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Fundamental factors for assessing controls: a semantic analysis

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FUNDAMENTAL FACTORS FOR ASSESSING CONTROLS: A SEMANTIC ANALYSIS

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ABSTRACT

This paper reports a study designed to develop a measure of control effectiveness to evaluate controls in empirical research and practice. In particular, a psychometric measure of meaning, called a semantic differential [Osgood *et al*, 1971], is developed for the evaluation of computer controls. F*unctionality, strength* and *practicality* are the three factors underlying auditor judgements. These factors resulted from a factor analysis of responses to the semantic differential instrument. A variety of uses are identified for this three factor measure of control effectiveness and include applications in audit research, audit education, and the practice of auditing.

INTRODUCTION

The need for companies to have sound systems of internal control, and for auditors to assess those systems, stems from professional standards[1], legislation[2], and case law[3]. Because of the importance attached to internal controls, audit researchers have investigated how to appraise the effectiveness of internal control systems. However, at present there is no independent measure for auditors' evaluations of the effectiveness of a particular control or internal control system.

As Ashton [1974] and Scott [1984] assert, one major limitation of Lens Model studies is the inability of researchers to specify the *true state* of an internal control system. In other expert judgment situations the accuracy of the judgment, and the cues that promote accuracy, can be assessed. For example, the accuracy of a radiologist's judgment is confirmed by subsequent operations or autopsy. Similarly, subsequent weather patterns may validate the accuracy of a meteorologist's weather forecast. In contrast, there is no way to assess the before and after states of an internal control system. Internal controls are artificial constructs and hence their attributes have no observable-physical correlated.

Nevertheless, it is possible to measure the psychological attributes of artificial constructs that expert judges evaluate. EDP controls are an example of such a construct when they are evaluated by expert auditors. Thurstone [1947] showed that psychological scaling techniques measure psychological attributes of stimuli, such as controls, that have no measurable-physical correlate. Recently Bagranoff [1990, p.75] argued that the semantic differential, a particular scaling technique, is "underused" in accounting research relative to other social science disciplines. She surveys the accounting and auditing applications of the semantic differential including the work of

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1 The AICPA's [1984] second standard of field work requires that *"There is to be a proper study and evaluation of internal control as a basis for reliance thereon and for the determination of the resultant extent of the tests to which auditing procedures are to be restricted."*

2 The Foreign Corrupt Practices Act of 1977 requires management, among other things, to devise and maintain a system of internal accounting controls to provide reasonable assurance that transactions are executed in accordance with management's authorization; transactions are recorded to permit the preparation of financial statements that conform to GAAP; and access is permitted only in accordance with management's authorization.

3 See Ernst & Ernst v Hochfelder [U.S. Supreme Court, 1976].

Houghton [1987a, 1987b, 1988], Houghton and Messier [1990], McNamara and Moores [1982], Flamholtz and Cook [1978], Haried [1972,1973] and Oliver [1974]. Bagranoff [1990] provides a prescription for using the semantic differential to measure the connotative meaning of accounting stimuli, such as the effectiveness of controls.

The objective of the current study is to address the deficiency identified in the internal control literature by developing a measure of control effectiveness for use in evaluating controls. Further, psychological scaling techniques provide a measure of the psychological attributes of controls. In particular, a psychometric measure of meaning, called a semantic differential, is developed [Osgood *et al*, 1971] for the evaluation of computer controls. *Functionality, strength* and *practicality* are identified as the three factors underlying auditor judgements from a factor analysis of responses to the semantic differential instrument developed in the study.

The remainder of this paper proceeds as follows. The next section presents the psychological basis for the measure of control effectiveness developed in the paper. The third sections details the development of the test instrument, the subjects, and the procedures followed. Section four describes the methods of analysis and the results for the factor analysis and reliability tests. The final section provides a summary of the findings of the paper.

PSYCHOLOGICAL BASIS

An auditor's interest is in the effectiveness of controls and how to evaluate that effectiveness. Osgood *et al* [1971] and Kelly [1965] proposed that people make all such judgments through a series of cognitive filters. The filters, also called factors, represent the dimensions of the attribute of the things being judged. In this case the attribute, whose factors are of concern, is a control's effectiveness.

Each factor is like a cognitive force that combines to make a vector of effectiveness analogous to a vector of force in physics. One factor expected to influence auditors' evaluations of effectiveness is the strength of the control. However, Osgood's theory suggests that human evaluations of a complex attribute, such as a control's effectiveness, involves multiple factors. Using one factor in assessing a controls effectiveness may result in misleading results. For example, a control that is *strong* (high on the strength factor) but *impractical* (low on the practicality factor) is less effective than a control that is both strong and practical. Evaluating controls on just the strength factor may result in invalid conclusions or the development of spurious relationships.

If the factors used in audit control judgments can be identified, they may be used to develop an empirical measure for use in research and practice. Such judgments are represented by a postulated psychological space [Torgenson, 1967, p. 250]. In representing this space, Osgood *et al.* [1971] and others[4] assume that the factors involved in judgments are independent (orthogonal). Thus, they may be represented as axes in Euclidian space. Figure 1 shows an example of the Euclidian model of judgments involving three factors: x_1, x_2, and x_3. Each axis in the figure represents one of the factors involved in making some judgment. V_1 is the judgmental vector that results from the influence of the factors. Averaging the ratings an individual makes on any one set of scales gives the score for a given axis. In Figure 1, these scores are a_1, a_2, and a_3 - the scores on factors (axes) x_1, x_2, and x_3 respectively.

Insert FIGURE 1 Here

Other spatial models of evaluation, like Attneave's [1950] 'City Block Model', use a linear combination of factors rather than a Euclidian distance measure. These models may be suitable in some contexts, but a substantial psychological literature supports a Euclidean-space model [see Torgenson, 1967].

Osgood's semantic differential has been used widely to identify the cognitive structure and the measurement of differences in meaning for a variety of constructs. It seems robust across cultural boundaries when compared to Likert scales or Stapel Scales [Menzies and Elbert, 1979]. However, the semantic differential does not attempt to determine all the attributes (and therefore all the factors) relating to a thing being judged. For example, auditors could be given the task to evaluate sets of statements representing controls with varying functions present. The theory posed by Osgood *et al.* [1971] suggests that the auditors will ignore irrelevant attributes of the control statements such as the number of words, letters, vowels, or consonants. Instead, they

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4 Kelly's [1965] repertory grid also assumes that the use of cognitive factors affects the judgmental processes of individuals and that these factors are orthogonal. Torgenson [1967] provides a thorough discussion of these issues.

will respond to the underlying phenomena that the statements represent (in this case controls).

Accounting and information systems research also recognizes that people make judgments on multiple factors represented as points in Euclidean space [Houghton, 1988; McNamara, 1982; Flamholtz and Cook, 1978; Haried, 1972, 1973; Oliver, 1974]. This prior research has presented conflicting findings about the number of factors that are employed in accounting judgements. However, the varying results have often been the product of the incorrect application of the statistical procedures for identifying the number of factors. While there is no theoretical limit to the number of factors involved in a judgment, Osgood's research suggests three such factors for general judgments[5]. These factors are an evaluative factor, a potency factor, and an activity factor. However, evidence also suggests that the general factors cannot be applied to specialist areas of judgment [Osgood *et al.*, 1971, p. 54]. Thus, the factors used by auditors to evaluate controls need to be identified before using a semantic differential in audit judgement research.

If auditors' judgments are multidimensional, research designs must recognize the need for multidimensional measures of those judgments. Two criteria guide the application of the semantic differential to a specialized area such as internal controls. First, the semantic differential must be tailored to the specific domain of internal controls. Second, factor simplicity and clarity must be pursued in the analysis. Prior accounting and information systems studies employing semantic differentials have had varying success in relation to these standards. Oliver [1974] failed to meet the first criterion. Haried [1972, 1973] and Flamholtz and Cook [1978] used the semantic differential in their research but did not meet the second criterion. Haried's research concluded that the semantic differential is not a useful metric for accounting measurements. Bagranoff [1990, p. 75] suggests that this conclusion in conjunction with a lack of understanding have contributed to the low frequency of semantic analysis studies in accounting. However, Houghton [1988] showed that by meeting the second criterion, simplicity and clarity, the semantic differential is a useful measure of the meaning of accounting concepts. Further, the semantic differential's usefulness, validity, reliability and

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5 A literature search based on the Social Science Citation Index revealed in excess of 5000 uses of the semantic differential from 1975 to 1980. All of the psychological research identified in this literature search found or used three factors regardless of the domain of interest.

effectiveness in other settings and in other countries [Bagranoff, 1990] suggests it is also suitable for audit research.

A SEMANTIC DIFFERENTIAL MEASURE OF EFFECTIVENESS

The development of a semantic differential proceeds in three phases. In the first phase, the researcher develops a set of bipolar scales. These scales represent the attributes auditors perceive in their evaluation of controls. In the audit context, an attribute refers to a particular property of a control. A common attribute discussed in the literature is the strength or weakness of a control. Thus, one bipolar scale might be the *strength - weakness* of a control. We would expect controls to have multiple attributes. The attributes may be grouped into factors that are the underlying determinants of audit judgments. Accordingly, it is essential to identify all attributes in the first phase of the semantic differential's development. In the second phase, the scales are reduced to parsimonious and orthogonal sets. These sets of scales are the factors auditors use in their evaluations. In the third phase, the researcher assesses the reliability of the scales identified with each factor.

Phase One: Bipolar Scales for Control Attributes

In the current study, bipolar scales were developed using a procedure devised by Triandis [1959]. This procedure involved six subjects. All were expert EDP auditors working for the internal audit departments of major financial corporations in the Australian State of Queensland. Each auditor had at least four years EDP audit experience.

Subjects were presented with three computer controls (a triad). Their task was to classify the controls such that two controls were similar in some way and different from the third control. To elicit the bipolar adjectives, the subjects were asked a series of questions as prescribed by Stewart and Stewart [1981]. The questions centred on how the computer controls in a pair were similar to each other but at the same time were different from the third control. The responses were tape recorded, and bipolar adjectives were thus obtained. The triads were drawn from nine controls and these concepts represented the five-control categories used by Weber [1980]. Table 1 shows the nine controls and their presentation order. The responses to each triad produced a series of bipolar adjectives. This stage of the semantic differential's development was concluded when no new adjectives were elicited from new subjects.

Insert TABLE 1 Here

Phase Two: Identification Control Evaluation Factors

The semantic differential theory proposes that the bipolar adjectives are the product of some underlying factors. To discover these factors, the bipolar adjectives are used to assess a number of computer control concepts. If common factors affect these judgments, then scores on the adjectives reflecting the same factor should be correlated. Factor analysis was used on the correlations to cluster adjectives into their respective factors.

Subjects for this stage of the analysis consisted of 167 individuals who had completed at least one undergraduate course in auditing. The subjects judged four separate EDP control concepts on each of 23 bipolar scales identified in the first phase. Table 2 shows the 23 bipolar scales. The test instrument presents each pole of the scale separated by a seven-point continuum. Appendix A contains the test booklet for the development of the factors.

Insert TABLE 2 Here

The matrix of judgments was factor-analyzed to classify the scales according to the factors they represent. A PA1 factor analysis with a varimax rotation determined the factors that were extracted and rotated according to the scree test [Kim and Mueller, 1978]. Each subject's scores were averaged across concepts for analysis. A separate analysis of each control concept was performed to ensure a common set of factors was obtained across all control concepts.

Phase Three: Reliability of Scales

The third phase determines the reliability of each set of scales identified in phase two. The reliability of an instrument is the degree to which the same scores can be reproduced when the same measuring instrument is rated repeatedly. The conventional notion of reliability in psychological measurement focuses on how consistently individuals score successive applications of a scale. Cronbach's Alpha is the most common measure of reliability used to validate factors. It is the maximum likelihood estimate of the reliability coefficient based on inter-item correlations [SPSSX, 1979, p. 125]. Assessing the reliability of a factor proceeds in the same manner as the factor development. Subjects judge a number of controls on sets of scales. The scales represent the factors, the reliability of which is to be tested.

In this research, the scales representing the factors found in phase two were tested for reliability over four control concepts. These concepts were the same as those used in phase two. Fifteen expert EDP auditors, identified by the partners of two chartered accounting firms, were the subjects for the reliability tests. These subjects were not used in any previous phases of the study.

Subjects and Procedures

The first stage to develop a semantic differential to measure auditors' judgments of control configurations involved eliciting 23 bipolar adjectives from expert EDP auditors. These were obtained from when the auditors sorted controls presented in triads. The 23 adjectives were then presented as a set of seven-point bipolar scales for use in judging four control concepts. The subjects' scores on these scales were analyzed to develop a parsimonious set of scales that represent the factors underlying auditor judgments. The following is a summary of the procedures used to develop these factors:

1. 167 subjects, all trained in audit, assessed four controls on 23 scales;
2. The raw data was initially summed across controls and presented as a matrix of scales by average control scores;
3. Correlated variables were grouped together as factors by successively reducing the dimensionality of the space. Factor analysis was used for this purpose; and
4. The factors derived from the summation procedures were confirmed by an analysis of individual control judgments.

Figure 2 gives a diagrammatic representation of the data collected for factor analysis. Each cell represents a judgment of one control by one subject on one scale. The combination of controls, scales, and subjects gave a 4 x 23 x 167 data matrix for analysis.

Insert FIGURE 2 Here

Each subject provided a set of 23 judgments on four controls. This procedure gave 668 responses to each scale with each of the 167 subjects responding once to each of the four controls.

ANALYSIS AND RESULTS

Because factor analysis works on the variability in the data, any variables with a standard deviation of less than one would distort the underlying factor structure [Rummel, 1970; Childs, 1978]. Hence, before factor analyzing the data matrix, "frequencies" were calculated. A scale with consensus judgment (a standard deviation less than one) is important to control evaluations but must be eliminated from the scale-development procedures. Such a scale would be one where every auditor believed it to be an equally meaningful description of the concept being judged. However, it would exhibit no variability as a data scale. Thus a scale with complete consensus would not be captured in any analysis that works on correlations. None of the scales were found to have a standard deviation less than one.

The matrix of data obtained from the test booklet may be factor analyzed in a number of ways depending on the purpose of the analysis [Muthen *et al.*, 1977]. Whatever the purpose, normal factor analysis techniques cannot accommodate three-dimensional data as represented in Figure 2[6]. Accordingly, the data matrix may be analyzed one slice at a time (in this case, one control at a time) which would give four sets of 23 scales by 167 subjects. Alternatively, the matrix may be collapsed into two dimensions by summing across scales or by summing across controls [Muthen et al., 1977].

Summing across the four controls gives a reduced data set comprising an average scale score for each subject. This reduced data set, when factor analyzed, would cluster scales in sets that represent the factors influencing control judgments. Such an analysis should be supported by evaluating the judgments on individual controls to determine the stability of the factors. The second method of collapsing the data into two dimensions is to sum across scales. Summing across the 23 scales gives a reduced data

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6 Tucker [1966] developed a three-mode factor analysis technique to analyze all modes of variation in a data set - variation among concepts, among scales, and among subjects. The three-mode technique is rarely used due to the difficulty found in interpreting the results [Levin, 1955; Tucker, 1966].

set comprising four total control scores per subject. Analyzing this data set determines the number of classes of controls that may exist. Only one class of controls was expected, namely, computer controls. If more than one class of controls existed, the factors affecting judgments could vary between these classes of controls.

Factor Analysis - Summation Across Controls

To obtain factors underlying the auditors' evaluation of controls, the data set was summed across controls to obtain an average score on each scale. For example, each auditor scored each of four controls on the scale "necessary - unnecessary." These four scores were averaged to give one value for the "necessary - unnecessary" scale. The procedure was repeated for each of the 23 scales for each subject. The average scores of the 167 subjects for each scale gave a 23 x 23 Pearson's product-moment correlation matrix which is summarised in Table 3.

Insert TABLE 3 Here

Using the correlation matrix, communality estimates were produced for the factor analysis of the auditors' judgments. The communality of a variable, in this case a bipolar scale, is that portion of its variance common to the factors. A scale with a communality of 0.70 would have 70 per cent of its variance in common with the other scales whose scores are influenced by the same factor. The corollary is that 30 per cent of its variance is unique.

Communality estimates can have a significant effect on the factor patterns that emerge where the off-diagonal correlations of the correlation matrix is small and/or where the number of variables is small. Researchers use one of two approaches to communality estimation. The first approach assumes the communality estimate is one. This approach implies that the factors underlying audit judgments account for all the variance in those judgments. Rummel [1970] cautions against the use of the first approach where the number of variables (scales) is less than 70. In such cases, a communality estimate of one may give a factor structure that does not accord with the *true* factor structure[7].

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7 These findings result from various simulation studies such as those conducted by Francis [1972].

As the number of scales in this research is 23, the first approach is inappropriate according to Rummel [1970]. The second approach uses a process of refactoring until the estimated communality converges on a stable value. The essence of this approach is for the program to estimate a starting value for the communality and then proceed to adjust the communality estimate after each iteration. This approach produces the best approximation of the communality in the data set. The second approach was used in this research producing reasonable communality estimates (above 0.30).

The initial unrotated factor matrix was then obtained and is shown in Table 4. This matrix must be rotated to give a parsimonious set of scales. Before rotating the factor matrix, the researcher must choose the number of factors to extract based on the initial factor matrix. The number of factors extracted and rotated is always a matter of judgment. Kim and Mueller [1978] provide a summary of the various approaches and rules of thumb that have been developed to aid researchers in factor extraction. Of these various methods, the Scree Test combined with interpretability appears to be the most reliable technique. Scree is a geographical term for the debris that collects at the foot of a slope. The test requires the eigenvalues to be graphed with factors extracted up to the point where the graph begins to level off. Figure 3 shows the Scree Test for this analysis.

Insert TABLE 4 Here

Insert FIGURE 3 Here

The elbows in Figure 3 indicate possible points for terminating the number of factors rotated. The slight elbows at factors two and three suggest that the desired structure may be two-to-three factors. Three factors were extracted for rotation. Francis [1972] shows that the rotation of too few factors can significantly distort the factor analysis results such that they bear no relation to the underlying pattern. Rummel [1970] canvasses the debate on the number of factors to be rotated. He concludes that it is preferable to rotate too many factors rather than too few, although the matter is far from settled [Rummel, 1970; Childs, 1978].

In addition to the three factor solution a four-factor rotation was also performed. Other semantic differential studies show a stable three-factor structure for psychological phenomena [Tzeng, 1976], with researchers extracting three and four factors and selecting the most interpretable structure. Appendix B shows the varimax three-factor and four-factor rotations.

Tables 5 and 6 show the scales with major loadings (greater than 0.40) for the three-factor and four-factor rotations. The complete factor matrices are found in Appendix B. Where a scale loads on multiple factors, it is normal to exclude it from the factors on which it loads. Accordingly, such scales were excluded from the tables.

Insert TABLE 5 Here

Insert TABLE 6 Here

The number of factors rotated has a definite effect on the way in which variables load on the various factors, as can be seen by comparing Table 5 with Table 6. Because of interpretability, three factors were selected for the final phase of the scale development. The three factors were tentatively labelled as follows:

Factor 1	Functionality
Factor 2	Strength
Factor 3	Practicality

Naming factors is always a matter of personal judgment. However, the choice of name given to a factor should reflect the scales comprising that factor as well as possessing meaning for the domain in question. For the control domain, the strength factor has significant support in the literature. The functionality and practicality factors have some intuitive appeal. Auditors want a control that does the job. That is, the control should be functional. Furthermore, the control must be capable of implementation, that is, it should be practical.

A second issue in selecting the number of factors to represent judgments is the amount of variance they explain. The three-factor pattern accounted for 48 per cent of the total variance, while the four-factor pattern added an additional seven per cent. In both cases, the first factor accounted for 25 per cent of the common variance. Table 5 shows the amount of variance explained by each factor in the three-factor structure. In more general domains of meaning, such as those examined by Osgood *et al.* [1971], the amount of total variance explained is approximately 30 per cent. Haried [1973] and

Houghton [1988] found approximately 45 per cent of variance explained by their factors. Thus, the results of this study compare favourably with other research.

Factor Analysis - Individual Controls

The three factors extracted must be stable across a range of computer controls for the measure to be useful. Accordingly, an analysis of subject scores on each of four controls was performed. The varimax-rotated factor matrix for each of the four controls involved in the study can be found in Appendix C. This appendix shows both a three-factor and four-factor pattern for each control. While some multifactoriality in the scales existed, the majority of scales for most of the controls displayed "clean" factor loadings. Scales that loaded on similar factors for the analysis of each of the four individual controls, as well as on the collapsed data set, were selected as stable for reliability analysis. Table 7 shows the three stable factors together with their representative scales.

Insert TABLE 7 Here

Factor Analysis - Summation Across Scales

A further test of the validity of the three factors was made by analyzing the subjects' scores summed across scales. Each subject's score was averaged on each set of 23 scales they rated. Thus for each subject there are four scores, one for each control. If subjects lacked consensus in the meaning of the controls chosen or the controls were not part of the computer control domain, then more than one factor should result from factor analyzing this reduced data set.

Only those factors with eigenvalues greater than one were extracted. With this approach, other significant factors may have been overlooked due to the use of this arbitrary cut off. Rather than refactor with a lower eigenvalue criterion, Lawley's Modification of Bartlett's Test for Sphericity [Thorndike and Hagen, 1978, p. 281] was applied. This test assumes that the remaining residual vectors should cluster randomly in a sphere around the origin if all factors are first extracted. The test is a Chi-square test. Using this test, no significant additional factors were present at the 0.05 level.

Scale Reliability

The next stage in the instrument development process involved testing the reliability of the adjectives comprising each of the three factors identified in phase two. The reliability-test data comprised the judgments of 14 expert auditors on the bipolar scales identified in the factor analysis phase. For each factor, the reliability of the scales was made over four separate controls - password (access), batch (input), edit (processing), and database (output).

Reliability was assessed using Cronbach's alpha and standardized alpha. The SPSSX [1987] statistical package was used to estimate these measures. Cronbach's alpha for the *functionality* factor was 0.87, with a standardized alpha of 0.89. Scales are usually accepted for use in basic research applications where the factor-scale has a Cronbach's alpha of 0.70 or greater [Nunnally, 1967, p. 226]. The alpha for the *strength* factor was 0.78, and the standardized alpha was 0.79. The analysis of the *practicality* factor gave a Cronbach's alpha of 0.76, and the standardized item alpha equalled 0.79. The alpha level has to be read with regard to the overall sample size available. If the sample was to be expanded, a higher alpha would be expected. Table 8 shows the three sets of bipolar scales with proven reliability. The scales representing each factor display consistent correlations in their applications.

Insert TABLE 8 Here

CONCLUSIONS

This study set out to develop a semantic differential scale that could be used to evaluate the effectiveness of EDP controls. A set of 23 bipolar adjectives were elicited from EDP auditors when they sorted controls presented in triads. These adjectives were then presented to 167 auditors as a set of seven-point bipolar scales for use in judging four control concepts. The subjects' scores on these scales were analyzed to develop a parsimonious set of scales that represent the factors underlying auditor judgments.

The constructs elicited in the first phase of the research reveal some interesting information about how expert auditors view controls. For example, scales such as 'effective - less effective' are not dictionary opposites. However, "A construct is not necessarily composed of a phrase and its semantic opposite; it is a contrast but not a simple dictionary opposite" [Stewart and Stewart, 1981 p. 17]. The bipolar constructs provide a discipline to understanding by putting words into their context. In the context of EDP controls, the contrast to an effective control is a less effective control. By definition, a control is something that reduces the probability of unlawful events -

something that does not achieve this objective is not a control. Experts naturally think of a control as making some contribution, however small. Thus, experts judge controls on their degree of effectiveness rather than being effective or ineffective. The fact that effective and less effective were elicited as a construct is a positive sign for the adequacy of the mapping of semantic space. It indicates that the constructs generated in stage one of the analysis are relevant to the computer control domain.

Functionality, *strength* and *practicality* were the labels assigned to the three factors that emerged from the factor analysis. These factors were found to be robust to the procedures employed to reduce the data for use in the factor analysis. In addition, the Cronbach alphas for each factor indicated that the scales are reliable for a hold-out set of respondents.

The labelling of these scales is somewhat arbitrary, however the labels do accord with some of the internal control literature. The *strength* dimension has significant support with most researchers and practitioners referring to the need for auditors to assess the strength and weakness of a control. The scales representing this factor include powerful, unrestricted, and cost. These scales all denote a notion of strength. The strength factor is similar to the potency dimension identified in Osgood's research, although the specific scales differ.

The *functionality* dimension is similar to the relevance dimension identified in Osgood's research. Here the scales include the effectiveness, reliability, comprehensiveness, preciseness, and the confidence provided by the control. The audit literature does not normally refer to the functionality of a control. This is perhaps because it is assumed in the literature that the controls that are considered are functional. That is, they achieve their purpose. The *practicality* factor is the control domain's equivalent of the activity factor. The practicality factor has some currency in the applied literature. Practitioners are always exhorting researchers and theorists to consider the practical consequences of control implementation.

Knowing the factors used to evaluate controls may improve our ability to educate students. Osgood *et al.* [1971] suggest that such factors may be used to reduce any ambiguity in meaning between individuals. For example, suppose two individuals differ in their evaluation of a control because of their perception of its *functionality*. In this case the educator can concentrate on those issues that affect the control's functionality. If educators know what factors are important to a control in a given situation, they can help students understand the key issues and thus change the students' perceptions of what factors an effective control should possess.

Further, the scales developed in this study may be used to measure the effectiveness of controls in both the experimental and practical situations. The procedures used to assess the reliability of the semantic differential instrument comply with generally accepted methods [Carmines and Zeller, 1979]. The value of alpha reported in any research is a lower bound to an unweighted scale. That is, it is a conservative estimate of the true reliability of an instrument [Novick and Lewis, 1967]. Thus, the semantic differential instrument used in this research may be considered reliable for its purpose.

However, before it can be used in other research situations, it needs further validation. Carmines and Zeller [1979, p. 51] argue that an alpha of .80 is required if a set of scales, such as the semantic differential, is to be widely used. To obtain more reliable scales, items may need to be added to the strength and practicality scales. When these limitations are met, the semantic differential scale developed in this study will be of interest to other auditing researchers interested in measuring judgements on the effectiveness of an EDP control. The euclidean distance formula can then be used to assess competing control situations.

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FIGURE 1: EUCLIDEAN MODEL OF JUDGMENTS

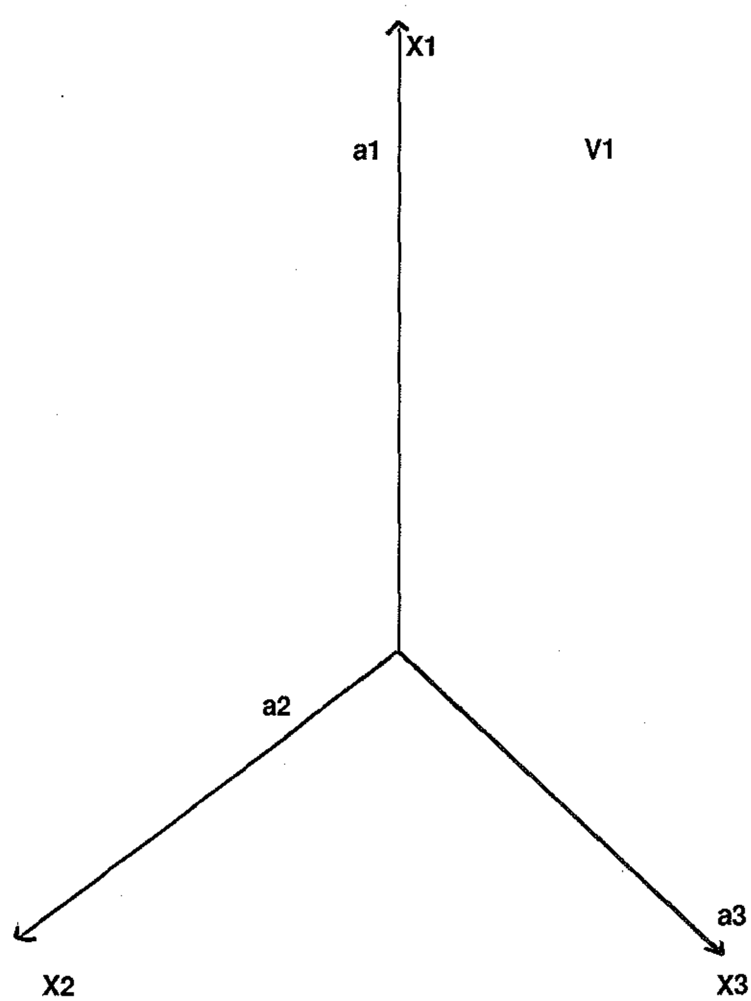

FIGURE 2: JUDGMENTS ON SEMANTIC SCALES

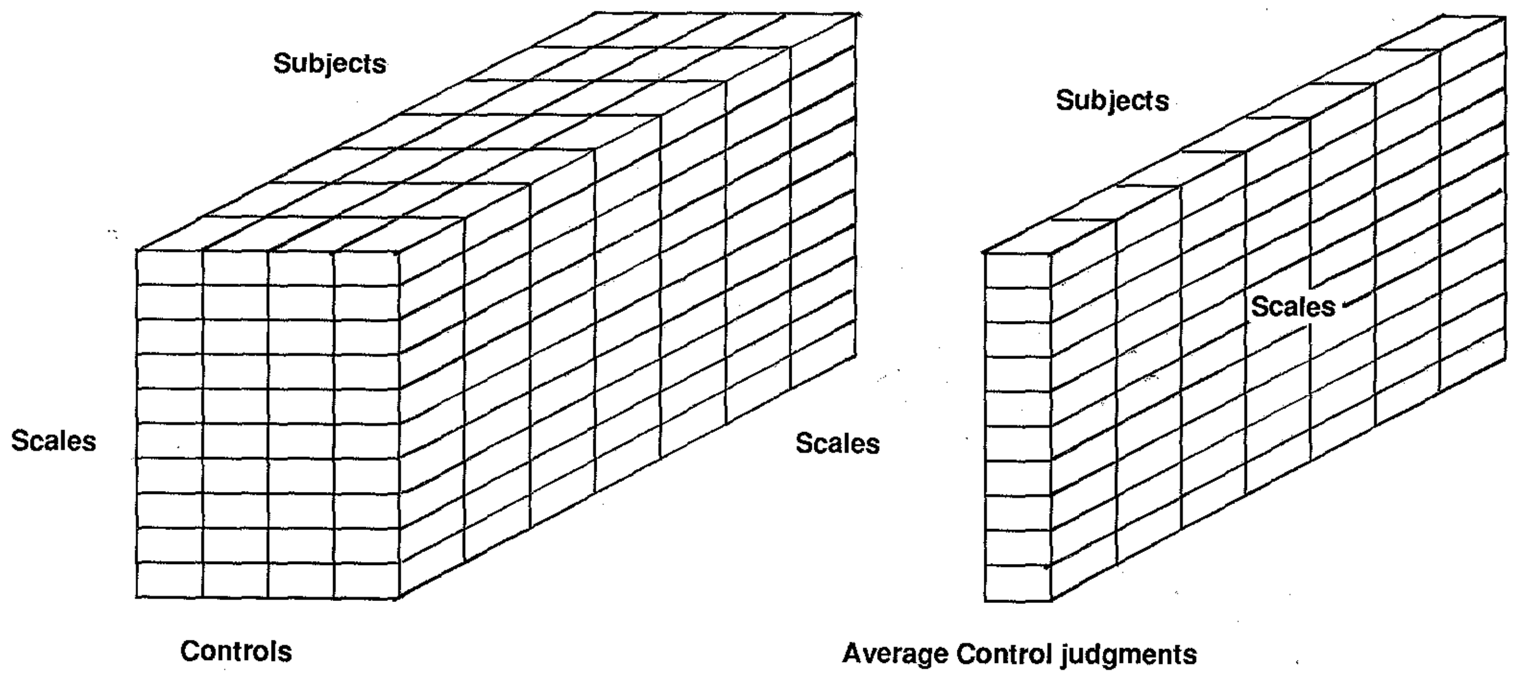

FIGURE 3: SCREE TEST

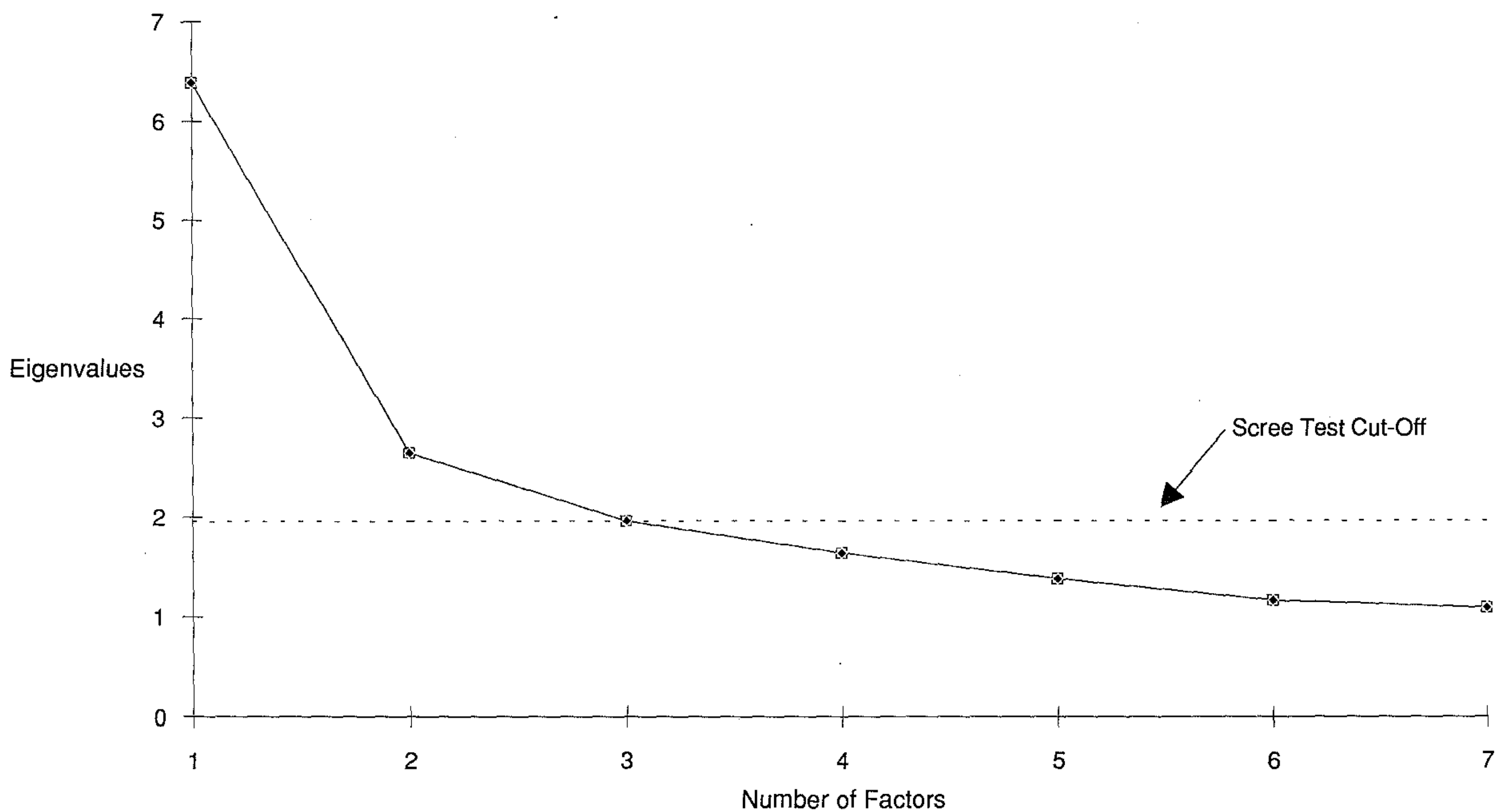

TABLE 1: CONTROL CONCEPTS FOR SCALE DEVELOPMENT & PRESENTATION ORDER

PANEL A: CONTROL CONCEPTS

Control Number	Control Description
1)	Password
2)	Batch Control
3)	Programmed Field Check
4)	File Label Verification
5)	Run-to-Run Reconciliations
6)	Output Report Standards
7)	Feasibility Study for Systems
8)	Program Documentation Standards
9)	Transaction File Back-up

PANEL B: PRESENTATION ORDER

	Pres. 1	Pres. 2	Pres. 3
Controls	1, 2, 3	1, 4, 7	1, 5, 9
	Pres.4	Pres.5	Pres. 6
Controls	4, 5, 6	2, 5, 8	2, 6, 7
	Pres. 7	Pres. 8	Pres. 9
Controls	7, 8, 9	3, 6, 9	3, 4, 8

TABLE 2: BIPOLAR ADJECTIVES - CONTROL ATTRIBUTES

Variable Number	Pole One Adjectives	Pole Two Adjectives
1	effective	less effective
2	general	specific
3	weak	powerful
4	asset safeguarding and & data integrity	effectiveness and efficiency
5	gives confidence	gives less confidence
6	unreliable	reliable
7	restricted	unrestricted
8	necessary	not necessary
9	useless	important
10	precise	less precise
11	not comprehensive	comprehensive
12	difficult to test	easy to test
13	confident it works	less confident it works
14	applications	environment
15	acts earlier	acts later
16	does not compensate for weakness	does compensate for weakness
17	common	unusual
18	detection	hygiene
19	useful	less useful
20	acceptable losses	unacceptable losses
21	immediate impact	not an immediate impact
22	costly to implement	more costly to implement
23	tangible to error detection	less tangible to error detection

TABLE 3: PEARSON CORRELATION MATRIX FOR AVERAGE CONTROL SCORES

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23
V1	1.00																						
V2	-0.21	1.00																					
V3	-0.20	0.36	1.00																				
V4	0.25	-0.07	0.01	1.00																			
V5	0.55	-0.23	-0.14	0.42	1.00																		
V6	-0.56	0.23	0.27	-0.24	-0.59	1.00																	
V7	0.23	-0.05	0.30	0.20	0.34	-0.20	1.00																
V8	0.58	-0.18	-0.19	0.36	0.51	-0.52	0.32	1.00															
V9	-0.60	0.28	0.25	-0.30	-0.49	0.62	-0.26	-0.79	1.00														
V10	0.50	-0.19	-0.14	0.07	0.43	-0.47	0.32	0.58	-0.61	1.00													
V11	-0.39	0.14	0.27	0.09	-0.33	0.44	-0.08	-0.20	0.31	-0.48	1.00												
V12	-0.24	0.21	0.21	-0.18	-0.24	0.30	-0.01	-0.22	0.26	-0.16	0.11	1.00											
V13	0.51	-0.11	-0.09	0.24	0.57	-0.53	0.30	0.48	-0.52	0.49	-0.35	-0.46	1.00										
V14	0.30	-0.16	-0.10	0.26	0.27	-0.25	-0.12	0.32	-0.30	0.27	-0.05	-0.30	0.31	1.00									
V15	0.34	-0.21	-0.17	0.30	0.36	-0.31	0.10	0.36	-0.40	0.17	-0.12	-0.43	0.44	0.32	1.00								
V16	-0.14	0.20	0.29	-0.32	-0.30	0.30	0.04	-0.12	0.18	-0.11	0.14	0.28	-0.23	-0.26	-0.19	1.00							
V17	0.42	-0.24	-0.37	0.40	0.47	-0.43	0.10	0.60	-0.55	0.29	-0.17	-0.38	0.40	0.18	0.49	-0.24	1.00						
V18	0.43	-0.33	-0.10	0.12	0.26	-0.38	0.06	0.31	-0.31	0.34	-0.22	-0.28	0.38	0.39	0.39	-0.09	0.30	1.00					
V19	0.60	-0.17	-0.23	0.31	0.56	-0.64	0.25	0.76	-0.76	0.64	-0.36	-0.24	0.53	0.34	0.39	-0.24	0.63	0.34	1.00				
V20	0.01	0.21	0.07	-0.21	-0.02	0.00	0.05	-0.09	0.15	-0.09	0.04	0.10	-0.05	-0.12	-0.14	0.13	-0.18	-0.06	-0.09	1.00			
V21	0.45	-0.24	-0.28	0.13	0.35	-0.40	0.11	0.34	-0.40	0.40	-0.31	-0.34	0.43	0.27	0.50	-0.26	0.42	0.30	0.44	0.03	1.00		
V22	0.09	0.09	0.09	0.12	0.15	-0.08	0.17	0.23	-0.17	0.08	0.09	-0.13	0.30	0.09	0.16	0.13	0.20	0.16	0.22	-0.05	0.12	1.00	
V23	0.29	-0.02	0.10	0.07	0.37	-0.28	0.34	0.37	-0.34	0.46	-0.16	-0.23	0.42	0.25	0.13	-0.07	0.18	0.30	0.35	0.06	0.25	0.24	1.00

NUMBER OF OBSERVATIONS: 167

TABLE 4: COMPONENT LOADINGS - UNROTATED FACTOR MATRIX

VARIABLES	BIPOLAR ADJECTIVES		FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
MEAN(8)	necessary	- not necessary	0.805	0.096	0.147	-0.219
MEAN(9)	useless	- important	-0.793	-0.124	0.017	0.247
MEAN(1)	effective	- less effective	0.760	0.214	-0.013	-0.094
MEAN(5)	gives confidence	- gives less confidence	0.750	0.346	0.125	0.030
MEAN(13)	confident it works	- less confident it works	0.719	0.295	-0.082	0.304
MEAN(17)	common	- unusual	0.716	0.093	0.066	0.186
MEAN(6)	unreliable	- reliable	-0.702	-0.230	0.344	0.108
MEAN(10)	precise	- less precise	0.661	0.208	-0.188	-0.310
MEAN(15)	acts earlier	- acts later	0.564	-0.149	0.270	0.423
MEAN(19)	useful	- less useful	0.193	-0.631	-0.040	-0.249
MEAN(21)	immediate impact	- not an immediate impact	0.013	0.617	-0.275	0.159
MEAN(23)	tangible to error detection	not tangible to error detection	0.359	-0.583	0.099	-0.350
MEAN(3)	weak	- strong	-0.331	0.511	0.480	0.007
MEAN(7)	restricted	- unrestricted	0.235	0.414	0.614	-0.280
MEAN(4)	asset safeguarding & data integrity	- effectiveness & efficiency	0.459	0.020	0.596	0.110
MEAN(11)	not comprehensive	- comprehensive	-0.415	-0.094	0.555	0.293
MEAN(12)	difficult to test	- easy to test	-0.374	0.175	0.142	-0.593
MEAN(22)	costly to implement	- more costly to implement	0.417	-0.332	0.160	0.431
MEAN(16)	does not compensate for weaknesses	- does compensate for weaknesses	-0.336	0.287	0.131	-0.277
MEAN(18)	detection	- hygiene	-0.446	0.340	-0.198	0.182
MEAN(20)	acceptable losses	- unacceptable losses	-0.251	0.486	-0.352	0.170
MEAN(14)	applications	- environment	0.486	-0.298	-0.244	0.159
MEAN(2)	general	- specific	-0.226	0.122	0.196	0.113
	PERCENT OF TOTAL VARIANCE EXPLAINED		27.756	11.494	8.511	7.098
	EIGENVALUES (LATENT ROOTS)		6.38	2.64	1.95	1.63

TABLE 5: THREE-FACTOR STRUCTURE

Variable Number	SCALES	FACTOR 1	FACTOR 2	FACTOR 3	
5	Confidence	0.831			
1	Effective	0.778			
8	Necessary	0.775			
13	Works	0.772			
9	Important	-0.769			
6	Reliable	-0.717			
17	Common	0.689			
10	Precise	0.678			
20	Acceptable losses		-0.649		
23	Tangible to error		0.639		
21	Immediate impact		-0.622		
19	Useful		0.551		
18	Detection		-0.525		
22	Costly to implement		0.489		
3	Powerful			0.718	
7	Unrestricted			0.655	
11	Comprehensive			0.544	
14	Applications			-0.459	
4	Safeguarding			0.415	
16	Compensates			0.319	
					Total
	PERCENT OF TOTAL VARIANCE EXPLAINED	24.779	12.774	10.209	47.762

TABLE 6 : FOUR-FACTOR STRUCTURE

Variable Number	SCALES	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	
9	Important	-0.805				
8	Necessary	0.774				
10	Precise	0.770				
6	Reliable	-0.767				
1	Effective	0.762				
5	Confidence	0.745				
13	Works	0.635				
17	Common	0.573				
11	Comprehensive	-0.560				
23	Tangible to error		0.738			
21	Immediate impact		-0.651			
20	Acceptable losses		-0.644			
19	Useful		0.644			
18	Detection		-0.529			
7	Unrestricted			0.711		
3	Powerful			0.643		
4	Safeguarding			0.556		
12	Easy to test				-0.706	
15	Acts earlier				0.680	
22	Costly to implement				0.659	
16	Compensates				-0.456	
14	Applications				0.420	
	PERCENT OF TOTAL VARIANCE EXPLAINED	27.756	11.494	8.511	7.098	Total 54.859

TABLE 7: BIPOLAR SCALES LOADING ON INDIVIDUAL CONTROLS

Factor, Variable and Scale	CONTROL CONCEPTS			
	PASSWORD	BATCH	EDIT	DATABASE
FUNCTIONALITY				
1 effective	0.730	0.593	0.450	0.578
6 reliable	-0.662	0.450	0.726	0.631
10 precise	0.579	0.659	0.473	0.537
11 comprehensive	-0.536	0.612	-	0.504
13 confident it works	0.497	0.469	0.619	-
STRENGTH				
3 powerful	-0.478	0.735	0.635	0.663
7 unrestricted	-0.685	0.736	0.542	-
14 applications	0.704	0.478	0.518	0.626
22 costly to implement	-	0.525	0.435	0.526
PRACTICALITY				
4 asset safeguarding & data integrity	0.692	-	0.567	0.617
5 gives confidence	0.510	0.499	0.578	0.654
8 necessary	0.528	0.747	-	0.789
12 easy to test	-0.405	0.639	0.537	0.555
17 common	0.628	0.553	-	0.650

TABLE 8: RELIABILITY-TESTED SCALES

FACTOR 1	FACTOR 2	FACTOR 3
FUNCTIONALITY	*STRENGTH*	*PRACTICALITY*
effective reliable precise comprehensive confident it works	powerful unrestricted applications costly to implement	asset safeguarding & data integrity gives confidence necessary easy to test common
Alpha = 0.87	Alpha = 0.79	Alpha = 0.76

APPENDIX A

RESEARCH BOOKLET
COMPUTER CONTROL CONSTRUCTS

NAME:..

OCCUPATION:..............................

The purpose of this study is to determine the constructs used when evaluating computer controls. This is achieved by having people judge selected computer control concepts on a series of descriptive scales. There is no right or wrong answer to anything contained in this booklet. What is important is **YOUR JUDGMENT** of the controls presented.

On the next page are the directions on how to complete the research booklet. Following that, you will find a page for each control to be assessed. The control is centred at the top of the page and is presented in bold capital letters. Beneath the control are a set of scales to be used in assessing the control. You are to do each page of the booklet in order. Please turn to the directions.

HERE IS HOW YOU ARE TO USE THE SCALES:

If you feel the control at the top of the page is **VERY CLOSELY RELATED** to one end of the scale, you should circle the number **1** or the number **7** as appropriate. e.g.

PASSWORD

general : 1 : 2 : 3 : 4 : 5 : 6 : 7 : specific
OR
general : 1 : 2 : 3 : 4 : 5 : 6 : 7 : specific

If you feel the control is **QUITE CLOSELY RELATED** to one or the other end of the scale, you should circle the number **2** or the number **6** as appropriate. e.g.

BATCH CONTROL

necessary : 1 : 2 : 3 : 4 : 5 : 6 : 7 : Unnecessary
OR
necessary : 1 : 2 : 3 : 4 : 5 : 6 : 7 : Unnecessary

If the control seems **SLIGHTLY RELATED** to one side as opposed to the other, you should circle the number **3** or the number **5** as appropriate. e.g.

FILE LABEL CHECK

strong : 1 : 2 : 3 : 4 : 5 : 6 : 7 : weak
OR
strong : 1 : 2 : 3 : 4 : 5 : 6 : 7 : weak

The number you circle depends upon which of the two ends of the scale seems most characteristic of the control you are judging. If you consider the concept to be **NEUTRAL** on the scale, both sides of the scale equally associated with the control, or if the scale is **COMPLETELY IRRELEVANT** or **UNRELATED** to the control, you should place a circle around the number **4** as follows:

PROGRAMMED EDIT CHECK

dynamic: 1 : 2 : 3 : 4 : 5 : 6 : 7 : weak

BE SURE TO:

1. Circle a number on every scale - **Do not omit any.**
2. Never put more than one circle on any scale.
3. Do not look back and forth - **Assess each control independently.**
4. Work quickly - **Immediate reactions are needed; do not deliberate.**

It is your first impressions that are important in this research.

NOW COMPLETE THE RESEARCH BOOKLET

APPLICATIONS PASSWORD CONTROL

effective	1	2	3	4	5	6	7	less effective
general	1	2	3	4	5	6	7	specific
weak	1	2	3	4	5	6	7	powerful
asset safeguarding & data integrity	1	2	3	4	5	6	7	effectiveness & efficiency
gives confidence	1	2	3	4	5	6	7	gives less confidence
unreliable	1	2	3	4	5	6	7	reliable
restricted	1	2	3	4	5	6	7	unrestricted
necessary	1	2	3	4	5	6	7	not necessary
useless	1	2	3	4	5	6	7	important
precise	1	2	3	4	5	6	7	less precise
not comprehensive	1	2	3	4	5	6	7	comprehensive
difficult to test	1	2	3	4	5	6	7	easy to test
confident it works	1	2	3	4	5	6	7	less confident it works
applications	1	2	3	4	5	6	7	environment
acts earlier	1	2	3	4	5	6	7	acts later
does not compensate for weaknesses	1	2	3	4	5	6	7	does compensate for weaknesses
common	1	2	3	4	5	6	7	unusual
detection	1	2	3	4	5	6	7	hygiene
usefulness	1	2	3	4	5	6	7	useful
acceptable losses	1	2	3	4	5	6	7	unacceptable losses
immediate impact	1	2	3	4	5	6	7	not an immediate impact
costly to implement	1	2	3	4	5	6	7	more costly to implement
tangible to error detection	1	2	3	4	5	6	7	less tangible to error detection

BATCH CONTROL

effective	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: less effective
general	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: specific
weak	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: powerful
asset safeguarding & data integrity	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: effectiveness & efficiency
gives confidence	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: gives less confidence
unreliable	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: reliable
restricted	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: unrestricted
necessary	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: not necessary
useless	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: important
precise	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: less precise
not comprehensive	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: comprehensive
difficult to test	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: easy to test
confident it works	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: less confident it works
applications	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: environment
acts earlier	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: acts later
does not compensate for weaknesses	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: does compensate for weaknesses
common	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: unusual
detection	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: hygiene
usefulness	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: useful
acceptable losses	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: unacceptable losses
immediate impact	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: not an immediate impact
costly to implement	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: more costly to implement
tangible to error detection	:	1	:	2	:	3	:	4	:	5	:	6	:	7	: less tangible to error detection

PROGRAMMED EDIT CHECKS

effective	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: less effective
general	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: specific
weak	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: powerful
asset safeguarding & data integrity	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: effectiveness & efficiency
gives confidence	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: gives less confidence
unreliable	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: reliable
restricted	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: unrestricted
necessary	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: not necessary
useless	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: important
precise	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: less precise
not comprehensive	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: comprehensive
difficult to test	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: easy to test
confident it works	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: less confident it works
applications	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: environment
acts earlier	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: acts later
does not compensate for weaknesses	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: does compensate for weaknesses
common	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: unusual
detection	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: hygiene
usefulness	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: useful
acceptable losses	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: unacceptable losses
immediate impact	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: not an immediate impact
costly to implement	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: more costly to implement
tangible to error detection	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: less tangible to error detection

DATABASE ACCESS CONTROL

effective	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: less effective
general	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: specific
weak	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: powerful
asset safeguarding & data integrity	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: effectiveness & efficiency
gives confidence	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: gives less confidence
unreliable	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: reliable
restricted	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: unrestricted
necessary	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: not necessary
useless	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: important
precise	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: less precise
not comprehensive	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: comprehensive
difficult to test	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: easy to test
confident it works	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: less confident it works
applications	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: environment
acts earlier	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: acts later
does not compensate for weaknesses	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: does compensate for weaknesses
common	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: unusual
detection	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: hygiene
usefulness	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: useful
acceptable losses	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: unacceptable losses
immediate impact	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: not an immediate impact
costly to implement	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: more costly to implement
tangible to error detection	: 1	: 2	: 3	: 4	: 5	: 6	: 7	: less tangible to error detection