December 2001

Incentives, Base Rate Expectations, and False Alarms in the Detection of Data Errors

Barbara Klein
University of Michigan-Dearborn

INCENTIVES, BASE RATE EXPECTATIONS, AND FALSE ALARMS IN THE DETECTION OF DATA ERRORS

Barbara D. Klein
University of Michigan–Dearborn
bdklein@umd.umich.edu

Abstract

Incentives and base rate expectations have been shown to affect the detection of data errors. Unfortunately, the incentives that most improve error detection also have a large false alarm rate in low error rate environments. False alarms are problematic in environments with a high cost of investigating possible data errors. This experiment will improve our understanding of how incentives can improve error detection without contributing to excessive false alarms.

Introduction

Studies of data quality have estimated that one to ten percent of data items in organizational databases are inaccurate (Laudon 1986; Morey 1982; Redman 1992; Redman 1996). Managerial decision making is improved if data errors are detected and corrected. However, several studies have been critical of human ability to find data errors (Davis et al. 1967; Laudon 1986; Ricketts 1990). More recently, evidence demonstrates that users of information systems can detect data errors in certain circumstances (Klein et al. 1997; Klein forthcoming). Experiments show that incentives and base rate expectations developed through direct experience with data errors affect both the hit rate (the proportion of data errors successfully detected) and the false alarm rate (the proportion of correct data values incorrectly flagged as data errors). Regrettably, the experiments indicate that the type of incentive that gives the best hit rate also leads to many false alarms when the error rate is low. The experiment proposed here aims to improve our understanding of incentives and false alarms in this detection task.

The remaining sections of this paper present (1) a discussion of the theoretical foundation of the study, (2) results of prior experimental studies, (3) the research question, (4) the experimental methodology, and (5) conclusions.

Theoretical Foundation

A theory of error detection that provides the foundation for this study is outlined in Klein et al. (1997) and summarized briefly here. Signal detection theory conceptualizes the four possible outcomes in error detection tasks (Baker and Schuck 1975). Errors can be successfully detected (hits) or missed (misses). When no error exists, one may conclude that there is an error (false alarm) or conclude that there is no error (correct rejection). The theory of error detection predicts that expectations about the base rate of errors and incentives will affect the hit rate and the false alarm rate.

Prior Experimental Studies

Two laboratory experiments have been conducted to examine the effect of incentives and base rate expectations on the detection of data errors. Subjects calculated pension benefits using data containing embedded errors.

Independent Variables in Experiment 1. Four incentive structures and three levels of base rate expectations were tested (Klein et al. 1997). Expectations were operationalized using a short memo. In the high base rate condition, the memo stated that the clients providing the data tend to provide data containing a lot of errors. In the low base rate condition, the memo stated that the

clients providing the data tend to provide data mostly free of errors. No mention of the error rate was made in the memo for a control condition.

Four different incentive structures were tested (Detection, Pension Calculation, Detection With False Alarm Penalty, and Control). In the Detection, Pension Calculation, and Detection With False Alarm Penalty conditions, subjects were told that their performance on the task would be evaluated and that the thirty percent of subjects with the best performance would have a chance to win $100. Subjects in the Detection and Detection with False Alarm Penalty conditions were told that their error detection performance would be weighted three times as heavily as performance on the accrued pension calculations, while subjects in the Pension Calculation condition were told that performance on the accrued pension calculations would be weighted three times as heavily as their error detection performance. Subjects in the Detection with False Alarm Penalty condition were told that both the number of errors noted and the amount of unnecessary costs incurred by the client to investigate false alarms would be considered in the evaluation of their performance. All subjects in the control group were eligible to win $100.

Independent Variables in Experiment 2. In the second experiment the treatments divided subjects into three base rate expectations (High, Low, and Control) and three incentives (Detection, Random, and No Incentive) (Klein forthcoming). The expectation construct was operationalized through direct experience. In the High base rate expectations condition, subjects performed the pension calculations using a dataset containing an error rate of 30 percent before performing the pension calculations for a second target division. In the Low base rate expectations condition, subjects performed the pension calculations using a dataset containing an error rate of four percent before performing the pension calculations for a second target division. For the Control condition, subjects performed the pension calculations for the target division before doing the task for any other divisions.

The Detection level of the incentive structure factor was identical in the two experiments. The Random level of the incentive structure factor was identical to the Control condition in the first experiment. A new condition (No Incentive) with no prize was also used in this experiment.

Results of Experiment 1. In experiment 1, the incentive structure factor had a main effect on the hit rate but no effect on the false alarm rate. The Detection with False Alarm Penalty condition suppressed the false alarm rate compared to the Detection condition (.03 vs. .05), but the effect was not statistically significant.

Results of Experiment 2. Both the incentive structure factor and the base rate expectations factor had a main effect on both the hit rate and the false alarm rate (Klein forthcoming). Unfortunately, subjects assigned to the Detection level of the incentives factor and the Low level of the base rate expectations factor had significantly more false alarms (more than seven on average) than subjects in all of the other eight conditions (fewer than one on average).

Research Question

This study will test whether an incentive system that rewards hits while penalizing false alarms will keep the false alarm rate from increasing significantly when users have low base rate expectations developed through direct experience. In order to examine this question, an experiment will be conducted examining the effect of the Detection with False Alarm Penalty condition (from experiment 1 described in section 3.0) together with the base rate expectations manipulated through direct experience (as in experiment 2 described in section 3.0). Additional levels of the incentive structure factor (Detection and Control) will also be tested for comparison with prior studies.

Experimental Methodology

A laboratory experiment will be conducted to examine the research question. The task, treatments, dependent variables, and subjects will be similar to the two earlier experiments described in section 3.0.

The experimental treatments divide subjects into three base rate expectations (High, Low, and Control) and three incentives (Detection, Detection with False Alarm Penalty, and Control). The expectation factor is operationalized through direct experience as in the second experiment described in section 3.0 of this paper. The incentives factor is operationalized through $100 prizes as in the first experiment described in section 3.0 of this paper.

The dependent variables are the hit rate, the false alarm rate, and two measures of discrimination as described in Klein et al. (1997).

162 students (18 per experimental condition) will participate in the experiment.

Conclusion

The results of this experiment will clarify the extent to which incentives can encourage error flagging activity without creating an excessively high false alarm rate in environments with a low base rate of errors. The results of the study will have implications for managers of operations with a low error rate and a high cost of investigating possible data errors.

References

Baker, E.M., and Schuck, J.R. "Theoretical Note: Use of Signal Detection Theory to Clarify Problems in Evaluating Performance in Industry," *Organizational Behavior and Human Performance* (13:3), 1975, pp. 307-317.

Davis, G.B., Neter, J., and Palmer, R.R. "An Experimental Study of Audit Confirmation," *Journal of Accountancy* (123:6), 1967, pp. 36-44.

Klein, B. D. "Detecting Errors in Data: Clarification of the Impact of Base Rate Expectations and Incentives," *Omega*, forthcoming.

Klein, B.D., Goodhue, D.L., and Davis, G.B. "Can Humans Detect Errors in Data? Impact of Base Rates, Incentives, and Goals," *MIS Quarterly* (21:2), 1997, pp. 169-194.

Laudon, K.C., "Data Quality and Due Process in Large Interorganizational Record Systems," *Communications of the ACM* (29:1), 1986, pp. 4-11.

Morey, R.C. "Estimating and Improving the Quality of Information in a MIS," *Communications of the ACM* (25:5), 1982, pp. 337-342.

Redman, T.C. *Data Quality: Management and Technology*, New York, NY: Bantam Books, 1992.

Redman, T.C. *Data Quality for the Information Age*, Norwood, MA: Artech House, Inc., 1996.

Ricketts, J A. "Powers-of-Ten Information Biases," *MIS Quarterly* (14:1), 1990, pp. 63-77.