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PERSUASIVE DECISION SUPPORT: IMPROVING RELIANCE ON DECISION SUPPORT SYSTEMS

Alison Parkes
The University of Melbourne, aparkes@unimelb.edu.au

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Abstract

The primary role of a decision support system is to guide and support a decision maker. As reliance on a decision support system is largely discretionary the persuasiveness of the system becomes critically important. In this paper characteristics thought to affect systems persuasiveness are examined. This paper asserts that the target and source of a decision support message, along with the design of the message itself, act to influence the persuasiveness of the decision support provided. Using a purpose built experimental platform with seventy subjects the research finds that the persuasiveness of a decision support message is varied by the perceived difficulty of the task being undertaken, and the perceived usefulness of the decision support provided. The type of decisional guidance provided also affects persuasiveness of the system; in particular, providing suggestive decisional guidance is shown to significantly improve system persuasiveness. The implications of these findings relate to the appropriate design of decision support systems, and the contexts within which a decision support system can be expected to persuade decision makers to reply on the support provided.

Keywords

Decision support, persuasiveness, decisional guidance, task difficulty, perceived usefulness

1 INTRODUCTION

The role of effective decision support is *"to guide and direct the decision-maker towards a better solution"* (Todd and Benbasat 1999:356), however, unlike most other computer systems, the use of a decision support system is frequently discretionary. If a decision maker under uses, or avoids, a decision support system it provides little or no value (Davern and Kauffman 2000). Given this optional use aspect, an important characteristic for decision support is the degree of persuasiveness of the system; a persuasive decision support system will convince a decision maker to rely on the decision support provided.

The definition of persuasiveness used is taken from work by Hovland (Hovland 1957; Hovland et al. 1982), who explored persuasive messages. Hovlands' theories of persuasion tell us that while persuasion cannot alter personality variables, it can alter attitudes, especially in response to some form of communication. This has important implications for decision support, suggesting that the success or otherwise of a decision support system has causal roots far broader than simply the design of the system itself. Successful decision support potentially encompasses the nature and form of the communications provided by that system, and the intended target of those system outputs.

Hovland (1982) argues that three main factors affect the persuasiveness of a message: the characteristics of the person who receives and processes the message (the target), the credibility of the source of the message (the source) and the nature of the message itself (the message). Although Hovlands' work explored human interactions, ideas relating to persuasiveness have been expanded into information systems contexts.

Jiang et al (2000) found that the target, message and source characteristics of communications all contributed to the persuasiveness of an expert system. Artificial intelligence research has a growing interest in persuasive technologies, evidenced by a number of workshops and conferences focusing on these systems[1]. Recent IS publications describe persuasive technologies in domains as diverse as healthy eating habits (Mazzotta et al. 2007) and environmental sustainability (Midden et al. 2008). These prior studies provide some expectation that theories of persuasiveness originally framed in a human context will translate meaningfully to information systems contexts.

The approach this paper takes is to examine how the characteristics of the target, source, and message provided by a decision support system affect the persuasiveness of that decision support system; evidenced by the degree to which a decision maker chooses to rely on the decision support system. The paper focuses on the perceived task difficulty experienced by the decision maker as characteristic of the target, and the perceived usefulness of the decision support system as characteristic of the source. The characteristics of the message itself are explored by adopting concepts from the decisional guidance literature (Silver 1990; 1991). The research question addressed by this paper is "What impacts the persuasiveness of decision support systems?"

The structure of the remainder of the paper is as follows: the following section describes the theoretical basis of the work and presents the hypotheses. The methods employed and results obtained are then presented. In the final section of the paper these results are discussed, along with the conclusions reached and their related implications.

[1] For example the "AISB 2009 Symposium on Persuasive Technology and Digital Behaviour Intervention"; and "Persuasive 2009, The 4th International Conference on Persuasive Technology".

2 THEORY AND HYPOTHESES

2.1 Persuasiveness

"*A Decision support system cannot successfully achieve its objectives if it is never used*" (Silver 1990:54). Existing theories of technology usage (e.g. Davis et al. 1989; Mathieson 1991) explain physical usage of the decision support system, which is a necessary, but not sufficient, precursor to reliance. Reliance conceptually extends beyond use of the decision support system to include the influence of that decision support system on the decision maker. Reliance is more broadly concerned with how decision support system outputs are used and integrated into decision-making (Arnold and Sutton 1998; Hampton 2005; Davern 1998). Decision support system use can be organisationally mandated; however reliance, as a matter of course, cannot. In this study reliance is adopted as a proxy for persuasiveness, *ceteris paribus* a more persuasive decision support system will induce a decision maker to increase their level of reliance on that system.

2.2 Message target characteristics

Hovlands' theories (1982; 1957) propose three factors that affect the persuasiveness of a message. The first factor is the characteristics of the person receiving and/or processing the message, example characteristics include intelligence and self esteem. In the current study the message target is characterised by the perceived difficulty experienced by the decision maker undertaking the decision task.

The complexity of a task is calibrated independently of the decision-maker (Wood 1986); the difficulty of a task is determined by reference to that decision-maker (Van de Ven and Delbecq 1974). A task may contemporaneously be perceived as difficult by one decision-maker and not difficult by another, supporting the claim that perceived task difficulty is a characteristic of the target. It is anticipated that the more difficulty the decision maker experiences when performing the task, the more likely it is that this difficulty will persuade the decision maker to rely on a decision support system, in a manner similar to the effort accuracy tradeoffs explored by Johnson & Payne (1985). This expected relationship is hypothesised as

> ***H1: Decision support system persuasiveness is positively influenced by the perceived difficulty of the decision task being undertaken.***

2.3 Message source characteristics

The second persuasiveness factor identified by Hovland (1982; 1957) relates to the characteristics of the source of the message; example characteristics include expertise, trustworthiness, attractiveness, credibility. In this study the attractiveness and credibility of the message source is characterised by the perceived usefulness of the decision support system. Perceived usefulness reflects the degree to which the user believes the system will improve their task performance (Davis 1989); it is a well established predictor of intention to use the system. A decision support system perceived as reflecting the positive characteristic of usefulness is likely to persuade the decision maker to rely on the decision support system, this relationship is hypothesized as

> ***H2: Decision support system persuasiveness is positively influenced by the perceived usefulness of the decision support system.***

2.4 Message Characteristics

The third and final factor explored by Hovland (1982; 1957) relates to the persuasive nature of the message itself. In this study the message is characterised by the form of decisional guidance provided. Silver (1991:107) defines decisional guidance as *"how a decision support system enlightens or sways its users as they structure and execute their decision making processes."* Every decision support system, whether explicitly or implicitly, provides decisional guidance. In this study the decision support system provides explicit decisional guidance.

Prior research has found decisional guidance to be an important explanatory variable in understanding decision maker behaviour (Jiang and Klein 2000; Limayem and Desanctis 2000; Mahoney et al. 2003; Montazemi et al. 1996; Parikh et al. 2001; Silver 1991; Wilson and Zigurs 1999). Decisional guidance can provide support for decision-makers in differing ways. Silver (1990) suggests that there is a choice to be made between suggestive guidance (swaying a decision-maker by making recommendations) and informative guidance (enlightening decision-makers by providing them with unbiased pertinent information).

A single decision support system may contain both forms of decisional guidance, and either, or both, may be provided at any decision point. The decision support system used in this research delivered either informative or suggestive decisional guidance to the decision maker. Silver (1990) notes that *"Designers who seek to influence decision-makers will usually provide specific suggestions, but they may also do so by providing carefully selected informative guidance. Designers who seek to support but not influence decision-makers may rely heavily on informative guidance, but may also offer some suggestive guidance"* (Silver 1990:60).

This research is interested in influencing a decision maker to rely on the decision support provided, so it is expected that providing suggestive decisional guidance will improve the persuasiveness of the decision support system message. Given that the primary role of informative guidance is to support, rather than influence, it is not anticipated that providing informative decisional guidance will improve decision support system persuasiveness. Stated as the final hypothesis this becomes:

> ***H3: Decision support system persuasiveness is positively influenced by the provision of suggestive decisional guidance***.

To summarize, the persuasiveness of a decision support system is hypothesised to relate to the perceived difficulty of the decision task (the message target), the perceived usefulness of the decision support system (the message source), and the form of decisional guidance supplied (the message itself).

3 METHOD

The hypotheses were tested in a laboratory based experimental setting, using a 1 x 3 (informative guidance; suggestive guidance; no guidance) research design. Participants were on average 23 years old, had 1.5 years work experience, and no insolvency related work experience. The rationale behind selection of a novice cohort was that it provided an opportunity to limit variability in terms of any pre-existing notions of what would constitute suitable decision support for the decision task being undertaken. By removing any prior knowledge of the problem domain all participants were starting from the same point of zero knowledge or task expertise; helping to more accurately isolate the effect of the decision support system. Seventy subjects successfully completed the experiment. Subjects attended one of six experimental sessions and were randomly allocated to one of the three treatment groups, as shown in table 1. All experimental sessions used identical scripts and procedures[2].

	Informative guidance	**Suggestive guidance**	**No guidance**	**Total**
Subjects	24	23	23	70

Table 1. Subject distribution

After finalising the operationalisation and instruments for the study, a participant questionnaire was developed. The questionnaire was paper based as it was felt that requiring participants to answer a screen based questionnaire while concurrently using the decision support system had the potential to

[2] Sensitivity analysis was conducted; the lab session attended had no significant effect on any of the variables.

confound both the perceived task difficulty and reliance observations. Following development and testing of the software, case studies, and questionnaire, a pilot study was conducted to test the face validity and operation of these materials. The pilot study also served to test the design, sequencing, and timing of the experimental session. As a result of the pilot study minor changes were made to materials (e.g. font size on screens increased, paper materials presented in booklet form etc) prior to undertaking the main study.

3.1 Overview of the case study and decision task

The case study ("Message Wings") contains appendix materials collected by Arnold et al (2003). The case narrative was developed and written by the researcher based on the data contained in these appendices[3]. The case development included the creation of a narrative, and identification and appropriate insertion of information cues. The information cues were designed to map directly to the decision model contained in the decision support system. Additional original material was devised by the researcher to provide information cues not considered in the existing appendix materials.

The case study organisation was portrayed as operating in a high tech industry, providing electronic messaging systems. A new product was identified as being currently in the final stages of development but not yet available for sale. The case was designed to ensure it provided a challenge for decision makers, therefore ensuring a longer interaction with the decision support system and providing ample opportunity to observe the effects of the decisional guidance provided. The face validity and complexity of the case study was confirmed by three insolvency experts prior to use in the main experiment.

The context for the study was insolvency decision making where a decision must be made about the future of a company; whether to liquidate the distressed business or to trade-out of its present difficulties. The study used a purpose-built decision support system known as INSOLVE-DG.

3.2 Overview of the decision support system

Insolve-DG is a decision support system purpose built for a program of behavioural research about the effects of decisional guidance on decision making behaviour. It incorporates an underlying decision model and materials gathered in an extensive knowledge acquisition effort that had led to the original INSOLVE system (Leech et al. 1999; Collier et al. 1999; Arnold et al. 2004; Arnold et al. 2004), but in all other respects is an independent and distinct artifact. The decision model in Insolve-DG was validated by three expert insolvency practitioners, who indicated that the model accorded with their 'real world' view of the insolvency decision making process.

3.3 Operationalising reliance

The reliance measure used was a multi item construct, containing six items self assessed by participants; details of the reliance scale are contained in table 2. The items contained in a prior reliance study (Hampton 2005) formed a starting point for the operationalisation, along with the reliance definitions used in this research. Factor analysis showed all 6 items loaded onto a single factor which, taken in conjunction with a Cronbach alpha value of .88, indicates that the scale has sufficiently internal validity to support the use of the items as a single construct. The reliance measures were taken immediately after using Insolve-DG for decision making while completing the case study.

[3] All case materials are available on request

Item	Definition
I used InsolveDG to assist with my decision making.	Use of the system in decision-making
My decision was influenced by the recommendation made by InsolveDG.	How much weight recommendations are given
I followed recommendations made by InsolveDG.	How much users follow recommendations
I altered my decision making process when using InsolveDG.	Integration of outputs
I used information provided by InsolveDG	Use of the systems outputs
I followed recommendations made by InsolveDG that differed from my personal opinion.	How much users follow recommendations.

Table 2. Items contained in reliance scale

3.4 Operationalising perceived task difficulty

Perceived task difficulty was also self-assessed by participants. Existing perceived task difficulty measures were examined with the intention of re-using a previously calibrated instrument. The items adapted for the study were based on work by Van de Ven and Delbecq (1974) and Van de Ven and Ferry (1980) and are shown in Table 3. Factor analysis showed that these three items loaded onto a single factor, and a Cronbach alpha value of .74 indicates that the scale has sufficiently internal validity to support the use of the items as a single factor.

Difficult problems often arose during this task for which there was no immediate or apparent solution.
I spent a lot of actual *thinking time* trying to solve this problem.
The Message Wings case was very difficult for me.

Table 3 Items contained in Perceived task difficulty scale

3.5 Operationalising perceived usefulness

Perceived usefulness was measured using the existing six item validated instrument (Davis 1989), see table 4 for details. Consistent with previous analyses using this instrument, exploratory data analysis showed all six items loading onto a single factor, and a Cronbach alpha value exceeding .8, indicating that the scale had good internal validity.

Using InsolveDG helped me to accomplish the task more quickly
Using InsolveDG improved my task performance
Using InsolveDG increased my productivity
Using InsolveDG enhanced my effectiveness on the task
Using InsolveDG made it easier to do this task
I found InsolveDG useful in this task

Table 4 Items contained in perceived usefulness scale

3.6 Operationalising decisional guidance

For experimental purposes several versions of Insolve-DG were created; differentiated by the form of decisional guidance supplied. The underlying decision model was identical in all versions of Insolve-DG. Suggestive guidance was operationalised by leveraging the hierarchical structure of the decision model. Specifically, where multiple underlying factors contributed to an interim decision, the opportunity existed to ask users directly for an interim decision and provide suggestive guidance as to the interim decision. After extensive modelling exercises, an additive model was found to be the most effective way of generating the suggestive guidance. Figure 1 shows an example of underlying factors and resulting suggestive guidance.

Example underlying factors: Question 3. Will the practitioner get paid?

3.1 Will there be sufficient funds to pay the practitioners fees and ongoing expenses?

3.2 Is a challenge to the practitioner's priority to receive payment of their fees and expenses unlikely?

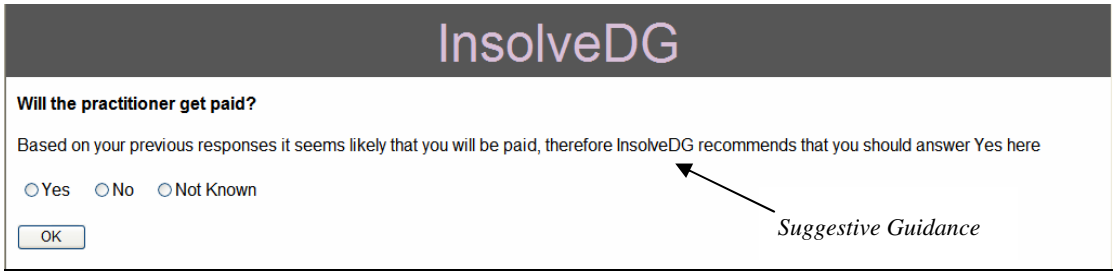

Figure 1 Suggestive guidance operationalisation

Informative guidance in the form of definitional text was also embedded into appropriate questions as illustrated in figure 2.

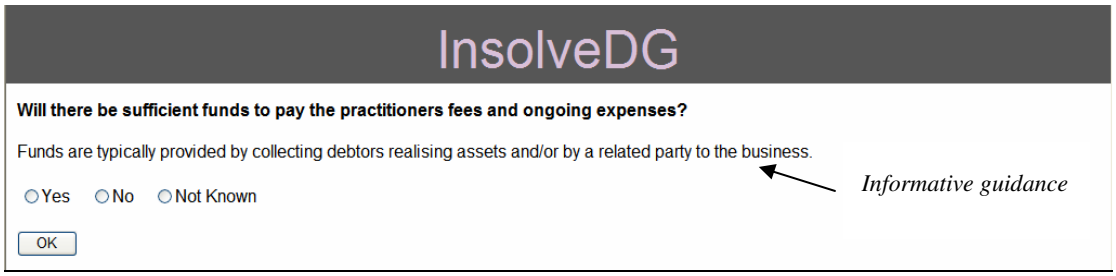

Figure 2 Informative guidance operationalisation

4 RESULTS

Factor analysis of the items contained in the perceived task difficulty, and perceived usefulness scales revealed that the items loaded onto the relevant factors, establishing the discriminate validity of the construct measures. Principal component analysis found two components with eigenvalues exceeding 1 for this set of measures; these two components explained 72% of the variance observed. The items for perceived task difficulty and perceived usefulness each loaded onto a single component, with no substantial cross loadings to the other component.

The data were analysed by regression analysis, using as regressors informative and suggestive guidance, perceived usefulness, and perceived task difficulty. The regression model was a good fit (R^2_{adj} = 56%), and the overall relationship was significant ($F_{4, 13}$ = 22.69, $p < 0.001$). With other variables held constant, reliance was positively related to perceived usefulness, perceived task difficulty, and suggestive decisional guidance. No significant relationship was observed between informative decisional guidance and reliance. The results of the regression analysis are contained in table 5.

4.1 Regression Results

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.763[a]	.583	.557	.76685

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	53.385	4	13.346	22.695	.000[a]
	Residual	38.224	65	.588		
	Total	91.610	69			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.044	.628		-.070	.944
	Informative guidance	.005	.228	.002	.023	.982
	Suggestive guidance	.699	.239	.287	2.922	.005
	Perceived usefulness	.659	.076	.731	8.692	.000
	Perceived task difficulty	.280	.100	.228	2.799	.007

Dependent Variable: Reliance

Table 5 Regression analysis results

Hypothesis 1 is supported. Perceived task difficulty is shown to be a significant and positive predictor of reliance, and therefore the persuasiveness of the decision support system. (p=.007).

Hypothesis 2 is supported. The perceived usefulness of the decision support system was shown to be a significant and positive predictor of reliance, and therefore the persuasiveness of the decision support system (p <.001).

Hypothesis 3 is supported. Suggestive decisional guidance was shown to be a significant predictor of reliance, and therefore the persuasiveness of the decision support system (p=.005). Descriptive statistics show that the mean value of reliance for decision makers provided with suggestive guidance was 4.8, by comparison those provided with informative guidance reported a mean value of 4.4; indicating that participants provided with suggestive guidance reported higher reliance levels.

5 DISCUSSION

This study explored factors contributing to the persuasiveness of a decision support system. The empirical results confirm that the characteristics of the target and source of a message, and the design of the message itself, explain a significant proportion of the variation observed. Decision makers were persuaded to reply more on the decision support system when perceived task difficulty and the perceived usefulness of the decision support increased. In line with expectations, the persuasiveness of the decision support system is shown to change when the target and source of the message change. Providing suggestive decisional guidance was shown to improve the persuasiveness of the system, by contrast no significant persuasion effect was detected when informative decisional guidance was provided.

5.1 Implications for future research

The study examined the research question: What impacts the persuasiveness of decision support systems?" with the intention of extending existing literature examining persuasiveness in information systems. The study explored the effect of target, source and message characteristics on persuasiveness, the results indicate that the explanatory power of these factors is high, suggesting that further exploration of these constructs will be of value in future research. Increased understanding of whether and where it is possible to improve the persuasiveness of decision support systems will help to extend the existing decision support literature; acting to link more closely the existing behavioural and technical perspectives explored in this literature.

5.2 Contributions for practice

The practical implications drawn from this study relate to ways of improving persuasion of decision support systems. Organisations spend time and money creating these systems with the intention of improving decision outcomes; however no improvement can take place unless decision-makers are persuaded to rely on the decision support system. An improvement in persuasion levels will return additional value to the organisation by improving decision quality. The results show persuasion is a function of the characteristics of the target, source, and message, and these should be taken into account when constructing decision support systems. In particular, practitioners should be mindful of the fact that systems success in decision support extends beyond the design of the tool itself; it also requires careful consideration of the characteristics of the decision makers who will be supported.

5.3 Limitations

In common with all experimental research this study has several limitations. Small cell sizes may act to limit the explanatory power of the tests undertaken. Data was collected in a laboratory based experimental setting, which maximised the ability to control the environment but introduced some limitations in terms of the richness of the experience for participants. Because of this behaviour of participants in a real world setting may differ. The experimental session and data identify only short term effects; a longitudinal study may result in different outcomes. Given the specific problem domain generalisability of the results may be limited, although these results will generalise to any non-

normative judgment task which contains similar characteristics to insolvency decision-making. There is also a possibility that the results obtained may relate only to the specific task and software artifact in use.

References

Arnold, V, N Clark, P.A Collier, S.A Leech, and S.G Sutton. 2004. Explanation Provision and Use in an Intelligent Decision Aid. *International Journal of Intelligent Systems in Accounting, Finance & Management* 12 (1):5 - 28.

Arnold, V, P.A Collier, S.A Leech, and S.G Sutton. 2004. Impact of Intelligent Decision Aids on Experienced and Novice Decision-Makers' Judgments. *Accounting & Finance* 44 (1):1 - 26.

Arnold, V, and S.G Sutton. 1998. The Theory of Technology Dominance: Understanding the Impact of Intelligent Decision Aids on Decision Makers' Judgments. *Advances in Accounting Behavioural Research* 1:175 - 194.

Collier, P.A, S.A Leech, and N Clark. 1999. A validated expert system for decision making in corporate recovery. *International Journal of Intelligent Systems in Accounting, Finance & Management* 8:75 - 88.

Davern, M. J, and R. J. Kauffman. 2000. Discovering potential and realizing value from information technology investments. *Journal of Management Information Systems* 16 (4):121 - 143.

Davern, M.J. 1998. Performance with Information Technology: Individual Fit and Reliance on Decision Support Systems. PhD, University of Minnesota PhD.

Davis, F. D. 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly* 13 (3):319-339.

Davis, F.D, R.P Bagozzi, and P.R Warshaw. 1989. User acceptance of computer technology: A comparison of two theoretical models. *Management Science* 35 (8):982 - 1003.

Hampton, C. 2005. Determinants of Reliance: An empirical test of the theory of technology dominance. *International Journal of Accounting Information Systems* 6:214 - 240.

Hovland, C. I. 1957. *Order of presentation in persuasion*, *Yale studies in attitude and communication*. New Haven, Conn.: Yale University Press.

Hovland, C. I, I.L Janis, and H.H Kelley. 1982. *Communication and persuasion*. Westport, Conn: Greenwood Press.

Jiang, J. J, G Klein, and R.G Vedder. 2000. Persuasive expert systems: the influence of confidence and discrepancy. *Computers in Human Behavior* 16:99 - 109.

Jiang, J.J, and G Klein. 2000. Side effects of decision guidance in decision support systems. *Interacting with Computers* 12:469 - 481.

Johnson, E.J, and J.W Payne. 1985. Effort and Accuracy in Choice. *Management Science* 31 (4):395 - 414.

Leech, S. A, P. A Collier, S. G Sutton, and V Arnold. 2003. Impact of intelligent decision aids on human knowledge acquisition: Australian Research Council Discovery Project Grant DP 0344241.

Leech, S.A, P.A Collier, and N Clark. 1999. A generalized model of decision-making processes for companies in financial distress. *Accounting Forum* 23 (2):155 - 174.

Limayem, M, and G Desanctis. 2000. Providing Decisional Guidance for Multicriteria Decision Making in Groups. *Information Systems Research* 11 (4):386 - 401.

Mahoney, L.S, P.B Roush, and D Bandy. 2003. An investigation of the effects of decisional guidance and cognitive ability on decision-making involving uncertainty data. *Information & Organization* 13:85 - 110.

Mathieson, K. 1991. Predicting User Intentions: Comparing the Technology Acceptance Model with the Theory of Planned Behavior'. *Information Systems Research* 2 (3):173 - 191.

Mazzotta, I, F De Rosis, and V Carofiglio. 2007. Portia: a user-adapted persuasion system in the healthy eating domain. *IEEE Intelligent systems* 22 (6):42 - 51.

Midden, C, T McCalley, J Ham, and R Zaalberg. 2008. Using persuasive technology to encourage sustainable behavior. Paper read at Pervasive Persuasive Technology and Environmental Sustainability Workshop; held at the 6th International Conference on Pervasive Computing, at Sydney, Australia.

Montazemi, A.R, F Wang, S.M.K Nainar, and C.K Bart. 1996. On the effectiveness of decisional guidance. *Decision Support Systems* 19:181 - 198.

Parikh, M, B Fazlollahi, and S Verma. 2001. The Effectiveness of Decisional Guidance: An Empirical Evaluation. *Decision Sciences* 32 (2):303 - 331.

Silver, M.S. 1990. Decision Support Systems: Directed and Nondirected Change. *Information Systems Research* 1 (1):47 - 70.

———. 1991. Decisional Guidance for Computer-Based Decision Support. *MIS Quarterly* 15 (1):105 - 122.

Todd, P, and I Benbasat. 1999. Evaluating the Impact of DSS, Cognitive Effort, and Incentives on Strategy Selection. *Information Systems Research* 10 (4):356 - 374.

Van de Ven, A. H, and A. L Delbecq. 1974. A Task Contingent Model of Work-Unit Structure. *Administrative Sciences Quarterly* 19 (2):183-197.

Van de Ven, A. H, and D. L Ferry. 1980. Measuring and assessing organizations. New York: John Wiley & Sons.

Wilson, E.V, and I Zigurs. 1999. Decisional Guidance and end-user display choices. *Accounting, Management & Information Technology* 9:49 - 75.

Wood, R.E. 1986. Task Complexity: Definition of the Construct. *Organizational Behaviour and Human Decision Processes* 37:60 - 82.