects were found to make substantially greater decision errors than their nominal optimal counterparts. Greater than optimal errors indicate that the subjects tended to use much less of the available knowledge than they possibly could. Further analysis revealed that, on average, they tended to effectively internalize only 53% of the explicit knowledge provided to them. Such finding seems to agree with our earlier discovery of human ability to utilise between 40% and 60% of explicit knowledge (Handzic and Bewsell 2005). The failure to achieve optimal performance resulted mainly from the participants' choice and application of inappropriate strategy placing too much reliance on their own judgement.

A potential explanation for the observed suboptimal performance may be the lack of vital knowledge regarding tool reliability. Subjects in the current research were not given any explicit analysis of the quality of their tool's past performance. As a result, they tended to place less reliance than they should have on the seemingly helpful decision aid. Earlier studies on learning from feedback in multivariate tasks reported improved performance due to task and cognitive feedback (Remus et al. 1996). Another potential explanation for the observed suboptimal performance may be the lack of opportunity to learn from one's own experience through task repetition. Earlier studies on learning (for review see Klayman 1988)

indicate that people can reasonably well learn multivariate tasks over a large number of trials. However, it seems that the period of ten trials was too short to induce effective learning.

Limitations

While the current study provides a number of interesting findings, some caution is necessary regarding their generalisation due to a number of limiting aspects. One of the limitations refers to the use of a laboratory experiment that may compromise the external validity of research. Another limitation relates to artificial generation of time series data that may not reflect the true nature of real business. The subjects chosen for the study were students and not real life decision makers. The fact that they were mature graduates may mitigate the potential differences. No incentives were offered to the subjects for their effort in the study. Consequently, they may have found the study tiring and unimportant and not tried as hard as possible. Most decisions in real business settings have significant consequences. Further research is necessary that would extend the study to other subjects and environmental conditions in order to ensure the applicability of the present findings.

Practical Implications and Directions for Future Research

Although limited, the findings of the current study may have some important implications for organisational decision support strategies. They suggest that decision makers could potentially benefit from additional knowledge management initiatives that would enhance their understanding of the value of explicit knowledge captured in organisational systems. One possible solution is to provide systems with more meaningful analysis, task/performance feedback and learning histories that might potentially help such workers better understand what works when and why (Kleiner and Roth 1998). This, in turn, may result in better performance. Alternatively, organisations may employ trustworthy specialists trained in analytical and statistical reasoning who would perform a knowledge filtering process for professional and managerial knowledge workers (Godbout 1999).

Initiatives aimed at creating working contexts that encourage communication and culture of knowledge sharing may also potentially have a beneficial effect on enhancing decision makers' working knowledge and performance. Organisations have come to realise that a large proportion of the knowledge needed by the business is not captured on hard drives or contained in filing cabinets, but kept in the heads of people. Sources report that between 40% (AAOTE, 1998) and 90% (Hewson 1999) of the needed knowledge is (in the lingo of the business) tacit. The spiral knowledge model postulates that the processes of sharing will result in the amplification and exponential growth of working knowledge (Nonaka and Takeuchi 1995; Nonaka 1998). Yet, little is known of the ways in which tacit knowledge is actually shared, conditions under which this sharing occurs, and the impact it has on performance.

Finally, by combining and integrating various knowledge management initiatives organisations may potentially create synergy effects that would lead to even higher levels of knowledge and performance. According to Davenport and Prusak (1997) only by taking a holistic approach to management may it be possible to realise the full power of knowledge ecology. Further research may look at some of these initiatives and approaches.

Conclusions

The main objective of this study was to investigate the effectiveness of two types of KMS in supporting individual decision makers in a predictive judgement task context. The results indicate that only a white-box type of KMS was useful, although insufficient to maximally enhance individual decision performance. White-box participants were found to utilise more knowledge and make significantly smaller decision errors than their black-box counterparts. However, they tended to utilise less knowledge and make significantly larger decision errors compared to notional optimal counterparts. Although limited to the specific task and context, these findings may have important implications for decision support strategies, as they suggest that individuals could potentially benefit from additional knowledge management initiatives to further enhance individual knowledge and performance. Therefore, more research is necessary to systematically address various knowledge management initiatives in different tasks and contexts, and among different knowledge workers.

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