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DETERMINATION OF A DEPENDENT VARIABLE IN THE MEASUREMENT OF DISCRETE EVENT COMPUTER SIMULATION SUCCESS

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ABSTRACT

The purpose of this study is to establish the external validity of two general information system instruments. This research seeks to determine if the Davis (1989) measure of *User Acceptance of Information Technology* and the Doll and Torkzadeh (1988) measure of *End-User Computing Satisfaction* maintain psychometric stability when used to measure discrete event computer simulation success. The investigation focuses on establishing construct validity, internal validity and reliability. If the hypothesized psychometric properties of these instruments are consistent with prior studies, the use of these instruments can be extended to the measurement of success in discrete event computer simulation.

1 BACKGROUND

The implementation of information system technology has traditionally been an uncertain process. Some systems are successful, others are not. In order to identify the determinants of success, a researcher must first be able to operationalize success. Many empirical studies in the area of information systems have been concerned with this task (Bailey and Pearson, 1983; Baroudi, Olson, and Ives, 1986; Ein-Dor, Segev, Steinfeld, 1981; King and Epstein, 1983; Mahmood, 1987; Srinivasan, 1985). A simple approach would be to ask users of computer simulation a single line item question such as *'Was your simulation a success?'*. At first glance, this may seem to be a straightforward method of obtaining a dependent variable for success. Upon deeper reflection, obvious problems come to light. In fact, the single item approach has been criticized as ambiguous or prone to misunderstanding (Cronbach, 1951; Straub, 1989). Modern instrument construction techniques and the ideas of construct validity and reliability are based on insuring these problems do not diminish the veracity of the measures (Cook and Campbell, 1979). For these reasons, other measures for simulation success were investigated.

Two existing instruments used for the measurement of information system success were investigated. The first one considered for use with discrete event computer simulation success was the Davis (1989) measure of *User Acceptance of Information Technology*. Davis' (1989) research centers around the pursuit of *"better measures for predicting and explaining use"* in information systems. He hypothesizes *perceived usefulness* and *perceived ease of use* to be determinants in user acceptance of information technology. Davis' (1989) original study has been corroborated other research citing sound psychometric properties of the constructs (Adams, Nelson and Todd, 1992; Hendrickson, Massey, and Cronan, 1993).

While optimistic about the findings in his studies, Davis (1989) cautions against adopting the instrument without further research into *"how the measures such as those introduced here perform in applied design and evaluation settings."* The purpose in studying Davis' instrument within the context of discrete event computer simulation is to establish instrument validity and reliability (Straub, 1989). This research seeks to determine if the ease-of-use and usefulness scales are generalizable to simulation use.

The second instrument considered for use in conjunction with discrete event computer simulation is the Doll and Torkzadeh (1988) measure of *End-User Computing Satisfaction*. Doll and Torkzadeh (1988) proposed an instrument for measuring end-user computing satisfaction (EUCS). Like Davis (1989), Doll and Torkzadeh (1988) developed a construct consisting of ease of use. In addition, they proposed a usefulness or information product component consisting of content, accuracy, format and timeliness (Bailey and Pearson, 1983). These five constructs comprise an instrument for end-user computing satisfaction. However, unlike Davis, their instrument is specifically designed to work within the current end-user computing environment consistent with current trends (Rockart and Flannery, 1983).

2 METHODOLOGY

The goal for this study was to establish whether the Davis (1989) and the Doll and Torkzadeh (1988) instruments are generalizable to the measure of success in discrete event computer simulation. Subjects were one thousand randomly selected users of computer simulation drawn from a seven thousand name mailing list owned by the Society for Computer Simulation. Mail surveys were distributed. Two forms were offered to each subject. One form asked questions from the perspective of the individual responsible for the development of a computer simulation (referred to as the analyst group). The second form asked questions from the perspective of the individual who uses simulation-generated outputs in decision making, but does not develop the model (referred to as the decision maker group). Due to the context of the questions, the analyst group was asked to respond to the Doll and Torkzadeh (1988) instrument and the Davis (1989) instrument. The decision maker group was asked only to respond to the Doll and Torkzadeh (1989) instrument.

Since the only known characteristic of the group being studied was an interest in computer simulation, demographics and other information were collected from both groups. Of the 171 respondents, 115 indicated they used discrete event computer simulation. The other 56 used different types of simulation. All other statistics and reporting in this research are based on only the discrete event computer simulation users. The highest percentage of respondents reported between 6 and 10 years experience. Almost thirty-two percent fell between 40 and 49 years of age. Most respondents had doctoral (40.9%) or master's degrees (36.5%). The occupations of the respondents were reported with the highest percentages being engineers (27.8%), educators (19.1%), analyst/programmers (14.8%), consultants (11.3%), scientists/researchers (11.3%) or managers/planners (8.7%). Most simulation use was not mandatory (53.2%). Many respondents reported their use of discrete event computer simulation as high (43.4%), while fewer reported moderate (35.4%) or low (21.2%) use. The main hardware platform used for simulation was micro computers with 64% of respondents fitting into this category. The primary simulation packages used by the respondents were GPSS/H, SIMAN, and SIMSCRIPT.

3 RESULTS

Due to the nature of the Davis instrument (1989) and the context of its questions, it was only administered to analysts. Ninety of the ninety-one analysts responding to the survey completed the Davis instrument. The objective of this part of the study was to assess the reliability and construct validity of the two scales comprising the Davis (1989) instrument--- *Perceived Ease of Use* and *Perceived Usefulness*.

Reliability for the Davis instrument was calculated with Cronbach's Alpha. The alpha for the *Ease of Use* scale was .93 and the alpha for the *Usefulness* scale was .94. These values compare favorably to reliabilities calculated by Davis (1989).

Construct validity was assessed to determine if *Ease of Use* and *Usefulness* form two distinct scales (Davis, 1989). This assessment was conducted using confirmatory factor analysis with SAS proc CALIS (SAS Institute, 1985). The results of the factor analysis were compared to the original Davis study results. The highest loading in the current study is .92. This compared to a loading of .98 in the original Davis (1989) study. While the twelve items appear to have divided into the two hypothesized factors, fit indexes indicated this was not quite the case.

The fit of the data to the hypothesized model was assessed using several statistics. The first of these was the Chi-square goodness of fit measure. The analysis indicated the data collected from discrete event computer simulation users did not fit the hypothesized factor structure (Chi-square=314.8, P<.0001). The Chi-square divided by the degrees of freedom statistic confirms this poor fit at 5.14 (Wheaton, Muthen, Alwin and Summers, 1977). The goodness of fit and adjusted goodness of fit indexes were .68 and .58 respectively, again indicating a poor fit. The root mean square residual was reasonable at .3 but the largest normalized residual was out of line at 6.7 (Hayduk, 1987). Bentler and Bonett's non-normed index was poor at .73 as was Bollen's non-normed index at .76 (Bollen, 1988).

Although reliability was present with the data analyzed, the factor structure did not appear to be consistent with the hypothesized structure. Validity was further assessed through a correlation analysis of the *Ease of Use* and *Usefulness* scales with measures of expected use and actual use (Davis, 1989). Although significant, the correlations were in this study were much lower than those reported by Davis in his original work.

The Doll and Torkzadeh (1988) measure of End User Computing Satisfaction was administered to both the analysts and the decision makers. One hundred and fifteen respondents completed this portion of the survey. The objective was to assess the reliability and factorial validity of the scales comprising this instrument. Doll and Torkzadeh originally proposed a five scale factor structure. Subsequent research has indicated a second order factor structure provides a better fit (Collins, Glorfeld and O'Keefe, 1993). The second level structure

is a single factor called *End-User Computing Satisfaction*. The first order structure matches the original factor structure of *Content, Accuracy, Format, Ease of Use* and *Timeliness*.

Reliability for the Doll and Torkzadeh instrument (1988) was calculated with Cronbach's Alpha and found to be .91. This compared favorably to an overall alpha of .92 in the original study. The item correlations were all significant ranging from a low of .499 to a high of .745. The effect on overall reliability upon the removal of each item was not significant. In all cases alpha remained at .894 or above indicating a good reliability. Construct validity was assessed to determine if the hypothesized factor structure did exist. A second level construct was formed together with five first level constructs. This assessment was conducted using confirmatory factor analysis with the SAS proc CALIS (SAS Institute, 1985). All constructs reported significant at the .10 level with the exception of F2- *Is Simulation Output Clear* ($p>.11$). The a Priori factor structure appeared to be present. This was confirmed by the fit indexes.

The fit of the data to the hypothesized factor structure was assessed using several measures. The Chi-square statistic divided by the degrees of freedom confirms indicated a reasonable fit at 1.98 (Wheaton, Muthen, Alwin and Summers, 1977). The goodness of fit reported close to the desired value of .9 and the adjusted goodness of fit index was good at .81. The root mean square residual was excellent at .06 and the largest normalized residual was reasonable at 2.0 (Hayduk, 1987). Bentler and Bonett's non-normed was good at .92 as is Bollen's (1988) non-normed index at .94. Both reliability and the construct validity appeared to be present. Validity was further assessed through a correlation analysis of the overall second level construct, End-User Computing Satisfaction. It was correlated with a single item measure of success and a single item measure of satisfaction. The correlations reported at .62 and .66 respectively.

4 CONCLUSIONS

The objective of this study was to determine if general information systems measure of success retain their psychometric properties when applied to discrete event computer simulation. The data collected in this survey indicate the Davis (1989) instrument did not retain these properties while the Doll and Torkzadeh (1988) instrument did. The findings of this study in no way diminish previous use of the Davis (1989) instrument in other information system applications. These findings do, however, indicate the Davis (1988) measure may not be appropriate for use with discrete event computer simulation.

References and full paper available upon request of author.

AUTHOR BIOGRAPHY

For eight years prior to his recent return to academia, ROGER MCHANEY was employed by the Jervis B. Webb Company. While there he simulated numerous materials handling systems for customers including General Motors, Goodyear, Ford, IBM, Chrysler, Kodak, Caterpillar, the Los Angeles Times, and the Boston Globe. His current research interests include automatic guided vehicle system simulation, innovative uses for simulation languages and artificial intelligence. Roger is author of the 1991 Academic Press book, *Computer Simulation: A Practical Perspective*.