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Abstract

Perceived usefulness has been found to be significantly correlated with self-reported current use and self-predicted future use of information systems. However, Davis (1989) points out that perceived usefulness is a subjective appraisal of system performance, and thus it may lead to under or over estimates of performance. Underestimates of system performance may lead to decreased satisfaction and a refusal to use the system, despite possibilities of objective performance enhancement, while on the other hand overestimates of system performance may lead to increased satisfaction and use of a system, even thought the system is objectively detrimental to performance. In the current study we examine the impact of two types of DSS support, decisional guidance and cognitive feedback, on user estimates of DSS performance and user satisfaction with the DSS. The results of the study show that subjects receiving cognitive feedback were as satisfied with their DSS as subjects receiving decisional guidance, despite having much poorer performance levels. We discuss the implications of these results for the accurate measurement of user perceptions of DSS usefulness.

Keywords: Cognitive feedback, user acceptance, decisional guidance

Introduction

In the attempt to develop measurement scales for user acceptance of information technology, *perceived usefulness* has been proposed and investigated by a number of researchers (Davis, 1989; Adams, Nelson, & Todd, 1992; Segars & Grover, 1993). Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance", and has been found to be significantly correlated with self-reported current use and self-predicted future use of an information system (Davis, 1989). While it has been shown to be a strong correlate of user acceptance, Davis (1989) points out that perceived usefulness is a subjective appraisal of system performance, and thus it may lead to under or over estimates of performance. Underestimates of system performance may lead to decreased satisfaction and a refusal to use the system, despite possibilities of objective performance enhancement, while on the other hand overestimates of system performance may lead to increased satisfaction and use of a system, even thought the system is objectively detrimental to performance. In the current research we examine the impact of two types of DSS support, decisional guidance and cognitive feedback, on user estimates of DSS performance and user satisfaction with the DSS.

Literature Review and Hypothesis

Decisional Guidance and Cognitive Feedback

Decisional guidance, as defined by Silver (1988, 1990, and 1991), enlightens or sways DSS users as they structure and execute their decision-making processes. He defines a number of sub-categories of decisional guidance, among them, suggestive, forward, and dynamic guidance. Suggestive guidance makes judgmental recommendations (what to do) to decision-makers. Forward guidance makes these recommendations before the decision or process occurs. Dynamic guidance takes current conditions into account before proffering advice to the decision-maker. In this study decisional guidance is suggestive, forward, and dynamic.

Subjects in the decisional guidance condition receive suggestions about what decision to make next based on the current state of the environment. Because these suggestions relieve the user from much of the information processing demands of implementing an effective strategy, we expect that decisional guidance will enhance task performance.

Cognitive feedback is defined as the provision of feedback about a decision-maker's cognitive strategy (Balzer, Hammer, Sumner, Birchenough, Martens, & Raymark, 1994). It can contain information regarding the extent to which he or she is executing a solution strategy as originally intended (Singh & Ginzberg, 1996) or information about the consistency of the strategy across a number of decision events (Balzer, Sulsky, Hammer, & Sumner, 1992). By definition, cognitive feedback is provided <u>after</u> a decision has been made. However, the amount of time between the decision and feedback may vary. In this study cognitive feedback is provided immediately after every decision. It compares the executed decision with the decision that would have been made for an optimal strategy, and returns a percentage fit for that comparison. The percentage fit for each decision is plotted on a chart so that the subject has information about strategy consistency. Because the provision of cognitive feedback does not lessen the information processing demands of implementing an effective decision strategy (and in fact, imposes an additional information processing load on the user if the feedback is to be monitored and assessed (Singh & Ginzberg, 1996)), we expect that cognitive feedback will not enhance task performance.

We expect the provision of decisional guidance and cognitive feedback to affect decision makers' satisfaction with the computerized support and their assessments of its usefulness. A number of studies have shown that perceived usefulness is determined in large part by decision makers' perceptions of performance benefits (Adams, Nelson, & Todd, 1992; Davis, 1989; Segars & Grover, 1993; Venkatesh & Davis, 1996). Because we expect decisional guidance to produce superior performance, it seems that subjects using decisional guidance should find their DSS more useful. However, there are other studies that show decision makers, especially those using systems that encourage their active involvement in the decision making process, overestimate performance benefits and therefore may overestimate system usefulness (Kotteman, Davis, & Remus, 1994; Davis & Kotteman, 1995; Singh & Ginzberg, 1996). Cognitive feedback encourages just such active involvement on the part of the decision-maker (Sengupta & Te'eni, 1993). We therefore predict, despite different performance benefits, that

> *Hypothesis: Decisional Guidance or Cognitive Feedback will result in higher levels of decision maker satisfaction and perceptions of system usefulness than a system that provides only performance feedback (our control condition).*

Cognitive Ability, Motivation, and Efficacy Perceptions: Important Covariates

We include several covariates in our study that we believe will have an impact on rule adherence, task performance, and/or satisfaction with the decision support system.

Previous research has shown that cognitive ability is capable of explaining and predicting human performance in a variety of complex tasks with substantial cognitive demands, for example, in psychometric mental-rotation tasks (Just and Carpenter, 1985), in on-line language comprehension (Just & Carpenter, 1992), and in phone-based interaction (Huguenard, Lerch, Junker, Patz, & Katz, 1997). We therefore include a measure of cognitive ability to control for its impact on our results.

Involvement (or motivation) is defined as the degree to which a person perceives an object, action, event, or situation to be personally relevant. A number of studies have shown that intrinsic involvement plays a significant role in shaping end user perceptions of computerized tools (Barki & Hartwick, 1994; Hartwick & Barki, 1994; Jackson, Chow, & Leitch, 1997). Motivation has also been shown to have an effect on decision makers' willingness to implement decision rules. Highly motivated decision-makers are likely to eschew proffered decision rules in the belief that their own efforts will prove superior (Kotteman et al., 1994). For both these reasons, we include a measure of motivation in our study to control for these potential effects.

Venkatesh and Davis (1996) found that an individual's perception of a particular system's ease of use was anchored to his or her general computer self-efficacy at all times. We therefore included a measure of decision support system self-efficacy to control for its effects on decision-maker satisfaction with the decision support system.

Method

Design

The study consisted of a 3 X 3 X 3 design with decision support type and decision rule complexity as the between-subject factors, and trial as the within-subject factor. The three decision support type conditions were decisional guidance, cognitive feedback, and no decisional guidance or cognitive feedback. The three decision rule complexity conditions were low, medium, and high.

Subjects were assigned to one of the nine decision support type/rule complexity conditions and then completed a total of three decision-making trials. The decision rule complexity factor was included in the design to address research questions that are addressed in (Ballou, Huguenard, Lerch, & Harter, 2001). Since decision rule complexity had no impact on the research questions addressed by the current paper, it will not be discussed further.

Subjects were 123 sophomore students at a private midwestern university who participated in the experiment as part of an in-class exercise. The analyses are based on the 369 decision-making trials completed by the 123 subjects.

Experimental Environment

We used a simulation that represented a part of the automated sorting processes found in a typical General Mail Facility (GMF) of the United States Postal Service (USPS). The primary purpose of a GMF is to sort incoming mail so that delivery trucks will be able to deliver the sorted mail to local post offices within a particular deadline time.

The simulation tool was built using Microsoft Visual Basic (version 5.0). The tool automatically recorded all decisions and calculated summary statistics (such as the amount of mail that missed the deadline) for each trial. In addition, the simulation tool was programmed to offer guidance with respect to the decisions the subjects were making (see Decision Support Type section under Independent Variables).

Task

The simulation scenario used in the three decision-making trials of this study had the following characteristics. Simulated time began at 2:00am and ended at 10:00am. The actual time for the task was held constant for all subjects at 15 minutes. A total of 1,008 trays of mail arrived during the task and had to be processed to meet delivery deadlines. It was possible, but difficult, to sort all 1,008 trays of mail in time for their delivery deadlines.

The subjects in this study were asked to assign sets of mail to five sorting machines so that they could be processed in time to meet their delivery deadlines. To do this subjects had to monitor waiting mail, mail currently being processed, and sorting machine status while attending to the simulated time clock. When they were ready to make a sorting assignment, subjects would use a mouse to first select a particular set of mail, and then select a sorting machine to assign the mail to. The subjects' goal was to minimize the total number of trays of mail that did not meet their delivery deadlines.

Independent Variables

Decision Support Type

All subjects received one of three types of computer-based decision support (decisional guidance, cognitive feedback, and neither decisional guidance nor cognitive feedback). Although the three decision support tools differed in the types of guidance they provided, the sorting environment and task were identical. In addition, all three support tools offered continuously updated performance feedback in the form of a total number of trays of mail that had missed their deadline.

The decisional guidance support system provided subjects with suggestions regarding which mail type to sort next. The simulation tool highlighted the mail type to sort next by turning its icon green. All other mail icons remained gray. If subjects followed these suggestions exactly, they executed their decision rules perfectly.

The cognitive feedback support system provided subjects with an evaluation percentage for each decision they made. The evaluation percentage was displayed immediately <u>after</u> each decision. The evaluation percentage was displayed in two different ways simultaneously, as a single percentage and on a graph that charted a subject's evaluation percentages across the entire trial. The evaluation percentage was calculated by comparing the mail sorting choice made by the subject with the mail sorting choice recommended by the decision rule the subject had been taught. When the experimental trial was over, an evaluation fit percentage for the entire trial was calculated and displayed. This overall evaluation percentage represented an average of the individual decision evaluation percentages.

The third decision support system provided neither decisional guidance nor cognitive feedback. It included only performance feedback in the form of a missed tray total. The missed tray total was updated every half-hour (simulated time) to include all trays

of mail whose deadline had passed. This missed tray information was also included in the decisional guidance and cognitive feedback support systems.

Trial
Subjects completed three trials of the experimental task.

Control Variables
We gathered data on three variables (intelligence, motivation, and DSS self-efficacy) we believed might affect performance so that we could control for their influence on our results.

Students signed permission slips allowing us to obtain their SAT scores from the registrar's office. We obtained both math and verbal scores for all students who took the SAT's. We used a standard concordance chart[1] to convert ACT composite scores to SAT total scores for those students who took only the ACT.

A six-item instrument was used to assess motivation with respect to the experimental exercise after a brief overview but prior to the experimental trials. These items were adapted from Baldwin and Karl (1987). A sample item is, "I am willing to exert considerable effort to improve my skills in this decision support system (DSS) training" (1 = Strongly disagree; 7 = Strongly agree). These items were averaged to form a motivation scale (Cronbach's alpha = .79).

A four-item instrument was used to assess decision support system efficacy beliefs after the brief overview. These items were adapted from Martocchio and Webster (1992). A sample item is, "I feel confident that I can use this DSS" (1 = Strongly disagree; 7 = Strongly agree). These items were averaged to form an efficacy scale (Cronbach's alpha = .78).

Dependent Variables

Performance Variable
Although task performance was not addressed in our hypothesis, we did collect data on one performance variable. It consisted of a count of trays with missed delivery deadlines for each of the three decision-making trials of all subjects.

Evaluation Variable
A twelve-item instrument was used to assess end-user satisfaction and DSS usefulness. These items were adapted from Doll and Torkzadeh (1988). A sample item is "The assistance provided by this DSS met my exact needs." (1 = Strongly disagree; 7 = Strongly agree). These items were averaged to form an end-user satisfaction scale (Cronbach's alpha = .92).

Procedure

The experiment was conducted in two sequential seventy-five minute class sessions with a gap of one day between the first and second session.

During the first session subjects were given a brief introduction to the DSS environment and task, and were then asked to fill out the efficacy beliefs and motivation instruments. Next the subjects received training in which they were familiarized with the task they would perform and the simulated mail-sorting environment in which they would be working. They also received computer-based training for the type of decision support they would see while performing the task. The first session concluded with the first experimental trial.

At the beginning of the second session the instructor conducted a review of the mail-sorting environment, followed by the second and third experimental trials. After the third trial the DSS satisfaction instruments were distributed, filled out, and collected.

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[1]National Concordance Study completed by NCAA, ACT, ETS, and College Board, Spring 1995

Results

Table One shows the means and standard deviations of the dependent measures for each decision support type condition. Tables Two and Three show the results of the statistical analyses for main effects and interactions, respectively. The analyses were repeated-measure, general linear models in which trial was the repeated measure, rule complexity and decision support type were the between-subject factors, and SAT's, motivation, and DSS efficacy were included as covariates. The two between-subject factors' interactions with each other and with trial were also included in all analyses. Next we present the results of our analyses regarding decision support evaluation.

Table 1. Means [Standard Deviations] of Dependent Measures by Decision Support Type

Dependent Measures	Decision Support Type		
	Guidance	Feedback	Neither
Performance: Missed Trays	72.61 [34.860	98.85 [58.06]	98.39 [47.23]
Evaluation: DSS Satisfaction	5.25 [0.77]	5.08 [1.06]	4.48 [0.93]

Table 2. F-Values for Statistical Tests on Dependent Measures (Main Effects)

Dependent Measures		RuleComp	DSS Type	Trial	SAT	Motive	Efficacy
	df:	2	2	2	1	1	1
Missed Trays		3.51*	8.01**	0.92	4.47*	5.54*	1.67
Satisfaction		0.24	5.36**	N/A	1.94	6.89**	0.08

*p < .05;**p < .01;   ***p < .001

Table 3. F-Values for Statistical Tests on Dependent Measures (Interactions)

Dependent Measures		RuleComp X DSS Type	Rule Comp X Trial	DSS Type X Trial
	df:	4	4	4
Missed Trays		0.62	1.93	1.43
Satisfaction		1.23	N/A	N/A

Evaluation of DSS Usefulness

In our hypothesis we predicted that subjects receiving decisional guidance or cognitive feedback would have higher levels of satisfaction with the decision support tool than subjects who received neither types of support (these subjects did receive performance feedback). We predicted this despite our belief that subjects receiving cognitive feedback would perform no better than subjects receiving neither types of support. There was a significant decision support type main effect on DSS satisfaction ($F(2, 109) = 5.26, p < .01$). Bonferroni pairwise comparisons (guidance/none, p = .01; feedback/none, p < .05) show that subjects receiving either decisional guidance ($M = 5.25$) or cognitive feedback ($M = 5.08$) were significantly more satisfied than subjects receiving only performance feedback ($M = 4.48$), providing support for our hypothesis.

Cognitive ability, motivation, and perceived DSS efficacy were included in the DSS evaluation analyses. Motivation significantly and positively affected DSS satisfaction ($F(1, 109) = 6.89, p = .01, B = .42$). Neither cognitive ability nor perceived DSS efficacy had a significant effect on DSS satisfaction.

Task Performance

In order to verify that our assumptions concerning task performance were reasonable, we performed an analysis of the task performance data. Decisional guidance and cognitive feedback had the expected effect on task performance, with those subjects receiving decisional guidance outperforming all other subjects. Using number of missed trays as the dependent variable, we found a significant decision support type main effect ($F(2, 109) = 8.01$, $p = .001$). Bonferroni pairwise comparisons ($p < .01$) show that subjects receiving decisional guidance had significantly fewer missed trays ($M = 72.61$) than those receiving either cognitive feedback ($M = 98.85$) or neither types of support ($M = 98.39$).

Discussion

In this study subjects were equally satisfied with the decisional guidance and cognitive feedback decision support types. Their level of satisfaction with these two DSS types was significantly higher than their satisfaction with the performance-only feedback version. Subjects receiving cognitive feedback were as satisfied as subjects receiving decisional guidance despite having much poorer performance levels. This result seems to contradict IS theory and research that shows performance assessments strongly influence users' system satisfaction and usefulness assessments (Adams, Nelson, & Todd, 1992; Davis, 1989; Segars & Grover, 1993; Venkatesh & Davis, 1996). However, other studies have shown that users are sometimes unable to accurately estimate system performance benefits (Kotteman et al., 1994). This seems to be particularly true when the evaluated software increases user involvement in the task. It may be that the provision of cognitive feedback increased decision-maker involvement in the task and that this involvement drove their system satisfaction level.

The strongly positive impact of motivation on DSS satisfaction is consistent with the results of other studies that have demonstrated the positive impact of intrinsic motivation on system satisfaction (Barki & Hartwick, 1994; Hartwick & Barki, 1994; Jackson, Chow, & Leitch, 1997). Implications of the motivation effect will not be discussed here, but will be addressed in a future paper that more fully investigates issues of DSS performance and user motivation.

Our results suggest that instruments that capture user perceptions of DSS satisfaction should be used in combination with other measures, for example, objective performance indicators. In addition, some researchers have suggested that end-user perceptions are more accurate in within-subject designs where each subject sees a number of software versions and can then make comparisons across them (Svenson, 1996). Taken together, these results indicate that users' assessments of a system should be balanced with other, more objective, information about their use of the software and their performance.

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