An Analysis of the Relationship between Analyst-User Cognitive Style Differences and User Resistance to Information Systems

Thesis submitted to the
Department of Accounting
in fulfillment of the requirements of a
Master's degree in Commerce
at the University of Cape Town

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1st July, 1989

Acknowledgements

I would like to thank the following:

my supervisor, Professor Peter M. Q. Lay of the Department of Accounting at the University of Cape Town for his untiring interest, enthusiasm and support;

Professor Michael J. Kirton of the Hatfield Polytechnic (United Kingdom) for his continued support and encouragement, and for permission to reproduce the KAI material contained in Appendices A, B and C of this thesis;

Dr Adrian F. Furnham of London University College for his advice concerning certain psychological aspects of this study;

First National Bank of South Africa for a sponsorship of one thousand rands;

my employer, the Cape Technikon, for lending me the course fees for this study and for granting me leave to collect data; and

the ten organizations and their subsidiaries who permitted me to collect data at confidential interviews with their staff. The organizations which refer are Adcock-Ingram, BP Oil, Caltex Oil, Cape Town City Council, First National Bank, Foschini, Metropolitan Life, Mobil Oil, OK Bazaars and WesBank.

I acknowledge that all references are accurately recorded, and unless otherwise stated, all the work contained herein is my own.

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Abstract

This study investigated the relationships between user resistance to new information systems and other factors, the chief of which was the differences in cognitive problem-solving styles between systems developers (analysts) and users. In addition, associations were tested between user resistance and the following: system accuracy, system reliability, the analyst's attitude, the analyst-user relationship, analyst-user dissonance, the user's age and the user's length of service with his current employer.

All data was collected at confidential interviews with the key users and key analysts of 34 post-implementation systems. Ages and lengths of service were recorded at these interviews. User resistance was determined from the number of *complaints* made by users regarding the systems and their manner of implementation. Cognitive style was measured using the Kirton Adaption-innovation Inventory (KAI). All other parameters were measured as responses to suitably phrased questions, quantified using seven-point scales.

A significant *positive* association between user resistance and analyst-user cognitive style difference was found. A model was then developed which enables the estimation of user resistance *prior to system development* with the aid of the KAI. Significant *negative* associations were found to exist between user resistance and system accuracy, and user resistance and system reliability. No relationships between user resistance and either user age or user length of service were found.

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Chapter 1

Introduction

1.1 Overview of the thesis

This study was chiefly concerned with user resistance to new computerized information systems, stemming from the differences in cognitive problem-solving styles between systems developers and users. Although only sparsely covered in the information systems literature (see Section 2.7), user resistance is generally described as negative in its impact.

In the light of various studies such as those of Markus (1983), Hirschheim and Newman (1988) and Keen (1981), there can be little doubt that user resistance implies the wastage of resources in terms of higher budgets, extra staff requirements and extra time. Such added overheads to the system development effort motivated the main aim of this study: a deeper understanding of user resistance. Improvements in the diagnosis, amelioration and/or avoidance of user resistance could then be suggested.

This study is also concerned with *cognitive style*, which implies an individual's approach to problem-solving (see Section 1.2). There are conflicting views regarding the influence of cognitive style on user resistance. Hirschheim and Newman (1988), for example, note that a user may resist a system because the mode of presentation of that system does not match the user's *cognitive style*. In other words, the system does not follow a problem-solving sequence which is totally acceptable to the user. Huber (1983), however, deduced from his own literary survey that cognitive style theory had not, and probably would never provide guidelines for system design. Nonetheless, a careful analysis of Huber's study (see Sections 2.4 and 2.6) reveals that it merely rejects attempts to match a *system* to a given user's cognitive style. It does not reject attempts to match the *systems developer* cognitively with a given user. On the contrary, Huber's study encourages the use of cognitive style theory for personnel selection and placement purposes (see Section 2.4). Since little direct evidence was found in the IS literature of previous attempts to match systems developers and users cognitively, it was decided to investigate user resistance along this more novel line.

In addition to the aspects of user resistance and cognitive styles already discussed, this chapter deals with definitions and terms used in the remainder of the study, the limitations of the study and a brief over-view of the knowledge which the reader is assumed to have. In Chapter 2, a more detailed survey of literature both on resistance to change in general and its specific role in the world of information systems is given. In addition, cognitive style theory literature is discussed more fully. Using this survey as a basis, several research hypotheses are developed and stated in Chapter 3. Chapter 4 then outlines the research procedure which was used to test these hypotheses. A discussion of how the research results were analyzed statistically, together with the analysis, is given in Chapter 5. Chapter 6 concludes the thesis with a summary of what was achieved by this study and suggestions for further research.

1.2 Definitions and terms used

Certain specialized terms have been used throughout this study. For instance, the term *information system* refers to a computer-based system of interrelated programs which is capable of analyzing, tabulating and interpreting source data to give required information. Persons making use of an information system are referred to as *users*, whilst those responsible for producing the system are called *systems developers*. A systems developer may fulfill the roles of *systems analyst* or *systems designer* or *both*. Experience showed that in some smaller installations, the systems developers also coded programs themselves, where they were generally called *analyst-programmers*. Since all analysts interviewed during the data collection procedure also had played a major role in the task of systems design, the terms "analyst" and "developer" are often interchanged. The abbreviation *IS* denotes either "information system" or "information systems *as a field of study*". The term *IS* has been used in preference to the alternatives *DP (data processing)* and *EDP (electronic data processing)* which are found but occasionally in recent literature.

Although definitions of *user resistance* occur in the IS literature (see Section 2.2), these were found not to be sufficiently definitive for the actual measuring of this phenomenon. Consequently, a new definition of user resistance was used, namely, *the sum of the severities of the complaints which a user will make to an independent consultant, in private, about the system and/or its manner of implementation*. This definition is justified in Section 3.2, where a formula is derived for the calculation of user resistance based thereon. User resistance so determined is termed the user's *R-score*. User resistance is assumed in this study to be the converse of *user satisfaction* (see Section 3.2). The latter is further assumed to be synonymous with the term *system (or IS) success*.

As previously mentioned, the purpose of this study was to test relationships between user resistance and *cognitive style*. This term, or the alternative, *cognitive problem-solving style*, is used to denote an individual's approach to problem-solving. The *Kirton Adaption-innovation Inventory (or KAI)* was selected as an instrument to measure cognitive styles (see Section 3.3). As discussed in Sections 2.4 and 3.3, the KAI, based on *Adaption-Innovation (AI) theory*, measures an individual's preference for either an "adaptive" or "innovative" approach to problem-solving. Adaptive problem-solvers tend to follow prescribed and traditional methods, whilst innovators seek new and often unexpected solutions.

The KAI provides a score which measures an individual's problem-solving style on a continuum between these extremes (see Section 4.2). A person's *cognitive problem-solving style*, within the scope of this study is thus defined as his *KAI score* after proper administration of the KAI instrument.

1.3 Limitations of the study

Having defined and described the key concepts and terms used in this thesis, the limitations of the research are considered next. Firstly, this study was essentially *descriptive* rather than *prescriptive*. Associations between cognitive style, user resistance, system characteristics, ages and lengths of service were tested to reveal patterns and principles. Prescription was limited to discussion concerning the application of certain of the results (see Sections 5.10, 5.11 and 5.13).

Based on the studies by Hirschheim and Newman (1988) and Markus (1983), it is argued in Section 3.2 that user dissatisfaction, expressed overtly in the form of complaints, is highly associated with certain types of user resistance. This in turn justifies the R-score method, which constitutes the direct observation and recording of user complaints. However, no claim can be made that the R-score is a *complete* measure of user resistance, since there are forms of resistance enumerated in the IS literature which are not necessarily associated with overt dissatisfaction. Such forms of resistance include, for example, such *covert* behaviours as absenteeism and withdrawal (Hirschheim and Newman, 1988). It is beyond the scope of the present study to investigate any form of user resistance which is not measurable in terms of overt expressions of user dissatisfaction.

1.4 Assumed knowledge of the reader

Certain assumptions regarding the reader's knowledge have been made in the presentation of this thesis. For instance, background knowledge of information systems is required to understand the terms and definitions given in Section 1.2, particularly the general roles played by systems analysts, systems designers and users in system development and implementation. In other words, a knowledge of the analysis, design implementation and maintenance phases of system development is assumed. Some knowledge of the technical side of system development and the related field of operational research is also required.

Beyond this, a basic understanding of the mathematical and statistical procedures used to analyze the data is assumed. These procedures include goodness-of-fit techniques of the Chi-square type, hypothesis-testing using null hypotheses, measurements of association and linear correlation, the natural logarithmic function (ℓn) and the laws of exponents and logarithms.

Having given a brief outline of the areas to be covered, an in-depth survey of research literature pertaining to this study follows in Chapter 2.

Chapter 2

Summary of prior research

2.1 Introduction

The topic of this thesis covers four areas of prior research. These are: IS user resistance to new systems; resistance to change in other areas not necessarily related to IS; the influence of cognitive problem-solving styles on resistance to change; and measures of system success and their application. Since IS success is largely a matter of user opinion, the aspect of user satisfaction and its measurement is covered under the discussion of the last area. As noted in Chapter 1, a link is claimed between user satisfaction (or dissatisfaction) and user resistance (see Section 2.5), thus the possibility of using user satisfaction as a converse substitute measure of user resistance is considered.

After a description of research studies in each of the above areas, this chapter concludes with an analysis of the procedural clarity, authenticity and credibility of those studies important to this thesis.

2.2 User resistance - IS studies

Only five studies of significance were found in the IS literature: those of Keen (1981), Hirschheim and Newman (1988), Bruwer (1984), Markus (1983) and De Brabander and Thiers (1984). Keen's study is a literature survey, in which he discusses long-term changes in organizations with emphasis on information systems. In this, he defines "social inertia" as, "no matter how hard you try, nothing seems to happen". He concludes that new systems which represent radical change, as opposed to those which cause incremental or evolutionary change, will be avoided or resisted. Also, since the redistribution of data caused by a new information system is a political resource, the interests of certain groups will be affected.

The study by Hirschheim and Newman (1988) is also a literature survey of user resistance, followed by the presentation of case-studies. In this, the authors define resistance as an adverse reaction to a proposed change, which may either be overt or covert. They suggest that the impact of user resistance emerging during implementation may take any of the following forms: low productivity, low effectiveness, high labour turn-over, disputes, absenteeism, psychological withdrawal, aggression, sabotage of machinery, the system being blamed for all difficulties experienced (including incorrect data entries), and lack of management support for the system. In addition, they identified eleven causes of user resistance in the IS literature. These may be taken as joint or several causes, and are summarized in Table 2-1.

Table 2-1

Causes of User Resistance: Hirschheim and Newman

(1) **Innate conservatism**
People in general try to preserve the status quo.

(2) **Lack of felt need**
Individuals cannot see the benefits which the change will bring.

(3) **Uncertainty**
The new system is seen as a threat which may cause job losses and/or transfers, or may necessitate the learning of new, difficult-to-master skills.

(4) **Lack of involvement in the change**
Users excluded from the decision to initiate the system, and/or not involved in the development of the system.

(5) **Redistribution of resources**
Individuals attempting to defend or improve their interests during the redistribution of resources resulting from change.

(6) **Organizational invalidity**
A mismatch between user requirements and certain system features.

(7) **Lack of management support**
Weak leadership by management, and consequent failure of management to appear to support and encourage the change.

(8) **Poor technical quality**
System not "user friendly", unreliable and/or has slow response-time.

(9) **Personal characteristics of the designer**
Systems developer(s) pre-occupied with the technical aspects of IS, hence the human side of systems development ignored.

(10) **Poor user training**
Users improperly trained, hence they tend not to use the system.

(11) **The user's "cognitive style" unmatched by the system**
System's mode of presentation and operation does not suit the user.

(Hirschheim and Newman, 1988)

In addition to those factors recorded in Table 2-1, others contributing to user resistance were found in the IS literature. Bruwer (1984) for example, in a study of resistance to computerization, claims that older managers with longer experiences are more negative towards computerization than are younger ones. This study was conducted in a single organization (unspecified), where 140 computerized systems, used by about 1 200 clerical staff and 114 managers, were investigated.

Details of the instrument used are not given, neither is a full set of empirical results.

Markus (1983) identified three general theories explaining user resistance from the IS literature, which she then assessed in the light of a single case study. These theories are: internal individual or group factors, such as a non-analytic cognitive style, cause user resistance; factors inherent in the system under implementation, such as technically deficient systems or systems which are not user-friendly, cause resistance; and certain interactions between factors inherent in the user and others intrinsic to the system cause resistance. For example, a system which centralizes control will be resisted by persons and groups who lose power during implementation and accepted by those who gain power. Markus concluded that of the three, only the latter theory was supported by her case study. This study investigated the introduction of a financial information system (FIS) into a large corporate organization. In the main, user resistance behaviours took the form of complaints against the system which were considered unfair. This, it will be noted, corroborated certain of the behaviours identified by Hirschheim and Newman.

De Brabander and Thiers (1984) studied certain defective implementation behaviours in the form of not adhering to plans, which resulted in reduced efficiency of task-accomplishment amongst users. Central to their experimental procedure, was a crime-solving problem. This was varied for a number of analyst-user teams in peripheral detail (names and dates) only, and so served as a standard hypothetical task for system development. Their experimental procedure for each of the analyst-user teams was in two parts. In the first, they observed a discussion between the team members on how the user would use an information retrieval system to solve the crime problem given. In the second, the user had to try to solve the problem within half an hour. By carefully analyzing the discussion between the analyst and user, and then observing the user's implementation behaviour, these authors measured the extent to which the user adhered to plans agreed to with the analyst. The speed with which the user solved the crime was used as a measure of his efficiency of task accomplishment. By varying conditions, for example, by introducing third parties, they were able to investigate circumstances during the discussion phase which modified the user's implementation behaviour. The respondents were dyads of university students who played the roles of analysts and users. 91 such teams participated in the study.

De Brabander and Thiers concluded that the main cause for their "users" not adhering to plans was that they were subject to the sanctionary powers of the corresponding "IS specialists". This effect, they noted, was enhanced by the presence of a *semantic gap* which they define as the employment of differing conceptual definitions for aspects of the same task. In other words, a *difference in definition* is implied. In Section 3.3, a link between the "semantic gap" and cognitive style difference is argued, making de Brabander and Thiers' study relevant despite the fact that they themselves did not test this link.

The implication of the "semantic gap" for system development is as follows: should a user and analyst engaged in the development of the same system fail to describe aspects of their joint task in the same terms, then user resistance behaviours can be expected. These authors found that a third party involved in the project could remedy user resistance if possessed of the necessary communicative skills to reduce the semantic gap between the other parties. Such a person would have to act as an interpreter between them, redefining descriptions by one party in terms familiar to the other.

As can be seen from the above, there has been little of a definitive nature in the IS literature pertaining to user resistance. This prompted an examination of studies that had been conducted on resistance in related fields.

2.3 Resistance to change in other areas

As with IS, very little could be found in the management literature that specifically addressed the question of resistance to change. Consequently, this section includes discussion of literature where resistance was implied, though not necessarily the direct object of a study.

Rosen and Jerdee (1976) conducted an enquiry into age stereotypes of employees which suggests that increased resistance to change is a generally believed characteristic of older employees. They drew up a questionnaire of 65 items drawn from various literary sources. These items were arranged in the four categories of performance capacity, potential for development, stability and interpersonal skills. 106 respondents (56 estate agents and 50 undergraduate business students) completed this questionnaire, ranging in age from eighteen to fifty-three years. Rosen and Jerdee found that there was a tendency for younger persons to be considered more receptive to new ideas, and older persons, by implication, more resistant to them. After a further intensive literature survey, however, they found that there was little research evidence to support such beliefs, and concluded that older employees are the potential victims of unjustified discrimination. This study, it should be noted, contradicts the findings of Bruwer.

Ettlie (1985) conducted a study of the impact of manpower-flows on innovation, from which inferences for resistance to change can be drawn. He developed five case-histories of the innovation processes, from which certain deductions were made. For example, his study offers support for the premises that innovation is aided by: an influx of new employees (if not too disruptive); the degree to which the organizational structure is decentralized; the complexity of the organization; and the availability of slack resources. Hence, by implication, the same factors must reduce resistance to innovation.

McFarlan and McKenny, although working in the IS field, devised a procedural model, prescribing to organizations how *in general* to manage the diffusion of new technologies (Raho, Belohlav and Fielder, 1987). This model applies to any proposed organizational change, and has obvious implications for coping with resistance to change. It identifies four phases of the diffusion process, as outlined in Table 2-2. A key feature of these phases is that they occur in the specific order shown, and stagnation at any one stage blocks progress to the next. Consequently, this model not only offers explanations for inertial resistance, but also assists in the diagnosis of where and why such resistance might have occurred. Raho, et al (1987) conducted a study which confirms that this model, in general terms, describes the diffusion process for new IS technology. This study was in the form of a survey which examined the assimilation of micro-computer technology into various organizations. Of the 2 000 questionnaires sent out, the

412 useable ones returned constituted their sample. Details of the questionnaire were not given.

Table 2-2

Phases of diffusion of new technologies: McFarlan-McKenny Model

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1) **Technology identification and investment**
In this phase the experience with the technology is so limited that participants are unable to perceive long-term implications. Stagnation is possible as a result of poor management, or if unsuitable choices of equipment or vendors occurs.

2) **Experimentation, learning and adaptation**
New developments, which may represent drastic differences, may occur at this stage. If managers are not allowed to develop and refine their understanding, stagnation will occur, and progress to the next phase will be blocked.

3) **Rationalization and management**
Management and operational control are sought. However, stagnation can take place if too much standardization takes place.

4) **Widespread technology transfer**
The benefits of the new technology are disseminated to other units in the organization.

(Raho, Belohlav and Fielder, 1987)

2.4 Cognitive problem-solving styles and resistance to change

The third area of analysis is that of cognitive problem-solving style and its impact on system success. If the way in which analysts define and describe tasks can be implicated in the phenomenon of user resistance, then it stands to reason that the cognitive approaches, or problem-solving styles of the analyst and user are also significant. This follows from the fact that definition and description are basic to cognitive information processing. Hence the implication of the semantic gap also suggests the role of cognitive differences between the user and the analyst in user resistance. Zmud (1983) notes in confirmation that cognitive differences between systems developers and users is a major deterrent to effective user involvement, and consequent IS success. The relevant study is a literature survey.

Woodruff (1980) identified the cognitive problem-solving style of systems developers in terms of a need for cognitive structure. A person exhibiting this need does not like ambiguity or uncertainty in information, wants all questions answered completely and prefers to make decisions based on definite knowledge rather than on probabilities. According to his enquiry into the personalities of IS people, systems developers exhibit a significantly above-average need for cognitive structure when compared with other occupational groups. Woodruff's study involved the administration of Jackson's Personality Research Form, based on Murray's variables of personality, to 202 IS staff. This tested twenty needs amongst them, of which the following six exhibited significant deviation from the norm:

Achievement Willing to put forth effort to attain excellence.

Aggression Enjoys combat and argument; may seek to get even.

Cognitive Structure Does not like ambiguity or uncertainty.

Endurance Willing to work long hours; doesn't give up easily on a problem; persevering in the face of great difficulty; patient and unrelenting in work habits.

Harm-avoidance Avoids risk of bodily harm.

Social Recognition Concerned about what others think of him.

Woodruff's sample showed significantly *higher* needs for endurance (which he considers not surprising for IS staff), achievement, cognitive structure (as previously stated) and harm-avoidance. It showed significantly *lower* needs for aggression and social recognition.

Lusk and Kersnick (1979) conducted research into the problem-solving capabilities of persons with varying cognitive styles. Using the Embedded Figures Test (EFT) of Witkin, et al, they grouped 200 undergraduate students into "high analytic" and "low analytic" types. High analytic types of respondents are defined in terms of the EFT as those who approach problem-solving tasks in a structured, methodical fashion, whilst low analytic types are those who do not. Their sample of students were subjected to a task, which took the form of a 20-question comprehension test on a financial report. From the results of these tests, they deduced that EFT typing is associated with efficiency of task-performance; that more analytic types do exhibit significantly improved performance compared with less analytic types.

Huber (1983) published the literary survey referred to in Section 1.1. As previously noted, he concludes that the literature available on cognitive style research in IS does not support a satisfactory basis for recommendations on IS design. Also, he expresses pessimism that this approach will ever provide such guidelines. However, he does recommend cognitive style research in three areas: career counselling, personnel selection and placement, and coaching and training. The second of these has implications for the placing of the most suitable analyst with a given user, or vice versa.

One of the major research efforts covering cognitive problem-solving style has been performed by Kirton (1976, 1980, 1984, 1985, 1987, 1988) under what he terms Adaption-Innovation theory (Kirton, 1976). Adaption-Innovation theory, Kirton claims, explains in an empirical way many of the anomalies surrounding resistance to change in occupational situations. He proposes that any person can be located on a continuum ranging between two extreme cognitive styles; from an ability to adapt existing technologies (an adaptor) to an ability to use new or different technologies (an innovator). This proposition, he claims, is relevant to the analysis of organizational change, and offers new insights into the concept of resistance to change.

Characteristically, adaptors tend to work within the limits imposed by their organizational setting, being concerned with improving or doing the best with what is available or recognized as correct (Kirton, 1984). Innovators on the other hand, tend to show little regard for accepted ways of doing things, and derive unexpected and, very often, less acceptable solutions to problems. Innovators are often seen to range themselves against the establishment, whilst adaptors are frequently favoured by management as conformists to established norms and principles (Kirton, 1976). The general behaviour descriptions of adaptors and innovators are given in Appendix A.

Kirton's enquiry (Kirton, 1984) into the blocking of new initiatives in several large corporate institutions offers a fundamental conclusion regarding resistance to change. In general, a person will exhibit less resistance to ideas put forward by another of *similar cognitive style*. He further discusses the notion of an "agent for change", and stresses that it is not necessarily associated with innovation. An agent for change is rather a person "who can successfully accept, and be accepted into, an environment alien to his own", or "as a competent individual who has enough skill to be successful in a particular environment" (Kirton, 1984). In fact either an adaptor or an innovator can be an agent for change, depending only on group composition. If the group is innovative, the agent for change tends to be an adaptor, and vice versa.

The Kirton Adaption-Innovation Inventory (KAI) instrument provides a means for measuring individuals' cognitive problem-solving styles (Kirton, 1987). These scores are stable, and little variation is reported with time or age. This instrument rates innovators with higher scores than adaptors. These scores have relative as well as absolute significance, hence if A's KAI score is higher than B's, it is meaningful to describe A as "more innovative" than B, and B as "more adaptive" than A.

2.5 Measures of system success and user satisfaction

The final research area to be analyzed is that of system success and the related area of user satisfaction. Attempts are found in the literature to identify those attributes of systems which tend to satisfy (and/or dissatisfy) users. Certain instruments as discussed below have been devised which try to rate IS success against lists of factors thought important to users (Ives, Olson and Baroudi, 1983). One aspect of this approach is that user satisfaction can be (and has been) used as a *substitute* or *surrogate* measure of user involvement (Ives, et al, 1983). As will be argued more extensively in Section 3.2, user satisfaction and user resistance are negatively associated. In other words, user satisfaction can be used as a *converse* substitute measure for user resistance and a *direct* substitute measure for IS success.

Ives, Olson and Baroudi (1983) conducted a psychometric analysis of four "User Information Satisfaction" instruments. These were, Gallagher's questionnaire, Jenkins and Rickett's 20-item measure, Larcker and

Lessing's perceived usefulness instrument, and Pearson's 39-factor instrument. The authors conducted a literature survey for each of these instruments, making reference to the original research done on each. In conclusion, they favoured Pearson's instrument as the most predictive and exhibiting the greatest construct validity. They then proceeded to replicate Pearson's study by way of a postal survey. Of the 800 questionnaires which they sent out, 280 (35 %) were returned. Based on an analysis of this sample, they concluded that a shortening of Pearson's instrument was possible, with little loss in validity. Pearson originally proposed a weighting method, whereby each factor carried an "importance" rating (Bailey and Pearson, 1983). This meant that the respondent could specify both his opinion of a given satisfaction-factor and how important that factor was to him. However, Ives et al (1983) found a very high correlation between the weighted and unweighted factors of Pearson's instrument, suggesting that the importance rating was unnecessary. The shortened version of Pearson's instrument which they subsequently developed, they considered a promising advance in the measure of user satisfaction.

The original instrument developed by Pearson was researched and standardized by Bailey and Pearson (1983). As previously stated, it takes the form of a questionnaire with a list of 39 factors. Each factor is an area of possible user satisfaction or dissatisfaction. This list of factors was claimed by its authors to be complete, or very nearly complete.

The above authors based their research on a sample of 29 persons in mid-managerial positions in eight different organizations. In Pearson's original study, 32 such persons had been interviewed as users of various systems, and their comments on the systems noted. 39 of these opinions were selected by Pearson and translated into factors for inclusion in his questionnaire. The 32 mid-managers were then asked to complete the 39-factor questionnaire. 29 responded, and this sample of 29 completed questionnaires formed the basis of their further analysis. The five of the thirty-nine factors found to be most significant by Bailey and Pearson were (in order): accuracy (correctness of output), reliability (dependability of output), timeliness (output available at a time suitable for use), relevancy of output, and confidence in the system. Several of the other factors together can be summarized as, "contribution to organizational efficiency and/or effectiveness". For example, the following features of a live (post-implementation) system would obviously affect the efficiency and effectiveness of the user-department in the carrying out of its functions: flexibility, completeness, precision, priorities determination, convenience of access, currency (age of output information), job effects (changes in the user's job freedom and job performance) and error recovery.

In addition to providing measures of user satisfaction with system characteristics, Pearson's instrument also measures satisfaction with the IS department and/or systems developers (Bailey and Pearson, 1983). The factors which refer are: relationship with the EDP staff (systems developers), communication with the EDP staff, attitude of the EDP staff, and organizational competition with the EDP unit. Bailey and Pearson found some evidence that these factors could influence user satisfaction. The factors found to be *least* significant by them were: a feeling of control, volume of output, vendor support, degree of training, and organizational position of EDP.

Eveland (1977), in a study of the implementation of innovations in organizations claims that user involvement has been endorsed as an important factor in bringing about user satisfaction. Eveland based this conclusion on a sample of five case-studies drawn from two health departments in the Baltimore metropolitan area. However, this view was contradicted by Olson and Ives (1981). In their literary survey covering user involvement and IS success, they found no strong support that the benefits of user involvement had ever been demonstrated. Robey and Farrow (1982), on the other hand, did find evidence that user involvement had "beneficial effects" on system success. In their study of the topic, they defined three phases of system development: initiation, design and implementation. Data was collected from 130 IS users in five different countries. Lengthy interviews were conducted, at which users were asked to rate their involvement during these phases. Further information was gathered using questionnaires, of which 62 were returned, completed in full. These questionnaires contained five-point scales designed to rate estimates of degree of participation during the three phases. From this sample of 62, the authors concluded that user involvement aided all three phases of system development provided that the user had meaningful influence. This, they considered, led quickly to conflict and its resolution, a process which they claim is necessary for ultimate user satisfaction.

Rushinek and Rushinek (1986), in a study of user satisfaction, concluded that short response times and well-informed users, who do not have unrealistic expectations of what a computer can do, are the key factors responsible for user satisfaction. These investigators devised an instrument which allowed respondents to give percentage-wise ratings for seventeen independent variables bearing on user satisfaction, and one dependent variable (overall satisfaction). 4 448 users, distributed over 179 systems, comprised their research sample.

2.6 Analysis of key research studies

Bruwer (1984)

It is difficult to establish precisely what Bruwer's model entails based on the article itself and no other sources are quoted to which the reader can refer. The sample was a single cluster of IS users drawn from a single organization. Whilst this author claims the organization to be "very large", no actual size is given. This invites the argument that Bruwer's results are biased in favour of the norms of the single organization from which his sample was drawn. Only sparse detail of the instrument is given. All that is specified is that it consisted of questions, "most of which" could be answered on seven-point scales. The suitability of the questions and the extensiveness of the area which they cover thus remain unknown. This study fosters the belief that older and more experienced users are more resistant to computer systems than younger and less experienced ones. The belief of greater inflexibility on the part of older employees contradicts conclusions reached by Rosen and Jerdee (1976). These authors found that such a belief is unjustified, and can result in unwarranted discrimination.

Markus (1983)

Some of the criticisms levelled at Bruwer's study also apply to Markus's research, because her results were based on one case study in a single organization of unspecified size. This is partially compensated for by the extensive level of detail with which the prior research and results are recorded. However, the research yields no positively prescriptive recommendations. One of the most significant findings was that user resistance manifests itself mainly in the form of complaints. This, however, was coincidental to the original purpose of the study.

__De Brabander and Thiers (1984)__

De Brabander and Thiers based their study of effective IS specialist-user communication on quoted earlier references in the IS literature. Both the procedure and the parameters are clearly defined, as are the origins of their hypotheses, with a complete list of all measurements, sample sizes and descriptive statistics. The summary and conclusions regarding the effects of the "semantic gap", as discussed earlier, are thus convincing. However, these authors point out correctly that their model is only a partial one, and that other "strong" factors are indicated. The impression is therefore created that a semantic gap is merely a *symptom* of some more fundamental factor or factors responsible for user resistance. Little discussion of what such factors might be was found in this study.

__Woodruff (1980)__

Woodruff's profiling study of IS people gives clear descriptions of his sample, and gives a reference to the instrument used. Results are displayed graphically, together with their precise values. However, the instrument was a "self-report questionnaire", meaning that it had to be completed unaided by the respondents. It is not clear precisely under what conditions the questionnaire was completed and returned. If completed voluntarily and returned by post, for example, then a possible bias exists in the sample; namely, towards those respondents who tend to return questionnaires. It can be argued that such persons would also have had a tendency towards certain needs found significant in the study, most particularly, the need for endurance, since this implies conscientiousness on the part of the respondent.

Lusk and Kersnick (1979), and Huber (1983)

Lusk and Kersnick's study of the effects of cognitive style on task performance is described with clarity, and the hypotheses it tests are developed based on previous research. The research uses the EFT; a successful instrument devised by Witkin, et al (Lusk and Kersnick, 1979), and cited by Kirton (1987). Tables of results are comprehensive enough for verification by the reader (Lusk and Kersnick, 1979). However, Huber (1983) concluded after his literary survey that cognitive style research such as the above does not support a satisfactory basis for recommendations on IS design. Furthermore, little else could be found in the IS literature to challenge Huber's position. Consequently, the implications of Lusk and Kersnick's study for IS design are either limited or in doubt.

Bailey and Pearson (1983)

The length of Pearson's 39-factor instrument to measure user satisfaction must lead to a similar reservation already advanced concerning Woodruff's survey: namely, that if completed on a voluntary basis, a sample excluding a significant number of less conscientious users is likely to be obtained. As previously noted, Ives, et al (1983) sent out 800 of these questionnaires of which only 35% were returned (see Section 2.5). This 35% they then used as their research sample. It could certainly be argued that such a sample was biased towards conscientious respondents; a characteristic associated with an adaptive cognitive style (see Appendix A). To an extent, Bailey and Pearson (1983) compensated for this by rating only those factors which received definite, non-neutral responses as contributing to the user's satisfaction/dissatisfaction measure. However, Ives, et al (1983) concur that the length presents psychometric difficulties in obtaining valid responses, and recommend a shortened version of this instrument.

Kirton (1987) and the KAI instrument

Some of the words used in the Kirton Adaption-Innovation Inventory (KAI) such as "proliferates" and "steady plodder" (see Appendix B) were thought to be rather difficult to understand by certain respondents; most particularly those who are not English-speaking or are of a low educational level. From time to time Kirton (1987) claims to have received requests from researchers to replace original words with easier ones. However, he reports that in such cases, statistically poorer results were usually obtained. He concludes that respondents from most backgrounds can accurately guess the appropriate meaning of such words and phrases without precise definition. He further reports that the KAI has produced consistently satisfactory results, with similar distribution patterns of scores, under a wide variety of conditions. Groups of target respondents have varied in terms of occupational, cultural and linguistic backgrounds, as indicated in Table 2-3. The KAI Manual provides a pool of 69 such studies. However, for the sake of brevity only those with sample sizes in excess of 200 have been included.

Table 2-3

Successful studies which used the KAI

Samples of 200 or more

Occupational Group	Country	Sample Size	Study*
Apprentices	U. K.	624	Flegg (in Kirton, 1987)
Managers in general	India	250	Hossaini (1981)
" " "	Iran	250	Hossaini (1981)
" " "	Singapore	695	Thomson (1985)
" " "	Italy	207	Prato Previde (1984)
R & D managers	U. S. A.	256	Keller & Holland (1978)
Black undergrads	S. Africa	243	Pottas (unpublished)
Undergrad. students	Italy	216	Prato Previde & Carli (1978)
High school	N. Zealand	412	Kirton (1978a)
Teachers in general	U. S. A.	430	Pulvino (1979)
" " "	U. S. A.	202	Dershimer (1980)
Managers on courses (mostly self-selected)	U. S. A.	534	Gryskiewicz et al. (1987)

* Cited by Kirton (1987)

(Kirton, 1987)

2.7 Conclusion

Kirton provides a theoretical framework (AI theory) and an instrument (the KAI), by which it is possible to stratify people into two cognitive types; adaptors and innovators (see Section 2.4). As has just been stated, though extensively replicated in several sizeable studies (see Table 2-3), no prior attempt has been made to use either AI theory in its present form or the KAI in the IS field. Certain other studies suggest the role of cognitive style theory in IS success. For example, Hirschheim and Newman identified eleven causes of user resistance, including the system's failure to match the user's cognitive style (see Table 2-1). Huber, however, concluded that cognitive style research does not produce useful recommendations for IS design (see Section 2.4).

Other causes of user resistance are suggested in the literature. For example, De Brabander and Thiers concluded that defective implementation behaviour on the part of users is associated with a semantic gap, that is, differences in the way analysts and users define and describe tasks (see Section 2.2). Raho, et al on the other hand, found that the McFarlan-McKenny model (see Table 2-2) holds in general for the assimilation of new computer technology into organizations. Stagnation at any stage prescribed by this model blocks progress to the next, and hence explains resistance to a new system (see Section 2.3).

Bruwer claims that resistance to computer-based systems is associated with the age and length of service of the user (see Section 2.2). However, Rosen and Jerdee found no evidence that older employees are more resistant to change than younger ones, and concluded that older employees can be the objects of unfair discrimination (see Section 2.2). Bruwer's study is also in conflict with AI theory, because studies involving the latter show that cognitive style differences (which exhibit little variation with age or time) are primarily responsible for resistance to new initiatives (see Section 2.4).

Instruments exist which claim to give measurements of user satisfaction. Examples are Pearson's 39-factor questionnaire (as modified by Ives, et al) and the 18-variable questionnaire devised by Rushinek and

Rushinek (see Section 2.5). If an inverse association is assumed between user satisfaction and user resistance, the measure of either one of these can be used as a converse substitute measure for the other (see Section 2.5).

It will be clear from the preceding discussion that the area of cognitive style theory, as it applies to user resistance, has only been sparsely researched, and that much of the research is open to criticism. In addition, two features of the prior research emerge: research applied directly to the question of user resistance but without reference to Adaption-Innovation theory, and Adaption-Innovation theory itself with little reference to IS. It will further be noted that there are reputable instruments such as the KAI (Section 2.4) which have never been replicated in the IS field.

Chapter 3

Development and statement of hypotheses

3.1 Introduction

The studies by Lusk and Kersnick, Kirton, and Hirschheim and Newman referred to in Section 2.4, suggest the important role of cognitive styles in occupational situations. This study thus investigated the analyst-user interface, with the object of determining a method of forecasting user resistance. It was noted in Section 2.4 that, in general, a person will exhibit less resistance to ideas put forward by another person of similar cognitive style. This in turn justifies the submission that user resistance is associated with differences in developer-user cognitive problem-solving styles.

The studies by Bailey and Pearson (1983) and Rushinek and Rushinek (1986) suggest the roles of certain factors, such as system accuracy and reliability, in user satisfaction (see Section 2.5). Such factors should also be related to user resistance if the assumption of a converse relationship between satisfaction and resistance is made.

The study by Bruwer (1984) suggests that user ages and lengths of service also play a significant role in user resistance. As discussed, whilst some doubt exists regarding the validity of Bruwer's results the beliefs fostered by his study can still be tested as hypotheses; namely, that user ages and lengths of service are associated with user resistance. Rosen and Jerdee (1976) certainly found such beliefs (which they challenged) to exist in respect of older employees.

In the light of the foregoing discussion, this study poses the following central questions:

1) During system development, implementation and maintenance, is there a relationship between user resistance and cognitive styles (or cognitive style differences) associated with the analyst-user interface?

2) Can cognitive style theory be used to predict certain general aspects and behaviours of a given analyst-user interface during the development and implementation of an information system?

3) Are there factors related to systems or their manner of implementation which are associated with user resistance?

A further question, to test the findings of Bruwer, was:

4) Do the ages and lengths of service of analysts and/or users play a role in user resistance?

Consequences of the literature-based discussions of Chapter 2 lead directly and indirectly to certain hypotheses regarding the causes of user resistance, which fall into the above categories. Before such hypotheses could be developed, however, reliable instruments to measure user resistance and cognitive style needed to be selected.

3.2 The choice of an instrument to measure user resistance

Had the link between user satisfaction and user resistance been assumed, an instrument which measures user satisfaction could have been chosen to yield a converse substitute measure for user resistance. Pearson's instrument for measuring user satisfaction has been acclaimed as one of the best in the IS literature to date. However, its length (and even the length of the modified version suggested by Ives, et al) must raise criticism. As suggested in Section 2.6, if the respondent is to complete and return the form on a voluntary basis, then the sample gathered would tend to contain the more conscientious respondents; namely, those who are prepared to fill in and return lengthy questionnaire forms. Since conscientiousness is claimed by Kirton (1984) to be associated with an adaptive cognitive style, the risk of bias is immediately evident with this questionnaire. An instrument other than a self-report questionnaire of the above type was thus indicated.

Ives, et al (1983) developed the notion of substitute or "surrogate" measures for entities not capable of direct measurement themselves. In the light of this and the reservations just expressed, an alternative instrument was devised, which constituted a quantified expression of dissatisfaction to a person independent of the user's organization. The potential weakness inherent in allowing respondents to complete and return their own forms was removed by collecting data at personal, confidential interviews with the users. The user of each system under investigation was asked to enumerate all the problems which he considered or heard had occurred during the implementation or early life of the system. He was effectively invited, in confidence, to make complaints against the system and/or its manner of development and implementation. Each complaint was recorded, and then the user was asked to weight his complaints in terms of severity on a seven-point scale (see Appendix D). The sum of the weights for each complaint was taken as the user's "**resistance score**" or "**R-score**".

The validity of the R-score is argued on the basis that user resistance can only be exhibited in one of four ways: by what the user says or by what the user does (overt resistance), or by what he does not say or does not do (covert resistance). Any one (or any combination) of these four phenomena, if measured and quantified, would be expected to provide an observable measure of user resistance. Furthermore, as an independent party is not part of the political structure of the organization, comments made to him about the system are likely to be more objective than hear-say filtering back to the management.

However, there are two issues which require clarification. Firstly, there is the question of whether or not overt user dissatisfaction, expressed in the form of complaints, is a legitimate measure of user resistance. Both the studies by Hirschheim and Newman (1988) and Markus (1983) suggest a significant association between user resistance and user complaint. The former study asserts that amongst the various types of user resistance, there are: aggression; and the system being blamed for all problems prevailing during implementation, including incorrect data entries. This is confirmed in the latter study, where user resistance was observed mainly to take the form of complaints, many of which Markus considered unfair. These literary sources thus support a method which quantifies user *dissatisfaction* as a substitute measure for user *resistance*.

However, there are types of resistance which *cannot* easily be proved to be associated with complaint. Examples of such are psychological withdrawal and absenteeism (see Section 2.2), because these are types of *covert* resistance whilst a complaint is a case of *overt* resistance. The answer to the first question, then, is that the study must be limited to investigating only those forms of resistance which are measurable in terms of overt expressions of dissatisfaction. Whilst this may at first seem restrictive, it should be noted that perceived success of the system to management is most likely to be tied to reports of success from its employee users. In other words, this measurement technique will appeal to managers whose interests are largely the warding off of complaints against new systems from their staff.

The second issue is the question of how *complete* the list of the user's complaints would be, or alternatively, what the significance would be if the user forgot to itemize certain problems. It is argued that this is not a significant issue, since the R-score method aims to observe the user *in the process of complaining*. If, as noted above, users tend to make unfair complaint as a resistance behaviour, then users will tend to *invent* or *exaggerate* complaints as an expression of their level of dissatisfaction. Quite clearly, the issue of whether or not the user remembers all the *real* problems which occurred during implementation then becomes less relevant.

The R-score approach does, however, prescribe certain stipulations which were borne in mind during the research design. Firstly, the users needed to be interviewed personally by a researcher to obtain their views of systems. This follows immediately from the need to relieve the respondent of the obligation to complete and return a form, as discussed above. Secondly, every effort had to be made to convince the user that all his responses were to be kept confidential; particularly from the analyst(s), management and potential business rivals. Without this stipulation, the advantage of having opinions expressed to an independent researcher (as mentioned above) would have been lost.

As far as the author is aware, this approach to measuring user resistance is a novel one, although the weighting of the severity of the complaints is based on a model developed by Wanous and Lawler (1972) for measuring a worker's job satisfaction. According to this model, an employee's overall job satisfaction is the weighted sum of his satisfaction with all significant facets of the job.

This can be expressed algebraically as

$$S = \sum_{i=1}^{n} s_i \, w_i \, , \qquad \text{f 3.1}$$

where

S = respondent's overall satisfaction with *n* significant facets of the job,

s_i = respondent's satisfaction with facet *i*, rated on a seven-point scale, and

w_i = the importance of facet *i* to the respondent, rated on a seven-point scale.

Wanous and Lawler (1972) tested this model, together with eight others, over thirteen different types of work in the plant and transport sections of a telephone company. Their sample consisted of 208 employees in all. The instrument which they used consisted mainly of a list of twenty-three facets bearing on job satisfaction. This instrument was arranged so that the list was repeated on five separate pages. In effect, the respondent expressed opinions on each facet in five different ways. Various combinations of these five sets of responses yielded the nine measures of satisfaction tested. For example, the sum of the products of the corresponding responses on their pages 4 and 5 gave the respondent's overall satisfaction score, S, defined in the formula above.

In addition, overall job satisfaction was rated directly in two ways: as the mean response over all nine measures of satisfaction, and the response on a seven-point scale to the single item, "Generally speaking, I am very satisfied with my job". Of all nine models tested, the model described above showed the highest correlations with these direct ratings, giving correlation co-efficients of r = 0,92 with the former, and r = 0,61 with the latter. The authors argue that the former direct measure, being a composite measure, is the more reliable of the two, hence the first of these correlations (r = 0,92) is considered the more significant. With such a high correlation between values derived from this simple weighting model and the better direct measure of overall job satisfaction, it was decided to adapt this model for the purpose of the present study.

Pearson also made use of this model in his 39-factor instrument discussed earlier (Bailey and Pearson, 1983). However, the R-score method makes three fundamental departures in its application of the same. Firstly, it assumes that weighted responses to *dissatisfaction* with various facets of a system and its manner of implementation will give a valid measure of overall *dissatisfaction*. It is difficult to see why all the arguments which apply to weighted measures of satisfaction cannot also apply to its antipode, dissatisfaction, hence this variation was assumed valid. Secondly, the R-score method assumes that overall dissatisfaction gives a valid measure of its surrogate, *user resistance*. This stems directly from the discussion above so long as it is understood that only those forms of resistance measured by overt expressions of dissatisfaction are intended. Finally, the facets of dissatisfaction are not pre-specified, but are enumerated by the respondent (that is, the user) himself. This was justified in terms of Wanous and Lawler's model by rating any complaint raised by the user with *unit importance* (and, of course, those not raised by the user with *zero importance*). This meant that the R-score could be measured simply by summing the user's dissatisfaction ratings for his own complaints against the system. In mathematical terms, the R-score, *R*, after the user has made *n* complaints in respect of the system and/or its manner of implementation, can be expressed as

$$R = \sum_{i=1}^{n} s_i , \qquad \text{f 3.2}$$

where s_i is defined as the severity of complaint *i* to the user, rated on the following seven-point scale:

(7) a totally insoluble problem

(6) a very serious problem

(5) a serious problem

(4) a rather serious problem

(3) a significant problem

(2) a slight problem

(1) not really a problem (see Appendix D)

In dealing with system satisfaction, Pearson replaced the term *facet* by the term *factor*. In the case of the R-score method, the term has undergone a further change to *complaint*. The R-score, then, is the *sum of the severities of the complaints which a user will make to an independent consultant, in private, in respect of a system and/or its manner of implementation.*

In the light of the previous discussion, the R-score was assumed to be a valid measure of user resistance, despite its novelty. Of course it can be argued that the R-score might change with the nature of the researcher conducting the interview. It was beyond the scope of this study to investigate such a conjecture, but since it was sufficient to show resistance in the relative sense only (comparing resistance between systems investigated by the same person), this criticism was not considered significant.

3.3 The choice of an instrument to measure cognitive style

From the discussions in Section 2.4, three instruments emerge which could provide measures of cognitive style; Jackson's Personality

Research Form (PRF), the Embedded Figures Test (EFT) of Witkin, et al., and the Kirton Adaption-Innovation Inventory (KAI).

Jackson's PRF tests twenty respondent needs, based on Murray's variables of personality (Woodruff, 1980). These include ratings for cognitive structure and the need for change. Together, they encompass most of the characteristics of cognitive styles as outlined by Kirton (Appendix A). However, some doubt has already been expressed against this self-report questionnaire on the grounds that a bias towards those respondents who tend to complete and return questionnaires is possible. Furthermore, the length of the instrument is increased by the measurement of twenty needs, only two of which were required for this study. This instrument was thus rejected in favour of an option more specifically devoted to cognitive style.

The choice thus remained between the EFT and the KAI. It has already been noted that both are reliable tests capable of rating cognitive style, and both provide valid results (see Section 2.4). However, the KAI is a somewhat more modern instrument than the EFT, and EFT literature is cited in the KAI Manual (Kirton, 1987). It was therefore thought that the KAI might be the more reliable test, since its development could have benefitted from research experience with the EFT. It is admitted that this argument is at the best tenuous, so a more rigorous test was applied. If Adaption-Innovation theory could explain most of the results obtained in the research discussed in Chapter 2, it was decided that the KAI would be selected. Should AI theory be valid for the IS developer-user interface, then findings elsewhere in the literature would be consistent with AI theory even though these findings were not, of themselves, so intended. If such findings were shown to be consistent with AI theory where researchers worked without knowledge of AI theory, a strong case would have been provided for using AI theory and replicating the KAI instrument in the IS area.

A consequence of AI theory is that a person will exhibit less resistance to ideas put forward by another of similar cognitive style (see Section 2.4). The reason for this is that persons of similar cognitive style tend to approach problem-solving in a similar way, sharing similar paradigms regarding the approach to any proposed joint operation (Kirton, 1984). To show the validity of AI theory in the IS area it therefore is sufficient to sift through the evidence provided in Chapter 2, to test whether reported findings are generally consistent with this theory.

In the case of Woodruff's survey of IS people, it has already been noted that questionnaires were most likely completed on a voluntary basis, and hence his sample was biased towards the more conscientious respondents (see Section 2.6). As adaptors are claimed to be more prudent, efficient and methodical than innovators (Appendix A), the risk inherent in this survey could be one of bias towards adaptive IS people. The findings therefore should correspond with descriptions of adaptors in AI theory; a testable conjecture.

Woodruff found that those IS people in his sample had higher-than-normal needs for achievement, cognitive structure and endurance (Chapter 2, Section 2.4). These correspond well with "authority within given structures", "seeks solutions . . . in tried and understood ways", and "impervious to boredom", which are descriptions of adaptors. In addition, Woodruff found that his sample exhibited an above-average need for harm-avoidance (see Section 2.4). This certainly would be consistent with the characteristic of providing a "safe base" for more risky operations; another adaptive trait. Two needs were found by Woodruff to be lower in his sample than in the general population; the need for aggression and social recognition (Section 2.4). Once again, these are easily associated with corresponding descriptions of adaptors. Adaptors, being typically sensitive to people, and able to bring about group cohesion are unlikely to exhibit over-much aggression. Furthermore, adaptors tend to high self-doubt, quite consistent with a low need for social recognition (see Appendix A for a complete description of "adaptors" and "innovators").

As stated in Section 2.4, Lusk and Kersnick (1979) used the EFT to classify respondents as "high analytic" or "low analytic". These groupings correspond approximately to "adaptors" and "innovators". They found that the "high analytic" group performed the same set task with greater efficiency than the "low analytic" group did. As high efficiency is a key feature of adaptors (Appendix A), this result is consistent with AI theory. As there was this agreement between their study based on the EFT and AI theory, evidence is provided that the KAI is at least as satisfactory as the EFT for assessing cognitive style.

The study by Huber (see Section 2.4) is significant to this research, because it represents a departure from the trend to match a user cognitively to a system's characteristics; that is, to design a system which is "cognitively suitable" for the user. Huber (1983) doubts that such an approach will ever be fruitful, but does suggest that personnel selection and placement may be a useful outcome of cognitive style research. These conclusions again are consistent with AI theory, since AI theory applies only to style-comparisons between *people*; never to style-comparisons between persons and *devices*; computer systems or otherwise. As far as placement of personnel is concerned, the possibility is certainly suggested that cognitive style research can help in the matching of the most compatible systems developers to a given user, or vice versa.

De Brabander and Thiers stress the role of the "semantic gap", or problem-definition differences between users and developers as a cause of user resistance (see Section 2.2). Quite clearly, the way a person defines problems and relates elements of problems will be highly related to his problem-solving style. Consequently, a "semantic gap" may well be nothing else than a symptom of a difference in cognitive style. This makes these authors' findings completely consistent with the predictions derived from AI theory.

One area of the research apparently in some disagreement with AI theory, is the study by Bruwer (see Section 2.4). Sufficient can be inferred from his study to suggest the belief that the ages and lengths of service of users are positively associated with user resistance. According to AI theory, people exhibit a *stable* preference for either an adaptive or an innovative approach. Consequently, neither ages nor lengths of service, either in the absolute or relative sense (see Section 3.7), should be associated with user resistance. It will be noted that this study would be in as much conflict with cognitive style theory whether the KAI or the EFT were chosen as a measuring instrument.

In all instances but for the study by Bruwer discussed above, the significant prior research supports AI theory for the IS arena. This means that justification exists for applying AI theory and the KAI instrument directly (and in preference to others) to the IS developer-user interface.

Since the KAI instrument was devised by Kirton, it was considered important to establish the credibility of Kirton himself as a cognitive style theorist in the occupational psychological field. Some of the journals containing his publications (or joint publications) are listed in Table 3-1.

Table 3-1

Journals containing articles by (or jointly by) M. J. Kirton

Journal of applied psychology	1976, 61, pp 622-629
Psychological reports	1977, 41, pp 289-290 1978, 42, pp 695-698 1980, 46, pp 1321-1332 1980, 46, p 950 1982, 51, pp 883-886 1985, 57, pp 487-490 1985, 57, pp 1067-1070
Current anthropology	1978, 19, pp 611-612
Perceptual and motor skills	1978, 47, pp 1239-1245
Human relations	1980, 3, pp 213-224
Planned innovation	1980, 3, pp 51-54
Long range planning	1984, 17, pp 137-143
Personality and individual differences	1986, 7, pp 141-146
R & D Management	1987, 17, pp 163-166
Journal of occupational psychology	1988, 61, pp 175-184

(Kirton, 1987)

In addition, Kirton has been cited by other scholars as recorded in Table 3-2.

Table 3-2

Number of times that Kirton has been cited by other authors

Period	Number of citations
1975 - 1980	19
1981 - 1985	55
1986	39
1987	40
January - April, 1988	5

(Social Science Citation Index (SSCI) of the Institute for Scientific Information (ISI))

Kirton's research and studies related to AI theory, having been represented in several respected research journals (Table 3-1), and having been cited by other experts (Table 3-2), were assumed credible in this study. The Kirton Adaption-innovation Inventory (KAI) was thus ultimately selected to measure analyst and user cognitive problem-solving styles.

3.4 The role of cognitive problem-solving styles

A submission based on AI theory, made earlier in this chapter (see Section 3.1) was that user resistance is associated with differences in developer-user cognitive problem-solving styles. This can now be stated as the following hypothesis:

H_1: *The user's R-score is positively associated with the absolute analyst-user KAI score difference for a given information system.*

3.5 The ability of adaption-innovation theory to predict aspects of the analyst-user interface

From the discussion of AI theory earlier (see Section 2.4), inferences can be drawn for particular cases of the analyst-user interface. To measure such aspects required a further data collection technique. It was decided to use the seven-point scale method (as did Wanous and Lawler, 1972), on which the user could quantify his reactions and opinions. In fact, apart from the demographic data, the R-score, and the KAI score, all user-related data were collected in this manner (see Appendix D).

Further hypotheses were thus formulated for testing. For example, a user should tend to see an analyst who is more innovative than himself spend surprisingly little time studying the system requirements. This follows from the tendency of innovators (Appendix A) not to wed themselves too long to any system, and to seek continued novelty of activity. Since the user will consider the analyst an "expert" (lacking in the beginning a frame of reference to consider him anything else), he should also assume that the analyst has absorbed all the details in this surprisingly short time. The degree to which a user will see the analyst as more innovative or adaptive than himself is measurable as the algebraic difference between their KAI scores. Hence the hypothesis:

$H_{2(a)}$: *The analyst-user KAI score difference is positively associated with the user's seven-point rating of how quickly the analyst absorbed (grasped) the system requirements.*

According to the behaviour descriptions of adaptors and innovators in Appendix A, innovators tend to pursue a course of action with more apparent certainty than do adaptors. This leads to the obvious conjecture that an innovative analyst, when dealing with an adaptive user, will tend to follow his own ideas rather than to pay over-much attention to the user. The adaptor, prone to high self-doubt, would be expected to give in to the analyst's views. Hence:

$H_{2(b)}$: *The analyst-user KAI score difference is positively associated with the user's seven-point rating of the extent to which the analyst followed his own ideas and/or ignored the user's opinions.*

Innovators, with their predilection for novelty, would be expected to add to the system development effort extraneous features, which the more adaptive user would consider unnecessary and time-wasting. This suggested the hypothesis:

***H*$_{2(c)}$:** *The analyst-user KAI score difference is positively associated with the user's seven-point rating of the extent to which the analyst wasted time on peripheral issues.*

The converse of the above would also be expected; namely, that a more *adaptive* analyst would tend to concentrate too much on a *limited problem area*, and not foresee all the facilities that a more innovative user would expect. This follows from the adaptor's tendency to "do well", perfecting each stage of development, and needing to be "dug out" in order to progress to the next (see Appendix A). The corresponding hypothesis is thus:

***H*$_{2(d)}$:** *The analyst-user KAI score difference is negatively associated with the user's seven-point rating of the extent to which the analyst concentrated on a limited problem area.*

Innovators are often seen as abrasive, creating dissonance (see Appendix A). Hence, a measure of dissonance would be expected to exist between individuals who differ markedly in cognitive style. In addition, Bailey and Pearson (1983) found that a user's relationship with the IS staff, as well as the attitude of the IS staff, influenced user satisfaction. By "attitude", Bailey and Pearson were referring to the analyst's willingness to assist the user. It is doubtful that a user would report friction between himself and the analyst, and then describe their relationship as sound, and the analyst as helpful. Consequently, the user's ratings of these three factors should be highly correlated. The testing of hypotheses based on them all was undertaken for the purposes of cross-validation. The corresponding hypotheses were:

$H_{2(e)}$: *The absolute analyst-user KAI score difference is positively associated with the user's seven-point rating of the extent to which there was dissonance with the analyst.*

$H_{2(f)}$: *The absolute analyst-user KAI score difference is negatively associated with the user's seven-point rating of his relationship with the analyst.*

$H_{2(g)}$: *The absolute analyst-user KAI score difference is negatively associated with the user's seven-point rating of the analyst's willingness to assist him as the user.*

3.6 The roles of factors associated with user satisfaction

In Section 2.5, the key factors thought by Pearson, and Rushinek and Rushinek, to play a role in user satisfaction were identified. As it is of interest to see how their approaches compared with that of this study, a short-list of user-satisfaction factors was drawn up. Negative associations were then postulated between these factors and the R-score.

System output *accuracy* and *reliability*, for example, were selected. Bailey and Pearson found these factors to be the most significant measures of user satisfaction in their study (see Section 2.5). It can be conjectured that such aspects are obvious requirements which would be imposed by any reasonable user. Since most other factors specified would bear directly on the efficiency and effectiveness of operation of the user and his department (see Section 2.5), *contribution to organizational efficiency and effectiveness* was a third item chosen.

As previously mentioned, *dissonance* (or lack thereof) between the user and the analyst is probably associated with the quality of the user's relationship with the analyst and the attitude of the analyst. Consequently, these last two factors were added to the list as well.

The hypotheses tested in respect of the above were thus:

$H_{3(a)}$: *There is a negative association between the user's R-score and his seven-point rating of the system's level of accuracy.*

$H_{3(b)}$: *There is a negative association between the user's R-score and his seven-point rating of the degree he can rely on the system's output information.*

$H_{3(c)}$: *There is a negative association between the user's R-score and his seven-point rating of the system's contribution to organizational efficiency and/or effectiveness.*

$H_{3(d)}$: *There is a negative association between the user's R-score and his seven-point rating of his relationship with the analyst.*

$H_{3(e)}$: *There is a negative association between the user's R-score and his seven-point rating of the analyst's willingness to assist him as the user.*

3.7 The roles of age and length of service

After examination of the study by Bruwer in Section 2.6, beliefs were identified that older and/or more experienced users in the organization will be most resistant to new computer systems. These beliefs infer the following hypotheses:

$H_{4(a)}$: *A user's R-score for a given information system is positively associated with his age.*

$H_{4(b)}$: *A user's R-score for a given information system is positively associated with his length of service in his organization.*

It is possible to investigate alternative cases of the above to give more complete testing; these are, that *relative* ages and *relative* lengths of service are significant. Hence the following further hypotheses were added:

$H_{4(c)}$: *A user's R-score for a given information system is positively associated with the absolute difference between his age and the analyst's age.*

$H_{4(d)}$: *A user's R-score for a given information system is positively associated with the absolute difference between his and the analyst's lengths of service in the same organization.*

The precise methodologies used to test all the hypotheses developed in this chapter are dealt with in Chapter Four. The analysis of the data and the results are then discussed in detail in Chapter 5.

Chapter 4

The research methodology and design

4.1 Introduction

To test the hypotheses developed in Chapter 3, measurements were required of cognitive problem-solving style using the KAI, user resistance using the R-score method, ages and lengths of service, and the responses of users and analysts, quantified using seven-point scales. In addition, certain precautions had to be taken. For example, to fulfil the conditions of confidentiality (see Section 3.2), user data had to be collected at personal, confidential interviews by the author, who travelled to the users' places of work. At these interviews, every attempt was made to impress upon each user that his responses were to be recorded in complete secrecy. With such points in mind, this chapter aims to describe fully the research instruments and research procedure used.

4.2 The research instruments

The research instruments used in this study were: the KAI instrument and feedback form, obtained directly from Professor Kirton (see Appendices B and C); the System Satisfaction Schedule, constructed specially for this research (see Appendix D); and the Analyst Interviewing Form, also produced specifically for this study (see Appendix E).

The KAI instrument is a single sheet of 33 trait-descriptions, against each of which the respondent is requested to rate himself. Using the first trait-item (see Appendix B) as an example, he is asked to consider how easy or difficult he finds it to present himself in the long term as "a person who is patient". He indicates his rating by making a cross on a scale of closely spaced dots, which represents a range from "very hard" to "very easy". The remaining 32 traits are then rated similarly. The first trait ("a person who is patient") is a "blind"; that is, it is not assessed. The form is in two parts bonded together at the edges so that the under-sheet is not visible to the respondent during administration. The under-sheet is sensitized and printed with a grid to facilitate scoring once the sheets have been separated. The top sheet has adequate instructions to the respondent, clearly presented. Likewise, the under-sheet has clear directions for scoring, reducing the possibility of errors on the part of the researcher. The KAI has a theoretical mean of 96, a theoretical range of 32 to 160 and standard deviation of 17,7 based on Kirton's overall sample of 808 respondents. The internal reliability for the KAI has been established with Cronbach alpha ranging from 0,76 to 0,91 over 14 studies. The test-retest reliability is given in the KAI Manual as ranging from 0,82 to 0,912 over 4 studies (Kirton, 1987).

The conditions for administration of the KAI are that the respondent must be comfortable, free from interruptions and not pressured time-wise (Kirton, 1987). Kirton encourages researchers to offer feedback to the respondents as "ethical psychological testing practice" (Kirton, 1987). This is done with the aid of a specially prepared feedback form supplied with the test (see Appendix C).

The other instruments were constructed with a few more precautions in mind, specific to the needs of this study. Firstly, age and length of service needed to be measured, to test hypotheses $H_{4(a)}$ to $H_{4(d)}$. These were recorded amongst other demographic information near the beginning of the interview.

In order to build up an information profile on each analyst and user, the Analyst Interviewing Form (Appendix C) and the System Satisfaction Schedule (Appendix D) call for responses to suitably phrased questions. After the method of Wanous and Lawler (see Section 3.2), a seven-point scale is supplied with each to facilitate the quantification of the responses. The questions were arranged in an order which it was assumed approximates the chronological order in which systems generally evolve. This was intended both to act as an aid to the respondent's memory, and to distract him from the real trends and issues underlying the research. The latter was assumed important to prevent him from anticipating results and structuring his responses accordingly.

It was made clear early on in the System Satisfaction Schedule that confidentiality would be maintained. The user's name was not entered on this form to emphasize that he could not be held accountable for his responses to anyone in the future.

4.3 The research procedure

Ten organizations in the Cape Town and Johannesburg areas willing to allow their IS staff to be interviewed and to respond to the instruments required for this study participated (see Acknowledgements). Within these organizations, thirty-four live (post-implementation) systems were selected. IS Managers in the organizations identified a few systems each, which they considered had exhibited a "fair range" from low to high user resistance. In addition, these systems had all been in operation for between two and twenty-six months, and in each case, both a key analyst and key user could be identified.

First the analyst was interviewed, since he could supply details of the user; most particularly, where the key user could be located. This information was recorded on an Analyst Interviewing Form (see Appendix E), together with the analyst's age and length of service. At the end of this interview, the KAI was administered to the analyst. Every effort was made to ensure that standard testing conditions prevailed during the administration of the KAI. However, as the author was not always in complete control of the interviewing environments, some interruptions did occur in the form of telephone calls and unexpected visits. These interruptions were relatively few, and were consequently assumed to have negligible effects on the results. In each case, the KAI was scored, the KAI report-back form was completed, and the results were discussed with the respondent.

Following this, the user was interviewed, and a System Satisfaction Schedule (see Appendix D) was completed. At the end of the interview, the KAI was administered to the user. The procedure and circumstances of the user interviews and KAI administration were similar to those described above for the analysts.

Except for the KAI form, the approach was taken that the author and the respondent were to complete the relevant instruments together. Consequently, the respondent witnessed and ratified all his own responses as recorded by the author.

It can be argued that the R-scores might have been at least partially generated by the author. What he wrote down may merely have been his *own interpretation* of what the user told him. However, as only the *number* and *intensity* of the user's complaints are relevant (see Section 3.2), it is difficult to see how the author's interpretation of these complaints could have invalidated the results.

Of greater significance is the question of whether or not the author distinguished complaints in a consistent manner. With this in mind, notes were carefully taken at each interview of any unusual occurrences and responses, and how they were handled. Similar action was thus ensured where similar circumstances arose subsequently. For example, experience soon showed that responses to seven-point scales required special handling, because several of the respondents could not remember all the options at once. Even though the respondent was shown the form, he often required help in making his assessment. This assistance was given in the form of a two-tiered approach. First, the respondent was asked to make a crude assessment out of options 2, 4 and 6, and then he was asked to refine his choice by making a selection within one of his original choice. For example, if he first chose option 6, he would then be asked to make a final assessment out of 5, 6 or 7.

Another problem which was soon detected, was that of repetition of the same complaint during the measurement of the R-score. In all cases where the author thought that the user had repeated a complaint, he responded as follows:
"I seem to have misunderstood, because I cannot tell the difference between that problem and a previous one you mentioned, which I have down as, "; and then the previous "problem" (complaint) was read. The user was thus effectively given the opportunity either of withdrawing the complaint, or of explaining why it was materially different from the previous one. If the user insisted that there was a material difference, the "repetition" was recorded as a separate complaint.

The criticism that the author had consciously or unconsciously recorded points of complaint to correlate with KAI scores and/or differences was counteracted in the research design as follows: the user R-score was measured close to the beginning of the interview, before the author had measured the user's KAI score, and before the author became well enough acquainted with the user to make a reliable guess of his KAI score. Other questions on the System Satisfaction Schedule were not asked until after the R-score had been measured in the case of a user, once again to avoid guesses on the part of the author as to the user's cognitive style.

The results of the research are enumerated and discussed in detail in Chapter 5, after a thorough discussion of the data analysis procedure.

Chapter 5

Findings and discussion

5.1 Introduction

This chapter starts with an examination of the research tools used, followed by a discussion of the results and an assessment of their impact on IS practice. As a first step the statistical methodologies are examined, so that the soundness of the theoretical base on which the analysis rests can be assessed. In this regard the method used to test for the associations postulated by the research hypotheses is of particular interest.

After a discussion of the above, the data, together with a preliminary analysis to determine basic statistics and distribution patterns, is presented. This is followed by the formal testing of the hypotheses, the results of these tests, and the discussions arising therefrom. The relevance of each finding to the practice of systems analysis is included in the discussions.

5.2 Statistical formulae and sample size

Mathematicians and statisticians frequently use differing conventions in their expression of formulae. On occasion therefore, formulae and/or parts of formulae quoted in this thesis have been replaced by mathematically equivalent forms for the sake of overall consistency. Of particular note, the symbol t denotes a *sample statistic*, whilst τ represents the corresponding *population parameter*.

In this study, thirty-four systems were researched, hence the data is divided into several univariate samples of thirty-four (that is, sample-size $n = 34$ in all cases).

5.3 Levels of significance

The process used to test associations in the bivariate populations, as postulated by the research hypotheses, involves the testing of corresponding *null hypotheses of independence*. This process is in accordance with the method described by Kendall (1970) and Liebetrau (1983). Liebetrau further indicates that this approach is an accepted one in the social sciences research area; an area to which this study belongs. Fortunately, tests for independence tend to be mathematically more tractable than those for specific non-zero associations (Liebetrau, 1983).

The significance level (p) is the probability of rejecting the null hypothesis of independence when the null hypothesis is, in fact, true. Consequently, the lower p is, the greater the probable strength of the association in the population. The problem arises in deciding at which level of p an alternative hypothesis can be decisively accepted (or, for that matter, decisively rejected). There are no purely statistical criteria for making such a decision, and precedents have to be sought within the research discipline concerned, or within closely related disciplines. Consequently, the actual levels employed in this study were based on the opinions found in human science and statistical literature. These opinions are summarized in Table 5-1.

Table 5-1

Ratings of significance levels for non-parametric statistics

Sig. level	Statistic	Opinion(s) of p	Source
p < 0,001	t	"very small" -Kendall (1970)	S
	r	"significant" -Kirton (1985)	P
p < 0,010	t	"small" -Kendall (1970)	S
	t	"significant" -Ettlie (1985)	M
	r	"significant" -Kirton (1985)	P
p < 0,025	w	"significant" -Weiss (1983)	I
p < 0,050	t	"small" -Kendall (1970)	S
	t	"significant" -Ettlie (1985)	M
	r	"significant..caution.." -Olson and Ives (1981)	I
p > 0,100	w	"not statistically significant" -Lusk and Kersnick (1979)	I

r = Spearman's rank correlation co-efficient
t = Kendall's rank correlation co-efficient
w = Wilcoxon rank-sum statistic

Source: (class of literature)
I - IS, M - Managerial, P - Psychological, S - Statistical

Based on the opinions of respected experts as recorded in Table 5-1, the qualitative ratings listed in Table 5-2 were assumed for this study.

Table 5-2

Qualitative ratings assumed for significance levels

Significance level	Qualitative ratings
$p \leq 0,001$	Highly significant Null hypothesis strongly rejected Alternative hypothesis strongly supported
$0,001 < p < 0,050$	Significant Null hypothesis rejected Alternative hypothesis supported
$0,050 \leq p \leq 0,100$	Not very significant No strong reason to reject null hypothesis Weak support for alternative hypothesis Inconclusive result
$p > 0,100$	Not significant No reason to reject null hypothesis No support for alternative hypothesis

5.4 Normality of the data

It is known that approximately normal distributions of data occur as a result of many kinds of experiments (Huntsberger et al, 1973). If a sample is approximately normally distributed, therefore, then the probability is that the measuring procedure was reliable. The converse, of course, is untrue. If a sample is not approximately normal, this does not discredit the measuring procedure, since the parent population itself could be far from normal for the measure concerned. Consequently, the presence of normally distributed data supports the measurement method as reliable. On the other hand, lack of normality yields *no information* regarding the success (or otherwise) of the measuring technique.

The normality of each univariate data sample was tested using a goodness-of-fit test of the Chi-square type. The reason for doing so was two-fold: to check the reliability of the measuring techniques used and to compare data obtained in this study with that obtained in others (see Section 5.8). The procedure used to test for normality is discussed in Appendix F. This tests normality of distribution as a *null hypothesis*. It gives rise to χ^2 values, which can be compared with critical values in tables (Hawkins et al, 1980). In accordance with Table 5-2, the levels of significance used to measure the extent of normality suggest that $p < 0,05$ implies a significant departure from normality, and $p > 0,10$, no significant departure (that is, approximately normal).

5.5 Measures of association

Next, consideration is given to the means of measuring association used in this study. Of the three choices of non-parametric statistic listed in Table 5-1, two are appropriate; namely Spearman's rank correlation co-efficient (r_s), and Kendall's rank correlation co-efficient (t). These estimate the corresponding population parameters, ρ_s and τ and hence the association between two population variables. Each ranges from -1 (for perfect negative association) to +1 (for perfect positive association), whilst in both cases the value 0 indicates independence as a zero association (Liebetrau, 1983). Either statistic could have been used as a measure of association in this study. In fact, the values and significance of *both* these statistics were evaluated for all hypotheses, (see Appendix G) since different statisticians apparently exhibit a preference for either one or the other. For example, Hawkins and Weber (1980) prefer t to r_s on the grounds of mathematical tractability and t's smoother distribution, which better approximates the normal distribution. Sachs (1982), on the other hand, points out that the power of a test (testing for the non-null condition), for the same level of significance is smaller for t than for r_s.

Liebetrau (1983) notes that t is more easily interpreted than is r_s. If two data pairs (X_1; Y_1) and (X_2; Y_2) are chosen at random from the bivariate population (X; Y), they are said to be *concordant* if $X_1 > X_2 \Rightarrow Y_1 > Y_2$. If the converse applies, they are said to be *discordant*. t then is the probability that the two pairs are concordant *less* the probability that they are discordant. The parallel interpretation for r_s is more complex, hence without loss of credibility only analyses involving t are considered further in this study. For a full discussion of the calculation of t and r_s and a complete list of results for both statistics, refer to Appendix G.

Of more importance is the question of *ties* in the data. Ties have to be accounted for in one of two ways, corresponding to one of two possible situations. These situations are (Kendall, 1970), a measure of association between a subjective assessment and a known, objective order (case (a)), and a measure of association between two subjective assessments (case (b)). Ties in a case (a) situation do not represent agreement, whilst in a case (b) situation they do (Liebetrau, 1983). Ties were taken into account as discussed in Appendix G, yielding two sets of t statistics, appropriately denoted t_a and t_b. Evidently serious errors can be expected if tying is extensive (Liebetrau, 1983) unless use is made of the appropriate tie-case formulae. In this study, tying occurred in all data samples (see Appendix H). Furthermore, several of the data were collected using seven-point scales to quantify user opinion. Ties clearly occurred extensively in these cases, since each sample (of 34 data) was distributed over seven possible responses. Reliance in this study was thus only placed upon statistics which were calculated using tie-case formulae.

As to which of the hypotheses should be tested as case (a) and which as case (b) situations, there is justification to test all as case (b) situations. This follows from the fact that each hypothesis merely asserts agreement between two subjective assessments. However, there is a reason for studying the hypotheses as case (a) situations as well. This is that inferences were required which assumed that one of the variables was able to decide a *quasi* objective order. KAI scores, for example, with their strong research support and tendency to normal distribution, fulfilled such a role on occasion (see Section 5.10).

5.6 Testing the significance of the measured association

Kendall (1970) claims that for $n > 10$, methods based on normal distribution theory can be used for testing the significance of t_a and t_b. The formulae for the variances and standard normal statistics required to test the significance of the associations are given in Appendix G. These formulae hold only for the null hypothesis (Liebetrau, 1983). However, as previously discussed (Section 5.3), this is entirely satisfactory for the current study. It will be noted from Appendix G that where only significance is to be tested, it makes not the slightest difference whether t_a or t_b be used as the measure of association.

5.7 Presentation and preliminary analysis of raw data

The batch of instruments for each system was assigned a unique system number in the integer range 1 to 34 inclusive. The raw data were then stratified into those univariate samples identified in Table 5-3 which have been listed without asterisks. Further samples were determined for investigative purpose, some of which were required for the testing of certain of the hypotheses. These samples, which needed to be derived from the others, have been denoted in Table 5-3 with asterisks.

Table 5-3

Data samples

User **R-scores**
Analyst KAI scores
User KAI scores
Mean KAI scores (user and analyst) *
Analyst-user **KAI** score *differences* (**ΔKAI**) *
Absolute analyst-user **KAI** score differences (**|ΔKAI|**) *

User opinions (7-options) of the systems analysts
in the following respects:
their **Speed of Comprehension** of system requirements
the extent to which the **User**'s opinions were **Ignored**
the **Time Wasted** on peripheral issues
the tendency to remain within a **Limited** problem **Area**

User opinions (7-options) of
the level of **Design Detail** (too much or too little)
the **Contingency-Coping** ability of the design
the level of **Dissonance with analyst**
the extent of the **Debugging Effort**
the extent of the **Enhancing Effort**
the level of **Manual Detail**

User opinions (7-options) of the systems in the
following respects:
their **Accuracy of Output**
their **Reliability**
their contribution to **Efficiency**/effectiveness of user operations

User opinions (7-options) of
their **Relationships with the Analysts**
the **Attitudes of Analyst**

Analysts' Ages (Years)
Users' Ages (Years)
Analysts' ages less users' ages (**ΔAge**) *
Absolute analyst-user age differences (**|ΔAge|**) *

Analysts' Lengths Of Service (**LOS**) (Years)
Users' Lengths Of Service (**LOS**) (Years)
Length-of-service differences (Analyst - User) (**ΔLOS**) *
Absolute Length-of-service differences (**|ΔLOS|**) *

* Determined from corresponding data in other samples

N. B. The bold letters, words and phrases indicate the abbreviations used elsewhere in this text

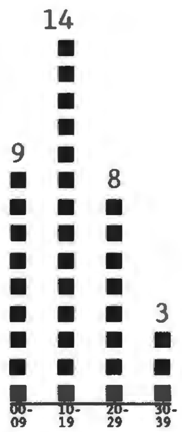
The mean and standard deviation were calculated for each sample, which was then tested for goodness-of-fit to the normal distribution (see Appendix F for the method). For the sake of clarity, approximate frequency distributions of all the samples were determined. The raw data are shown in the Tables H-1 to H-4 of Appendix H. Preliminary analyses of the data are found in Tables 5-4 to 5-7. These analyses will be discussed in the next section.

Table 5-4

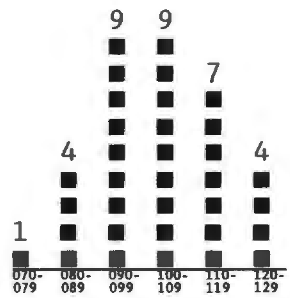
R-scores and KAI scores:

Frequency distributions and normality Tests

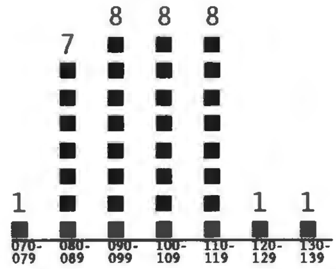
(All sample sizes: 34)



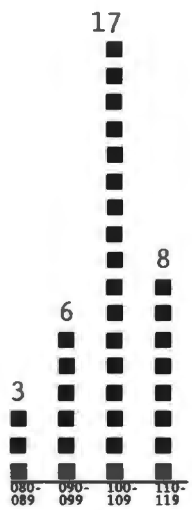
R-scores
$\chi^2 = 0,41$
$p > 0,80$ (vn)



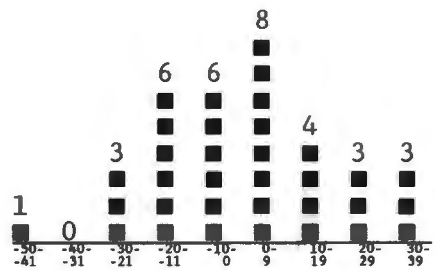
Analyst KAI Scores
$\chi^2 = 1,88$
$p > 0,30$ (n)



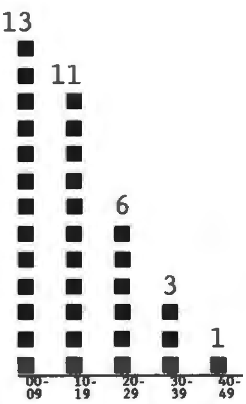
User KAI Scores
$\chi^2 = 1,59$
$p > 0,40$ (n)



Mean KAI Scores
$\chi^2 = 3,06$
$p > 0,20$



Analyst less User KAIs
$\chi^2 = 1,29$
$p > 0,50$ (vn)



|KAI differences|
$\chi^2 = 3,65$
$p > 0,10$

(xn): "Not normal": $p < 0,05$
(n): "Approximately normal": $p > 0,30$
(vn): "Very normal": $p > 0,50$
χ^2, p: Normality test statistics (see Appendix F)

Table 5-5

User opinions of the analysts and their problem-solving styles

Frequency Distributions and normality tests

(All sample sizes: 34)

Response*	1	2	3	4	5	6	7	χ^2	p
Variable									
Speed of Comprehension	0	3	2	9	7	9	4	3,06	>0,200
User Ignored	2	4	16	1	1	6	4	23,94	<0,001 (xn)
Time Wasted	0	0	1	2	2	18	11	35,12	<0,001 (xn)
Limited Area	0	2	8	4	2	11	7	8,65	<0,025 (xn)
Design Detail	3	4	2	21	3	1	0	41,00	<0,001 (xn)
Contingency Coping	2	5	4	7	2	12	2	12,18	<0,005 (xn)
Dissonance with analyst	17	8	0	1	5	3	0	29,82	<0,005 (xn)
Debugging Effort	1	6	8	13	2	3	1	12,76	<0,005 (xn)
Enhancing Effort	5	4	10	8	2	5	0	9,24	<0,010 (xn)
Manual Detail	8	2	2	19	1	1	1	31,00	<0,001 (xn)

* The seven-point scales produce ratings from 1 to 7 inclusive, where 7 implies the *greatest extent possible* for each item.

(xn): "Not normal": $p < 0,05$
(n): "Approximately normal": $p > 0,30$
(vn): "Very normal": $p > 0,50$
χ^2, p: Normality test statistics (see Appendix F)

Table 5-6

User Satisfaction/Dissatisfaction Factor Ratings:

Frequency distributions and normality tests

(All sample sizes: 34)

Response*	1	2	3	4	5	6	7	χ^2	p
Variable									
Accuracy of output:	1	2	1	3	5	13	9	15,65	<0,001 (xn)
Reliability of system:	2	1	0	2	6	14	9	17,71	<0,001 (xn)
Efficiency improvement:	2	2	1	7	6	7	9	2,09	>0,300 (n)
Relationship with analyst:	0	2	1	1	7	15	8	20,06	<0,001 (xn)
Attitude of analyst:	1	1	1	1	7	14	9	18,29	<0,001 (xn)

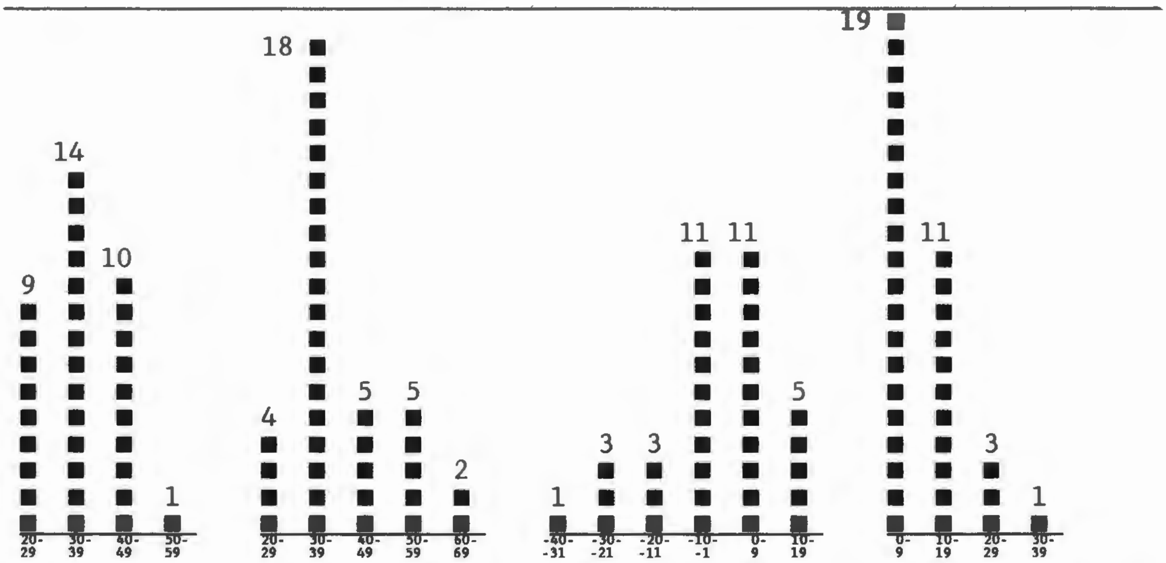
* The seven-point scales produce ratings from 1 to 7 inclusive, where 7 implies the *most favourable* response possible in each case.

(xn): "Not normal": $p < 0,05$
(n): "Approximately normal": $p > 0,30$
(vn): "Very normal": $p > 0,50$
χ^2, p: Normality test statistics (see Appendix F)

Table 5-7

Ages and LOS (Lengths of Service): Frequencies and normality tests

(All readings in years; all sample sizes: 34)

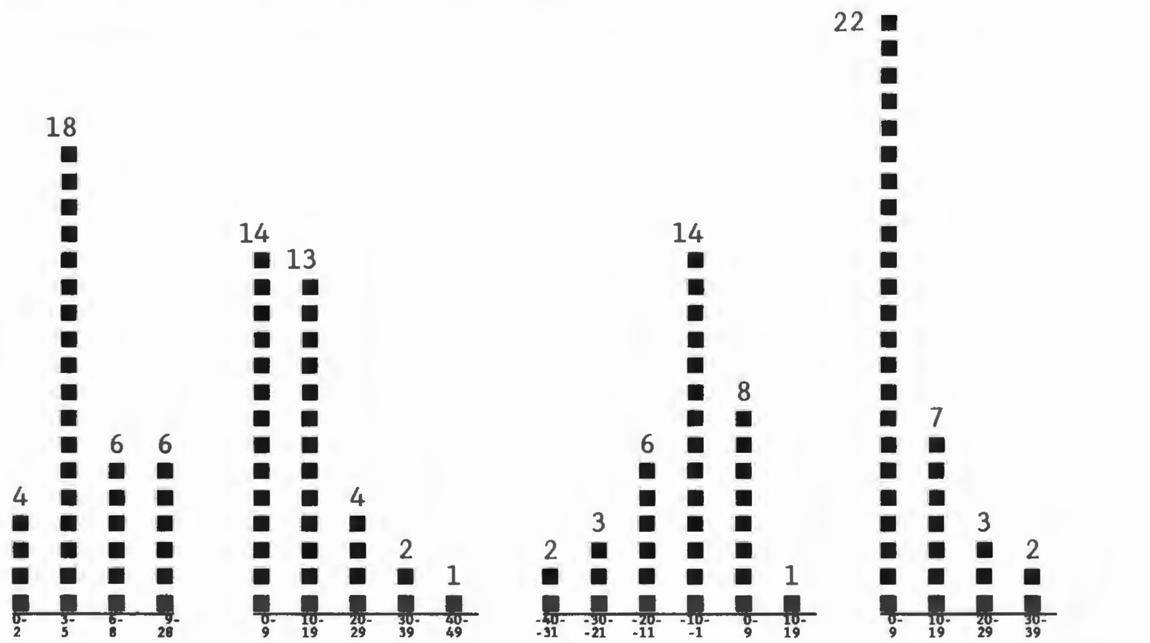


Analyst Ages $\chi^2 = 2,76$ $p > 0,20$

User Ages $\chi^2 = 7,76$ $p > 0,01$ (xn)

Age Differences $\chi^2 = 1,88$ $p > 0,30$ (n)

|Age Differences| $\chi^2 = 3,94$ $p > 0,10$



Analyst LOS $\chi^2 = 16,29$ (xn)

User LOS $\chi^2 = 7,76$ $p > 0,001$ (xn)

LOS differences $\chi^2 = 5,12$ $p > 0,05$

|LOS differences| $\chi^2 = 13,35$ (xn)

(xn): "Not normal": $p < 0,05$
(n): "Approximately normal": $p > 0,30$
(vn): "Very normal": $p > 0,50$
χ^2, p: Normality test statistics (see Appendix F)

5.8 The reliability of the data samples

From the distributions of the various univariate samples, reliability is indicated by normality in some cases. For example, the R-score sample tests strongly normal with $p > 0,80$ (see Table 5-4). The R-score method was thus accepted as a reliable measuring technique.

The means for the analyst and user KAI score samples are respectively, 102,9 and 101,6, whilst their respective standard deviations are 12,55 and 14,09 (see Table 5-4). Kirton's British sample of KAI scores for 562 persons exhibited a normal distribution with mean 95 and standard deviation 18 (Kirton, 1987). In studies cited by Kirton, in which the KAI scores for various occupational groups were determined, the means ranged from 78,3 to 114,0, and the standard deviations from 5,8 to 26,8 (Kirton, 1987). The two KAI-score samples obtained in this study thus exhibit basic statistics which are quite within established limits. These samples, as in the other studies mentioned, tested to be approximately normally distributed (see Table 5-4). In addition, the *differences* in KAI scores between users and analysts tested decidedly normal, with $p > 0,500$ (see Table 5-4).

Tables 5-5 and 5-6 (based on Tables H-2 and H-3 of Appendix H) display the preliminary analysis of the data collected by testing user opinion on seven-point scales. But for the items "Speed of Comprehension" in Tables 5-5 and H-2, and "Efficiency Improvement" in Tables 5-6 and H-3, the null hypothesis of normality in each case is rejected at a confidence level of 5 %. It has been argued in Section 5.4 that the measuring technique cannot be discredited without knowledge of the population distribution by such an occurrence. Nonetheless, caution should be exercised in the interpretation of results based upon these measurements since there is certainly a risk that the measuring technique used was unreliable. Experience with these scales confirmed this reservation. For example, the respondents at times tried to give intermediate responses, which were discouraged by the choice-presentation. Quite clearly, this would have limited tying in the data, producing preferences where none were actually recorded. A further problem encountered was unexpected responses which the wording of the seven options had not catered for. For example, with reference to the System Satisfaction Schedule (Appendix D), the users were asked to comment on the level of user manual detail (too much or too little). Some claimed that the important issue to them was the level of *technical* detail, not the level of detail per se.

Fortunately, reliable measures of association were still possible in the case of most of the non-normal, seven-option samples, where the responses could be meaningfully regrouped. Some sets of responses, for example, could be redefined as dichotomies or trichotomies. Kendall (1970) confirms that t_b is an appropriate measure in the case of such. Somewhat more confidence is thus indicated for measures where the responses can, on some legitimate criterion, be divided into two giving approximately 50 %, or three giving some 33 % of the readings in each class. Effectively, this means that an approximate maximum of 17 out of 34 readings should be present for any one of the options 1 to 7. On this basis, some faith can be placed in all but the samples "Design Detail" and "Manual Detail", which definitely do not meet this requirement (see Table 5-5).

An examination of Table 5-7 reveals that the user ages, analysts' lengths of service and users' lengths of service tested significantly non-normal. Another sample, analyst-user length of service differences, did not pass the test of normality strongly. For these samples the measuring technique cannot be in dispute, since it merely constituted the physical recording of periods of time. In any case, since all associations in this research were measured in terms of statistics which are not distribution-dependent, results based on these samples were assumed reliable.

5.9 The results

The hypotheses outlined for testing in Chapter 3 are summarized in terms of the associations to be tested, in Table 5-8.

Table 5-8

Hypotheses: Associations to be tested

H_1: User R-scores (R-score), versus
Absolute analyst-user KAI score differences ($|\Delta KAI|$)
(significant, **positive** association hypothesized)

H_2: Analyst-user KAI score differences (ΔKAI)
versus the following user opinions of the analysts:

- $H_{2(a)}$: their *speeds of comprehension* of system requirements (significant, **positive** association hypothesized)
- $H_{2(b)}$: extent to which they *ignored user opinion* (significant, **positive** association hypothesized)
- $H_{2(c)}$: extent to which they *wasted time* on peripheral issues (significant, **positive** association hypothesized)
- $H_{2(d)}$: the degree to which they confined themselves to a *limited problem-solving area* (significant, **negative** association hypothesized)

and Absolute analyst-user KAI score differences ($|\Delta KAI|$)
versus the users' opinions of:

- $H_{2(e)}$: the *dissonance* between themselves and the analysts (significant, **positive** association hypothesized)
- $H_{2(f)}$: their *relationships* with the Analysts (An Rel) (significant, **negative** association hypothesized)
- $H_{2(g)}$: the Analysts' *attitudes* (that is, their *helpfulness*) (significant, **negative** association hypothesized)

H_3: User R-scores versus User opinions of the systems
in the following respects:

- $H_{3(a)}$: the *accuracy of output* (significant, **negative** association hypothesized)
- $H_{3(b)}$: their *reliability* (significant, **negative** association hypothesized)
- $H_{3(c)}$: *contribution* to the *efficiency and/or effectiveness* of the users' operations (significant, **negative** association hypothesized)
- $H_{3(d)}$: their *relationships with the Analysts* (significant, **negative** association hypothesized)
- $H_{3(e)}$: the Analysts' Attitudes (An At) (significant, **negative** association hypothesized)

H_4: User R-scores versus

- $H_{4(a)}$: Users' ages (significant, **positive** association hypothesized)
- $H_{4(a)}$: Users' lengths of service (User LOS) (significant, **positive** association hypothesized)
- $H_{4(a)}$: Absolute analyst-user age differences ($|\Delta Age|$) (significant, **positive** association hypothesized)
- $H_{4(a)}$: Absolute Analyst-User Length-of-service differences ($|\Delta LOS|$) (significant, **positive** association hypothesized)

The associations were first computed and analyzed as Kendall's rank correlation coefficients (t_a and t_b) and then as Spearman rank order correlation co-efficients to ensure that no dissimilar conclusions could be reached (see Appendix G). Table G-1 was thus produced, of which Table 5-9 is an extract. The latter contains all the statistics required for further discussion.

Table 5-9

Tests of hypotheses: Statistical analysis

Hypothesis	t_a	t_b	p
H_1	,2888	,2981	,008 (s**)
$H_{2(a)}$	,1747	,1944	,068 (?)
$H_{2(b)}$	,1070	,1253	,171 (x)
$H_{2(c)}$	-,2389	-,3036	,014 (s*)
$H_{2(d)}$	-,1016	-,1142	,192 (x)
$H_{2(e)}$	,0695	,0853	,264 (x)
$H_{2(f)}$	,0036	,0043	,488 (x)
$H_{2(g)}$	-,0998	-,1180	,189 (x)
$H_{3(a)}$	-,3387	-,3922	,002 (s**)
$H_{3(b)}$	-,2478	-,2924	,015 (s*)
$H_{3(c)}$	-,0196	-,0219	,433 (x)
$H_{3(d)}$	-,1693	-,2025	,067 (?)
$H_{3(e)}$	-,1818	-,2156	,055 (?)
$H_{4(a)}$	,0749	,0773	,264 (x)
$H_{4(b)}$	,0909	,0943	,224 (x)
$H_{4(c)}$	,1462	,1521	,111 (x)
$H_{4(d)}$	,1159	,1208	,166 (x)

(s**) "significant" $p \leq 0{,}010$
(s*) "significant" $p \leq 0{,}020$
(s) "significant" $p < 0{,}050$
(?) "indecisive significance" $0{,}050 \leq p \leq 0{,}100$
(x) "not significant" $p > 0{,}100$

Sample Size: 34

N. B. All subjective assessments of *p* are as per **Table** 5-2

Table 5-10 contains a complete summary of the consequent findings.

Table 5-10

Summary of the findings

	Variables tested for association	Hypothesized Association	Finding
H_1:	R-score, $\|\Delta KAI\|$	s+	s+ **
$H_{2(a)}$:	ΔKAI, Analyst's speed of comprehension	s+	?+ #
$H_{2(b)}$:	ΔKAI, Degree analyst ignored user opinion	s+	x
$H_{2(c)}$:	ΔKAI, Time wasted by analyst on side-issues	s+	s- *
$H_{2(d)}$:	ΔKAI, Concentration by analyst on limited area	s-	x
$H_{2(e)}$:	$\|\Delta KAI\|$, Dissonance with analyst	s+	x
$H_{2(f)}$:	$\|\Delta KAI\|$, Relationship with analyst	s-	x
$H_{2(g)}$:	$\|\Delta KAI\|$, Attitude (helpfulness) of analyst	s-	x
$H_{3(a)}$:	R-score, Accuracy of output	s-	s- **
$H_{3(b)}$:	R-score, Reliability of system	s-	s- *
$H_{3(c)}$:	R-score, Efficiency/effectiveness contribution	s-	x
$H_{3(d)}$:	R-score, Relationship with analyst	s-	?- #
$H_{3(e)}$:	R-score, Attitude (helpfulness) of analyst	s-	?- #
$H_{4(a)}$:	R-score, User age	s+	x
$H_{4(b)}$:	R-score, User Length-Of-Service (LOS)	s+	x
$H_{4(c)}$:	R-score, Absolute analyst-user age-difference	s+	x
$H_{4(d)}$:	R-score, Absolute analyst-user LOS-difference	s+	x

s	"significant"	$p < 0,050$
?	"indecisive significance"	$0,050 \leq p \leq 0,100$
x	"not significant"	$p > 0,100$
+	"positive association"	$t_a, t_b, r_a, r_b > 0$
-	"negative association"	$t_a, t_b, r_a, r_b < 0$

** $p \leq 0,010$
* $p \leq 0,020$

\# $p \leq 0,070$

5.10 The role of cognitive problem-solving styles

Hypothesis H_1, which posits a significant positive correlation between the user R-scores and arithmetic difference in analyst and user KAI scores ($|\Delta KAI|$), tested significant at the 0,005 level. In other words, there is substantially more than minimal evidence (see Table 5-2) of a positive association between user resistance and analyst-user cognitive style differences. The implication is immediately obvious: to minimize user resistance, match users with analysts of similar cognitive style. However, some caution is in order. As can be seen from Appendix A, adaptors and innovators have need of each other in many occupational situations; the adaptor to add stability to the innovator's higher risk operations, and the innovator to motivate potentially needed changes. To match analysts and users of similar cognitive styles would deprive the system development effort of this balance. A system developed by two innovators, for example, would be expected to reach the implementation phase quickly, but with less ground-work than harder-working adaptors would have done. Hence debugging after implementation could be extensive. Two adaptors, by contrast, should take a longer time to implement the system as they would execute the analysis and design phases more thoroughly. The debugging effort would thus be lower. However, a greater enhancing effort would be expected, since certain novel features which motivated the system's development are likely to have been overlooked.

Obviously these conjectures needed testing, and so this study initially attempted to do so. The mean KAI scores for the analyst and user were used to measure the extent to which the analyst-user dyads were either two-innovator or two-adaptor. Associations were then sought between this sample and the length of implementation time, debugging time and enhancing time. Unfortunately, these tests had to be abandoned because the data were suspect. Almost none of the analysts could make a clear distinction between enhancing and debugging times. In fact, 14 out of 34 declined to offer even the wildest of guesses. Also, only in the case of 20 out of the 34 systems were some estimates of the installation times available, since the other 14 were under development on an on-going basis. In short, there may well be latent disadvantages in matching users and analysts of similar cognitive styles, despite this study's inability to find any.

It is suggested, therefore, that analysts' and users' cognitive styles be matched only where either user resistance is a high-risk, high-penalty overhead, or where any of the developing, debugging or enhancing efforts is likely to have a limited impact. Examples of the first of these types of situation were noted during the research, where radical changes in state policy had forced certain organizations into corresponding computer system changes. In such cases, failure to develop and adopt the new system quickly would have meant substantial losses. It is submitted that it is worth matching analysts and users of similar cognitive styles to minimize user resistance under such conditions.

Up to this stage, the association between the user R-scores and the absolute KAI score differences has only been qualitatively demonstrated. Since this association tested significant at 0,005, a level well below the assumed permissible maximum of 0,050 (see Table 5-2), an attempt to quantify the result was made. This attempt focussed on finding a direct proportion between the arithmetic KAI score differences and the R-scores by estimating the constant of proportionality. As a first step, the

Pearson correlation co-efficient was evaluated for the bivariate sample (R-score, $|\Delta KAI|$). This was found to be 0,3382, a discouragingly low figure where a direct proportion is sought in quantitative terms. However, with the aid of a mathematical model, the development of which can be found in Appendix J, estimates for the ratios of $|\Delta KAI|$/R-score and R-score/$|\Delta KAI|$ were shown to be possible. From these estimates, forecasts of user resistance can be made.

Using formula f J.8 of Appendix J and standard normal distribution tables (Huntsberger et al, 1973), Table 5-11 was produced. This gives approximate confidence intervals for the ratios R-score/$|\Delta KAI|$ at the confidence levels specified. It will be noted from the table, for example, that a R-score can be predicted to lie between 61 % and 245 % of $|\Delta KAI|$ with 60 % confidence. Hence for an analyst-user KAI difference of 10, there is 60 % confidence that the user would rate the system after implementation with a R-score from 7 (6,1 rounded up) to 24 (24,5 rounded down) inclusive.

For the sake of comparison, the raw and relative frequencies of the ratios R-score/$|\Delta KAI|$ for the 34 systems researched, which fell into each confidence interval, are given as well. It will be noticed that the relative frequency of the systems in each confidence interval agrees approximately with the corresponding confidence level. This provides some heuristic evidence that the method described above for estimating the ratio R-score/$|\Delta KAI|$ is valid.

Table 5-11

Confidence Intervals For Ratio R-score/|ΔKAI|

Confidence Level (%)	Lower Limit	Upper Limit	SF (Raw) (out of 34)	SF (Rel) (%)
55	,66	2,30	19	56
60	,61	2,45	21	62
65	,56	2,66	21	62
67	,55	2,75	22	65
70	,52	2,89	24	71
75	,48	3,17	24	71
80	,43	3,53	25	74
85	,38	4,02	27	79
90	,32	4,74	31	91
95	,24	6,17	33	97

SF (raw) = Raw Sample Frequency
SF (rel) = Relative Sample Frequency

At first sight, the confidence intervals given in Table 5-11 appear somewhat large, particularly for the higher confidences. However, forecasts based on the lower confidences may certainly be used for decision-making purposes. Additionally, one-sided forecasts may be preferable on occasion. For example, suppose that prior to its embarking upon a joint project, an analyst-user dyad exhibits an absolute KAI score difference of 10. Then any of the following statements, based on the values given in Table 5-11, are acceptable:

After implementation of the system,

1) there is a better than 50 % (namely 55 %) chance that the user R-score will be *at least* 7;

2) there is an approximately 80 % chance that the user R-score will be *at least* 5; and

3) there is an approximately 80 % chance that the user R-score will be *no more than* 35.

If user resistance constitutes a high-risk, high-penalty overhead, then one-sided forecasts based on the upper confidence limits give a safe but high "worst case", whilst those based on the lower confidence limits, of course, give the reverse.

A difficulty with which an organization is likely to be faced in the forecasting of user resistance on this basis is the interpretation of the R-scores. Unlike, for example, the Centigrade temperature scale, the R-score is not a measure with which people in general are familiar. Fortunately, this problem can be resolved intuitively by relating the R-scores to the numbers of complaints made in respect of each of the systems researched. With reference to Table 5-12, the Pearson correlation coefficient of the numbers of complaints versus the corresponding R-scores is 0,9126. This means that a *strong, linear relationship* (not merely an association) holds between these variables. Furthermore, the best-fitting regression line passes through (0, 0), since zero complaints implies a zero R-score (see Section 3.2). In other words, the numbers of complaints and the R-scores are in approximate *direct proportion.* Based on this finding, the constant of proportionality was estimated by taking the means of the ratios of the R-scores to the numbers of complaints (see last column of Table 5-12). The mean of this column of figures is 3,913. This means that the R-score is approximately *four times the number of distinct complaints* which the user will make, in confidence, to an independent consultant, in respect of the system and/or its manner of implementation.

Table 5-12

R-scores and Numbers of User Complaints

Reading	R-score	No. Complaints	R-score / No. Complaints
1	8	3	2,67
2	2	1	2,00
3	12	4	3,00
4	5	1	5,00
5	5	1	5,00
6	20	5	4,00
7	4	1	4,00
8	23	6	3,83
9	11	3	3,67
10	20	4	5,00
11	30	8	3,75
12	21	8	2,63
13	16	5	3,20
14	16	3	5,33
15	19	5	3,80
16	33	7	4,71
17	10	3	3,33
18	12	2	6,00
19	32	8	4,00
20	14	3	4,67
21	14	4	3,50
22	21	4	5,25
23	14	3	4,67
24	9	3	3,00
25	21	6	3,50
26	16	4	4,00
27	17	3	5,67
28	10	3	3,33
29	14	3	4,67
30	9	3	3,00
31	7	3	2,33
32	25	6	4,17
33	5	2	2,50
34	27	7	3,86
Mean	15,4	4,0	3,913

No. Complaints = number of distinct complaints made in confidence to the author in respect of the system and/or its manner of implementation.

The strength of the association demonstrated for hypothesis H_1 not only facilitates a quantitative forecast of user resistance, but supports the use of the R-score as a valid measure of user resistance. Insofar as user satisfaction and user resistance are related, the R-score is also a potential measure of user satisfaction. Of course this single study, carried out on one, comparatively small sample of systems, is insufficient to substantiate the R-score's general use in a positively prescriptive manner. For instance, the sensitivity of the R-score to the cognitive style of the researcher is left untested in this study (see Sections 3.2 and 4.2). Further research would be required to decide the issue (see Section 6.2).

5.11 The ability of adaption-innovation theory to predict aspects of the analyst-user interface

Following the successful testing of hypothesis H_1, significant associations between analyst-user KAI score differences and aspects of the analyst-user interface were expected. These associations are represented by hypotheses $H_{2(a)}$ to $H_{2(g)}$. Of these, hypothesis $H_{2(c)}$ tested significant at $p = 0{,}020$ *in precise contradiction* of the original posit. A tendency was thus demonstrated for a user *not* to view an analyst who is more innovative than he is as a person who tends to waste time on side-issues. It initially seems, therefore, that AI theory *failed* to predict this aspect of the analyst-user interface correctly. However, a reconsideration of hypothesis $H_{2(c)}$ suggests another, which both agrees with AI theory and the result obtained. That is, that the user, generally being a non-systems expert, really does not know whether the analyst is wasting time on peripheral issues or not. What he *rather* observes in a more innovative analyst is a confident, to-the-point individual, who does not *appear* to waste time on peripheral issues.

Unfortunately, it can be argued that this is merely an attempt to explain away an unexpected result, since the original hypothesis was a fair one, quite as soundly based on AI theory. The ultimate conclusion in respect of this matter must then be one of caution when trying to predict specific behaviours of an analyst-user dyad directly from AI theory.

Hypothesis $H_{2(a)}$ tested inconclusively significant at $p = 0{,}070$, although stronger support may have been achieved with a better measuring technique (see Section 5.8). In other words, there is some evidence that a user will find an analyst who is more innovative than he is to comprehend system requirements relatively quickly. These results may prove useful in situations where R-score / KAI testing of the persons involved is not immediately feasible or possible. In such cases, users who comment on the quick comprehension, confidence and brevity of the analyst could be suspected of belonging to analyst-user dyads in which the analyst is the more innovative. Such observations might also motivate the later administration of KAI tests or measuring of R-scores, so that a more precise analysis of user resistance (see Section 5.10) can be made.

On the basis of this study, the hypotheses $H_{2(b)}$, $H_{2(d)}$, $H_{2(e)}$, $H_{2(f)}$ and $H_{2(g)}$ cannot be considered as providing useful information. However, it is of interest to note a common feature of the last three of these. They all involved direct questioning of the user regarding his personal relationship with the analyst, implying potential negative criticism of the analyst in some way. Although in terms of AI theory all these associations should have been significant (see Table 5-10), it is submitted that few of the users responded sufficiently frankly to give reliable (that is, unbiased) results. In support of this view, reference is made to Table 5-5, "Dissonance with the analyst" and to Table 5-6, "Relationship with analyst" and "Attitude of analyst". These respectively were the aspects of the analyst-user relationship upon which hypotheses $H_{2(e)}$, $H_{2(f)}$ and $H_{2(g)}$ were based. In the case of "Dissonance with the analyst", it will be noted that the most positive response (1) was favoured. Similarly, in the case of both "Relationship with analyst" and "Attitude of analyst", the second most positive response (6) was favoured. This obvious lack of frankness occurred frequently, despite every attempt to convince the user that he was being questioned in total confidence. As a guideline, the questions concerned (see Appendix D), were probably too blunt to elicit reliable responses from users. However, a more subtle approach (as used to obtain the R-scores) where the user was asked to criticize the analyst's *system* rather than the analyst *personally*, produced useable results.

5.12 The roles of system satisfaction factors

Hypotheses $H_{3(a)}$ to $H_{3(e)}$ inclusive postulate associations between the user's R-score and his level of satisfaction with certain physical characteristics of the system and nature of his interaction with the analyst (see Section 3.4). Two of these, namely, $H_{3(a)}$ and $H_{3(b)}$, tested significant at $p = 0{,}020$. This suggests a strong negative association between the user's perception of the accuracy and reliability of the system, and user resistance. This study thus confirms that accuracy and reliability are key factors in the issue of user resistance. Insofar as user resistance and user satisfaction are negatively associated, these results are also in accordance with the findings of Bailey and Pearson (see Section 2.5).

Turning to hypotheses $H_{3(d)}$ and $H_{3(e)}$, only weak support was found at $p = 0,070$, for an association between user resistance and the user's rating of his relationship with the analyst and his rating of the analyst's attitude. In the light of observations already made regarding the reliability of these data, it is once again submitted that the questions concerned were too candid to elicit reliable responses. However, the associations did test more significant than their counterparts with the absolute KAI score differences. This suggests, though tenuously, that dissonance in the analyst-user relationship is more specifically tied to user resistance than to other aspects of cognitive style differences.

The higher significance of the tests for $H_{3(a)}$ and $H_{3(b)}$, together with the rather low value for the correlation co-efficients for $H_{2(a)}$ to $H_{2(g)}$, imply that factors other than cognitive style differences may play some role in user resistance. However, it must be conceded that the accuracy and the reliability of the systems were recorded as seen from the point of view of the user. These assessments, it can be argued, were coloured by the cognitive styles of the user. For example, an adaptive user might well view an innovative analyst's system as a non-conservative, higher-risk tool, in line with the general adaptor's views of innovators. Consequently, he would view the system as less accurate and less reliable. The reverse is as plausible. An innovative user might view an adaptive analyst's system as too traditional, failing to encompass all the novel features which the user believes he needs. Hence, once again, the user may view the system as less accurate and less reliable. In other words, the significant associations found for $H_{3(a)}$ and $H_{3(b)}$ actually agree with the predictions of AI theory.

5.13 The roles of age and length of service

The hypotheses $H_{4(a)}$ and $H_{4(b)}$ support the beliefs that the age and lengths of service of users are associated with user resistance. These hypotheses were both rejected at $p = 0{,}100$. Some doubt may be argued over the result for hypothesis $H_{4(a)}$, since the ages of users in the sample tested somewhat skew, with $0{,}050 > p > 0{,}020$. However, this apparent skewness cannot of itself explain away a low, distribution-independent correlation, unless it can be shown that the sample was deliberately biased. It is difficult to see how this was possible in the light of the research design. Each system investigated was selected without reference to the user's age or length of service (see Section 4.3). This study thus rejects the beliefs that older users, or users of longer service are more resistant than others to new information systems.

Hypotheses $H_{4(c)}$ and $H_{4(d)}$ examine alternative beliefs; namely, that users who differ substantially from the analyst in terms of age or length of service are more resistant than others to new systems. All sets of readings for these hypotheses tested normal. The results showed no support for these beliefs (at $p = 0{,}100$) either, and they are also rejected by this study.

Unfair discrimination of older employees, as suggested by Rosen and Jerdee (see Section 2.3), might occur in the IS area to older users. Such discrimination could well be motivated by studies such as Bruwer's (see Section 2.2), which suggest, inter alia, that older and longer-serving personnel *are* most resistant to new computer systems. Attention is drawn to the fact that neither the present study nor AI theory, nor the literature survey by Rosen and Jerdee support these beliefs. Unfair discrimination could certainly cost both individuals and organizations dearly in terms of unnecessary retrenchment and/or transfer of experienced staff.

5.14 Conclusion

Subject to the postulate that the user R-score is a legitimate measure of user resistance, certain causes and impacts of user resistance have been demonstrated by this study. Referring to Section 5.10, it has been shown that user resistance can be minimized by matching analysts and users of similar cognitive styles. However, care is suggested in applying such a policy indiscriminately, since there may be disadvantages in so doing despite this study's failure to show any. The high degree of association between user R-scores and absolute analyst-user KAI score differences permits approximate forecasts of the former given the latter (see Table 5-11).

Two phenomena associated with analyst-user dyads where the analyst is the more innovative, were implied by the results (see Section 5.11). The first of these is a tendency for the user to view the analyst as brief and confident, seldom wasting time on side-issues. The second (less convincingly), that the user may comment on the unexpected speed with which the analyst comprehends system requirements or specifications. It is suggested that these features be noted as diagnostic signs of the more innovative nature of the analyst, especially in situations where formal testing has not or cannot be conducted.

This study finds in favour of the hypotheses that perceived accuracy and reliability of the system are associated with lower user resistance (see Section 5.12). Consequently, further insights may be gained into a given user-analyst dyad by questioning the user on the accuracy and reliability of a system. For example, the less accurate and less reliable a user considers a system, the more user resistance can be expected, and consequently (from hypothesis H_1), the greater the absolute analyst-user KAI score difference is likely to be.

This study fails to find any support for the beliefs that the ages and lengths of service of users are associated with user resistance: or for the alternative beliefs that users who differ substantially from the analyst in terms of age or length of service are more resistant than others to new systems. Since neither the present study nor AI theory, nor the literature survey by Rosen and Jerdee (1976) support these beliefs, organizations should be alerted to the possibility of unfair discrimination against older and more experienced users.

Chapter 6

Conclusion

6.1 Achievements of this study

Whilst some discussion of user resistance exists in the literature (see Section 2.2) no direct, quantitative measure of this phenomenon had previously been attempted. This led to the development of the R-score, which is a direct measure of resistance in terms of observable complaints about the system, and which is significantly associated with the user's level of resistance to that system. The success of this measurement is demonstrated by the strong normality of R-scores in the sample of systems investigated (see Table 5-4).

Prior to this study, neither had Adaption-Innovation theory been applied to IS development, nor had the KAI instrument been replicated in the IS field. With the aid of these, it has been shown that user resistance can be minimized by matching users to analysts of similar cognitive style. Furthermore, by prior administration of the KAI instrument to analysts and users, approximate forecasts of user resistance are now possible. In other words, both AI theory and the KAI instrument have been shown to be valuable tools in assessing, understanding and forecasting user resistance (see Section 5.10).

This study lends some support to the method used by Bailey and Pearson (1983) to measure user satisfaction and IS success, in that the two most significant factors found by them to satisfy users, were also found to be negatively associated with user resistance (measured as R-scores) in this study. These factors were system accuracy and reliability (see Section 5.12). This further suggests that low user resistance is indeed associated with high user satisfaction, confirming that resistance and satisfaction can be used as inverse, surrogate measures for one another. The user's R-score in the post-implementation phase is thus indicated as a possible measure of system success. However, more research would be required to ensure that it is not also significantly dependent upon the cognitive style of the investigator: a factor which would preclude its use as a standard measure. The speed with which the R-score can be assessed, though an interviewing technique, would make it an attractive option to the more protracted Pearson-type questionnaire for measuring system success.

Finally, this study confirms that neither the ages nor the lengths of service of users play any significant role in user resistance, and alerts organizations to unfair discrimination against users on such grounds (see Section 5.13).

6.2 Areas for further research

Having considered the key achievements of this study, a discussion of further research follows.

As previously mentioned (Sections 3.2 and 6.1), there may be a dependence of the R-score on the cognitive style of the investigator since the R-score is determined as a result of his interaction with the respondent at an interview. In a further study, the effect of the researcher's own cognitive style on R-score evaluation needs to be investigated. Such a study might involve, for example, the administration of the R-score by several different persons to the same group of users, to investigate whether or not there were any significant differences amongst their results. If the R-score were shown to be insensitive to the nature of the investigator, it would then be useable as a system success standard as previously noted. If, however, the reverse were shown, then its use would remain limited to user resistance in the relative sense only. In other words, between systems investigated by the same researcher, as in this study.

As previously noted in Section 3.2, it remains to be shown to what extent the R-score is associated with *all* forms of user resistance. It would thus be of interest to construct other measures of resistance and test their associations with the R-score. There is some indication from Markus's study that complaints from users are a predominant form of user resistance. Further research which demonstrated this conclusively would make the R-score a more convincing global measure of user resistance than could be claimed in this study.

A further area for research is an analysis of the *similarities and differences* of the four general cognitive cases of analyst-user dyads, as given below:

1) analyst an adaptor, user an adaptor,
2) analyst an adaptor, user an innovator,
3) analyst an innovator, user an adaptor, and
4) analyst an innovator, user an innovator.

Of particular interest are the questions of which of these is most efficient and/or effective in the *short term*, and which in the *long term*. The main hypothesis (H_1) of the current study (see Section 5.10) shows that user resistance will be at a minimum when the analyst and user are of like cognitive styles. This in turn suggests that dyads 1) and 4) above might be more efficient and effective than the other two *in the short term*. However, no reliable inferences could be made regarding the effect of matching persons of similar or dissimilar cognitive styles in the *long* term. As recorded in section 5.10, an effort was made to carry out such tests. This failed because several of the systems investigated were under development on an on-going basis, and consequently insufficient reliable data could be collected. However, if sufficient systems which were known not to be subject to much on-going change were researched, such tests should succeed.

There has been an indication of the use by researchers of lengthy self-report questionnaires. Jackson's Personality Research Form used by Woodruff (1980), and the Pearson 39-factor instruments are examples (see Section 2.4). Such instruments are normally sent out by post in large numbers, and those returned used as the research sample. As previously noted (Section 2.6), this procedure invites speculation that the samples thus obtained will be biased towards the *more conscientious* respondents, who will take the trouble to fill in and return lengthy questionnaires. In fact, it could be argued that such persons would tend to be adaptors rather than innovators, since innovators are said to be capable of detailed work for short periods only (see Appendix A). Such speculation could be tested by interviewing a group of respondents, administering the KAI to each, and leaving each with a self-report form to be returned later by post. A dichotomous association between KAI score and those who returned the questionnaire after a certain time (versus those who did not) could then be tested. If it was found that the self-report/postal sampling technique described above provided a sample biased towards adaptors, then serious questions would have to be asked about the validity of results where aspects of cognitive style were at issue. In Woodruff's survey, for example, it has already been noted (Section 3.3) that the sampling technique could have favoured responses from adaptors. This may have led Woodruff to believe that he had identified characteristics peculiar to IS people, when really he had found nothing else than the personality characteristics of the more adaptive persons who were prepared to complete and return his questionnaire. A similar criticism can, of course, be levelled at surveys using the Pearson 39-factor instrument if data samples are collected in the same manner.

A further noteworthy point is the disappointing results obtained with the seven-point scales as opposed to the method of direct observation used for the measuring of the R-score (see Section 5.8). The finding of this study regarding such scales, is that in general they are not as successful as direct observation methods. Though the KAI itself uses several five-point scales, there are two important differences between these and the seven-point scales used in parts of the System Satisfaction Schedule (Appendix D). Firstly, the five-point scales are not initially visible to the respondent; he sees only continuous rows of closely spaced dots, along which he can indicate his responses where he pleases. This means that he is not distracted by the need for definite commitment to one option or another (although this is later covertly imposed by the method of scoring). Secondly, all 32 scored responses are jointly a measure for a single entity; that is, overall cognitive style. According to Wanous and Lawler (1972), composite measures are significantly more reliable than single-item ratings. In the System Satisfaction Schedule (Appendix D), by contrast, the seven-point scales rate *a single item each.*

Whilst the roles of age and length of service may not play a significant role in user resistance, it would be of interest to test the parallel result for IS staff. If, in general (as suggested by Rosen and Jerdee, 1976) older employees are the objects of unwarranted discrimination, then older and longer-serving analysts themselves could fall victim to such discrimination. This makes a fair and carefully constructed enquiry into the competence of such IS staff relevant.

Although it is submitted that this study has provided insight into the causes and nature of user resistance, the magnitude of the association statistics are all appreciably less than one (see Table 5-9). This means probably that cognitive style theory falls short of offering a complete explanation for user resistance, and studies in other directions should not be ruled out.

6.3 Conclusion

The important achievements of this study have been the development of a measure of user resistance and the successful replication of the KAI instrument in the IS field. These together enabled the development of a technique to forecast user resistance.

Further research is suggested by this study. Firstly, the R-score needs to be verified as either an absolute measure or a measure relative to the cognitive style of the researcher. Secondly, the extent to which the R-score measures user resistance *as a whole* needs further investigation. Further, a comparison of the efficiency and effectiveness of the four cognitive analyst-user dyads described in Section 6.2 is required, especially in the long term. In addition, the success of traditional research methodologies such as multi-interval scales and self-report questionnaires need sceptical re-evaluation in terms of reliability and bias. The extent to which IS staff themselves may fall victim to discrimination on the grounds of age and length of service is a further area of investigation. Finally, this study does not exclude the possibility that factors other than cognitive style are implicated in user resistance. However, it claims that through the application of cognitive style theory, most particularly Adaption-Innovation theory, some significant advancements have been made in the understanding of this phenomenon.

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Appendix A

Behaviour descriptions of adaptors and innovators

Adaptor	Innovator
Characterized by Precision, Reliability, Efficiency, Methodicalness, Prudence, Discipline, Conformity	Seen as Undisciplined, Thinking Tangentially, Approaching Tasks from Unsuspected Angles
Concerned with Resolving Problems Rather Than Finding Them	Could be Said to Discover Problems and Discover Avenues of Solution
Seeks Solutions to Problems in Tried and Understood Ways	Queries Problems' Concomitant Assumptions; Manipulates Problems
Reduces Problems by Improvement and Greater Efficiency, with Maximum of Continuity and Stability	Is Catalyst to Settled Groups, Irreverent of their Consensual Views; Seen as Abrasive, Creating Dissonance
Seen as Sound, Conforming, Safe, Dependable	Seen as Unsound, Impractical; Often Shocks his Opposite
Liable to Make Goals of Means	In Pursuit of Goals Treats Accepted Means with Little Regard
Seems Impervious to Boredom, Seems Able to Maintain High Accuracy in Long Spells of Detailed Work	Capable of Detailed Routine (System Maintenance) Work for Only Short Bursts. Quick to Delegate Routine Tasks.
Is an Authority Within Given Structures	Tends to Take Control in Unstructured Situations
Challenges Rules Rarely, Cautiously, When Assured of Strong Support	Often Challenges Rules, Has Little Respect for Past Custom
Tends to High Self-doubt. Reacts to Criticism by Closer Outward Conformity. Vulnerable to Social Pressures and Authority; Compliant	Appears to Have Low Self Doubt When Generating Ideas, Not Needing Consensus to Maintain Certitude in Face of Opposition
Is Essential to the Functioning of the Institution All the Time, but Occasionally Needs to be 'Dug Out' of His Systems	In the Institution is Ideal in Unscheduled Crises, or Better Still to Help Avoid them, if he Can be Controlled
<u>When Collaborating with Innovators</u>:	<u>When Collaborating with Adaptors</u>:
Supplies Stability, Order and Continuity to the Partnership	Supplies the Task Orientations, the Break with the Past and Accepted Theory
Sensitive to People, Maintains Group Cohesion and Co-operation	Appears Insensitive to People, Often Threatens Group Cohesion and Co-operation
Provides a Safe Base for the Innovator's Riskier Operations	Provides the Dynamics to Bring About Periodic Radical Change, Without which Institutions Tend to Ossify

(Kirton, 1976, 1984)

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Appendix B

The Kirton Adaption-innovation Inventory (KAI)

Character Traits*

Item Nos.	A PERSON WHO:
1)	is patient
2)	conforms
3)	when stuck will always think of something
4)	enjoys the detailed work
5)	would sooner create something than improve it
6)	is prudent when dealing with authority or general opinion
7)	never acts without proper authority
8)	never seeks to bend (much less break) the rules
9)	likes bosses and work patterns which are consistent
10)	holds back ideas until they are obviously needed
11)	has fresh perspectives on old problems
12)	likes to vary set routines at a moment's notice
13)	prefers change to occur gradually
14)	is thorough
15)	is a steady plodder
16)	copes with several new ideas and problems at the same time
17)	is consistent
18)	is able to stand out in disagreement alone against a group of equals and seniors
19)	is stimulating
20)	readily agrees with the team at work
21)	has original ideas
22)	masters all details painstakingly
23)	proliferates ideas
24)	prefers to work on one problem at a time
25)	is methodical and systematic
26)	often risks doing things differently
27)	works without deviation in a prescribed way
28)	likes to impose strict order on matters within own control
29)	likes the protection of precise instructions
30)	fits readily into 'the system'
31)	needs the stimulation of frequent change
32)	prefers colleagues who never 'rock the boat'
33)	is predictable

Transcribed from the KAI Response Sheet by permission of the Author, Professor Michael J. Kirton (see Acknowledgements).

Appendix C

KAI Report Back Form

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EXAMPLES OF AVERAGE SCORES FOR DIFFERENT OCCUPATIONAL GROUPS

Score	Sample	From
95-96	General population	U.K., U.S.A., Italy
95-97	Managers generally	U.K., U.S.A., Italy, Singapore, Canada
90	Managers generally	South Africa, India, Iran
83	Apprentices (Engineering)	U.K.
80-90	Bank Managers, Civil Servants, Accountants.	U.K., U.S.A., Italy, Canada, Singapore, Australia
80-90	"Line Managers" including: manufacturing managers, plant managers, production managers, accounts supervisors, machine superintendents.	U.K., U.S.A., Italy, Canada, Singapore, Australia
94-97	Teachers	U.K., U.S.A.
100-110	"Non-line" managers including: marketing, finance, planning, personnel, O.D. consultants.	U.K., U.S.A., Italy, Canada, Singapore
101-103	R & D managers	U.K., U.S.A.
108	Personnel Manager	U.K.
112-115	R & D managers special project teams	U.K., U.S.A., Canada

GENERAL NOTE:
Although the average score of groups may vary, the range of the individual scores in them usually does not – the range is wide. This means that groups nearly always contain people with scores some way from the average of their group. If the group is insightful and well managed these differences are found to add to those groups' effectiveness.

SPECIFIC NOTE:
The averages above (except for apprentices) have been obtained from the established members of their groups; new recruits generally have an average close to that of the general population. Studies show that a new intake, after a number of years, will have an average much the same as those who have been there longer. This is because people who score close to the group average are more likely to stay than those who are not so close.

KAI REPORT BACK FORM

Name: ______________________

____

Date: ______________________

The Adaption-Innovation (A.I.) theory posits that people differ in *the manner in which they define and solve problems* because of a *stable characteristic preference* for either an ***"adaptive"*** or *"innovative" approach to change.*

A KAI score is a measure, obtained using the Kirton Inventory, of a person's *stable preference* for, or *style* of, creativity, problem solving and decision making.

RANGE OF KAI SCORES

32.......48.......64.......80.......96.......112.......128.......144.......160

ADAPTORS — 67% of people are in this range (80–112) — INNOVATORS

YOUR KAI SCORE *

________ ________ ________ ________

COMPARED WITH

________ ________ ________ ________

for ______________________

NOTE: Average scores for other groups are shown on the back page.

* Remember it is not good or bad, right or wrong to prefer either an adaptive or an innovative approach. They are simply two different styles of problem solving and decision making. Each has its own strengths, and of course, its potential weaknesses. The purpose of the KAI is to help you understand more clearly your own and other people's preferences and likely behaviour patterns, which in turn helps to produce more effective performance.

Both insight and value are gained by discussing your score, the others on this page and the back page, and the characteristics summarised overleaf. As a suggestion consider:

- Important things I find easy/hard
- How I exploit things I find easy
- How I cope with things I find hard
- How I collaborate with colleagues of similar style to me
- How I collaborate with colleagues of different style from me

KAI Report Back Form

(continued)

CHARACTERISTICS OF ADAPTORS AND INNOVATORS

IMPLICATIONS	ADAPTORS	INNOVATORS
For Problem Solving	Tend to take the problem as defined and generate novel, creative ideas aimed at "doing things better". Immediate high efficiency is the keynote of high adaptors.	Tend to redefine generally agreed problems, breaking previously perceived restraints, generating solutions aimed at "doing things differently".
For Solutions	Adaptors generally generate a few well-chosen and relevant solutions, that they generally find sufficient but which sometimes fail to contain ideas needed to break the existing pattern completely.	Innovators produce numerous ideas many of which may not be either obvious or acceptable to others. Such a pool often contains ideas, if they can be identified, that may crack hitherto intractable problems.
For Policies	Prefer well-established, structured situations. Best at incorporating new data or events into existing structures or policies.	Prefer unstructured situations. Use new data as opportunities to set new structures or policies accepting the greater attendant risk.
For Organizational "Fit"	Essential to the ongoing functions, but in times of unexpected changes may have some difficulty moving out of their established role.	Essential in times of change or crisis, but may have some trouble applying themselves to ongoing organizational demands.
For Potential Creativity	The Kirton Inventory is a measure of style but not level or capacity of creative problem solving. Adaptors and innovators are both capable of generating original, creative solutions, but which reflect their different overall approaches to problem solving.	
For Collaboration	Adaptors and Innovators do not readily get on, especially if they are extreme scorers. Middle scorers have the disadvantage that they do not easily reach the heights of adaption or innovation as do extreme scorers. This, conversely is a positive advantage in a team where they can more easily act as "bridgers", forming the consensus group and getting the best (if skilful) out of clashing extreme scorers.	
For Perceived Behaviour	Seen by Innovators: as sound, conforming, safe, predictable, relevant, inflexible, wedded to the system, intolerant of ambiguity.	Seen by Adaptors: as unsound, impractical, risky, abrasive; often shocking their opposites and creating dissonance.

Appendix D

System Satisfaction Schedule

System name: ....

Organisation: ....

The purpose of this interview is to assess user opinion of the above computer system.
Please note that your responses will be treated in the **strictest of confidence**.
Please be as frank and as honest as possible.

Personal User Information

1) Age: ______ Years ______ Months

2) Sex: ______ (M / F)

3) User KAI: ______

4) For how long have you been employed by your organisation? ______ Years ______ Months

5) For how long have you worked with computers? ______ Years ______ Months
(include training and all work-related activities)

6) For how much time have you been involved in discussions with ____________________
regarding the abovementioned system?

____

7) How much time have you spent interacting with the abovementioned system?

____

User Problem Schedule

Please enumerate all the **Problems** which you considered or heard had occurred during the implementation and/or early life of the system.

____

____

____

____

____

____

____

____

____

____

____

Now please rate each of these problem-areas as follows:

(7)	(6)	(5)	(4)	(3)	(2)	(1)
a totally insoluble problem	a very serious problem	a serious problem	a rather serious problem	a significant problem	a slight problem	no real problem

(P. T. O.)

Global Considerations

1. How **accurate** (correct) would you say that the system's output information is?

____

____

□	□	□	□	□	□	□
excellent	very good	good	rather good	satisfactory	second-rate	poor

2. Comment on the **relationship** between yourself and the abovementioned systems analyst/programmer.

____

____

□	□	□	□	□	□	□
excellent	very good	good	rather good	satisfactory	second-rate	poor

3. How **reliable** do you consider the system's output information to be?

____

____

□	□	□	□	□	□	□
excellent	very good	good	rather good	satisfactory	second-rate	poor

4. To what degree does this system help your organisation to operate more **efficiently** and/or **effectively** ("better")?

____

____

□	□	□	□	□	□	□
an outstanding improvement	very much better	much better	significantly better	slightly better	no better	worse than before

5. Comment on the **willingness** shown by the abovementioned systems analyst/programmer to assist you as the user.

____

____

□	□	□	□	□	□	□
excellent	very good	good	rather good	satisfactory	second-rate	poor

Problem Definition

1) The analyst grasped the specifications of the system which I wanted him to produce in

□	□	□	□	□	□	□
far less time than I expected	significantly less time than I expected	slightly less time than I expected		slightly more time than I expected	significantly more time than I expected	much more time than I expected

---

2) The analyst had his own ideas, and disagreed with my views on how the system should operate and solve problems.

□	□	□	□	□	□	□
I strongly agree	I agree	I agree to an extent		I disagree to an extent	I disagree	I strongly disagree

---

3) The analyst had a tendency to concentrate more on peripheral issues than on the problem at hand.

□	□	□	□	□	□	□
I strongly agree	I agree	I agree to an extent		I disagree to an extent	I disagree	I strongly disagree

---

4) The analyst had a tendency to concentrate on a limited problem area, and failed to foresee other problems which could occur.

□	□	□	□	□	□	□
I strongly agree	I agree	I agree to an extent		I disagree to an extent	I disagree	I strongly disagree

---

Analysis/Design

1) The solution method (analysis/design) for the system, produced before the system was actually implemented, was in

□	□	□	□	□	□	□
far too little detail	too little detail	rather too little detail		rather too much detail	too much detail	far too much detail

---

2) The analyst should have produced a solution method (analysis/design) which covered a wider field of contigencies than it did.

□	□	□	□	□	□	□
I strongly agree	I agree	I agree to an extent		I disagree to an extent	I disagree	I strongly disagree

---

3) The analyst should have produced a solution method (analysis/design) which foresaw more problems.

□	□	□	□	□	□	□
I strongly agree	I agree	I agree to an extent		I disagree to an extent	I disagree	I strongly disagree

---

4) There was a degree of dissonance (friction) between myself and the analyst at times.

□	□	□	□	□	□	□
I strongly agree	I agree	I agree to an extent		I disagree to an extent	I disagree	I strongly disagree

---

(P. T. O.)

Implementation

1) The effort required to correct programming/system errors (bugs) was

□	□	□	□	□	□	□
most extensive	extensive	highly significant	significant	slight	very slight	nil

2) The effort required to produce additional functions/facilities was

□	□	□	□	□	□	□
most extensive	extensive	highly significant	significant	slight	very slight	nil

3) What was the relationship between budget and system development effort?

The **budget**				The **effort**		
□	□	□	□	□	□	□
far exceeded the **effort**	significantly exceeded the **effort**	to an extent exceeded the **effort**		to an extent exceeded the **budget**	significantly exceeded the **budget**	far exceeded the **budget**

4) The user's manual / hand book / operator's guide for the system was in

□	□	□	□	□	□	□
far too little detail	too little detail	rather too little detail		rather too much detail	too much detail	far too much detail

Further Notes

____

Thank you for your help and co-operation.

Appendix E

Analyst Interviewing Form

System Name: ....

Organisation: ....

System Type/description: ....

....

Completion date: ....

Analyst: ....

Address/Office: ....

Phone: .... Ext: ....

Principal User: ....

Address/Office: ....

Phone: .... Ext: ....

N.B. All information contained in this document will be treated as highly confidential.

Analyst's Demographic Profile

1) Age: ___ years ___ months

2) Sex: Male/Female (Delete whichever not applicable)

3) For how long have you been employed by your organisation? ___ years ___ months

4) For how long have you worked as an analyst and/or programmer? ___ years ___ months

5) About how many hours' work have you put into the abovementioned system? ___ hours

6) **Qualifications**: (Please list all your qualifications/courses attended. Underline those which apply directly to your work as an analyst and/or programmer)

....

Resource Details

Kindly estimate the **average number of staff** (analysts/programmers/users) and **number of days** involved during the:

1) analysis and design of the system; staff ___ days___

2) implementation of the system; staff ___ days___

3) maintenance during the **first** year to rectify program/system **errors**; staff ___ days___

4) maintenance during the **first** year to add **extentions** to the system. staff ___ days___

5) How many problems in respect of this system have **not** been solved/resolved **to date**?

□	□	□	□	□	□	□
all	most	rather too many	fifty-fifty	not too many	very few	none

6) What was the relationship between budget and system development effort?

	The **budget**				The **effort**	
□	□	□	□	□	□	□
far	significantly	to an extent		to an extent	significantly	far
	exceeded the **effort**.				exceeded the **budget**.	

Appendix F

Goodness-of-fit Normality Test using Chi-square Statistic

Huntsberger and Billingsley (1973) give the following procedure for the testing of the null hypothesis of population normality, given a random data sample drawn from that population.

The mean and standard deviation of the population are estimated using the corresponding sample statistics. The appropriate normal curve is then drawn, and area cells are constructed as dictated by convenience (that is, theoretically quite arbitrarily), as shown in Fig. F-1 (a). From standard normal distribution tables, the expected number of sample data E in each cell can be determined. Y is used to denote the number of data *actually observed* in each cell. Hence for cell i, E_i data are expected and Y_i data occur. Next, the χ^2 statistic is computed using the formula

$$\chi^2 = \sum_{i=1}^{n} \frac{(Y_i - E_i)^2}{E_i}$$

where n is the number of cells.

In the case of this test, the null hypothesis is one of normality. Hence, if the χ^2 statistic is greater than a critical value tabulated for some predetermined level of significance, the data distribution is considered non-normal. Tables of critical values of the χ^2 distribution for various levels of significance and degrees of freedom are readily available (Huntsberger et al, 1973). There are, in the case of this test, three degrees of freedom less than the number of cells (Huntsberger et al, 1973).

Improvements in reliability can evidently be achieved in the above procedure by following certain recommendations made by Moore. These recommendations (which were followed in this study) are as follows:

1) rather than making an arbitrary cell choice, cells should be chosen to be equiprobable; that is, there should be an equal probability of a random datum falling into any cell;
2) with equiprobable cells, there should be an average expected cell frequency of at least 1 when testing fit at the 0,05 level of significance, and at least 2 when testing at the 0,01 level of significance; and
3) there should be at least three cells

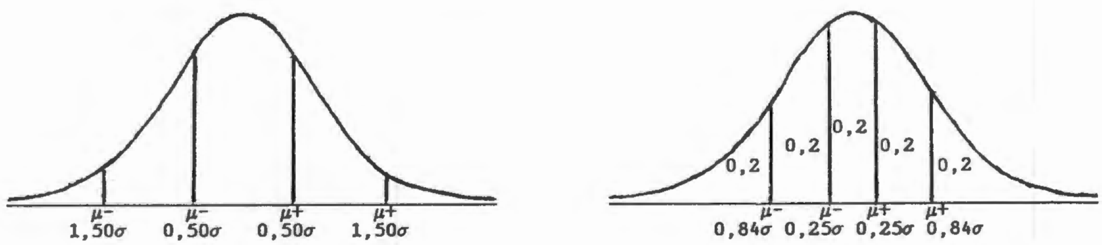
(Moore, 1986)

With $n = 34$, each data sample was tested for normality using 5 cells, with equal probabilities of 0,2. This fulfilled all the above conditions. The cell boundaries were identified with the aid of standard normal tables (Huntsberger et al, 1973) as $-\infty$, -0,84, -0,25, 0,25, 0,84 and ∞ standard deviations from the mean (See Fig. F-1 (b)).

The levels of significance used to measure the extent of normality were based on Table 5-2, with $p < 0{,}05$ implying a significant departure from normality, and $p > 0{,}10$, no significant departure (that is, approximately normal).

<u>Fig. F-1</u>

<u>Selection of cells, normal distribution goodness-of-fit test</u>



<u>a)</u> <u>Arbitrary cell choice</u> <u>b)</u> <u>Equiprobable cell choice</u>

Appendix G

Measures of Association

Kendall (1970) gives the formulae for τ and ρ_s, for populations with untied data:

$$\tau = \frac{2S}{n(n-1)} \qquad \text{f g.1}$$

where S = the number of concordant data pairs less the number of discordant data pairs, and

n = population size

$$\rho_s = 1 - \frac{6 \Sigma d_i^2}{n^3 - n} \qquad \text{f g.2}$$

where d_i = the difference in rank between the *i*th readings of the two variables, and

n = population size

The same formulae can be applied to samples of size *n* to obtain the corresponding sample statistics *t* and r_s. These sample statistics may be used to estimate their population counterparts, so long as tied rankings are absent. However, the presence of ties requires modification of these formulae in one of two possible ways, corresponding to the case (a) and case (b) situations discussed in Section 5.5.

Where ties occur, two appropriate formulae are thus available for each of *t* and r_s, corresponding to the cases (a) and (b). The alternative sample rank correlation co-efficients are appropriately denoted t_a, t_b, r_a and r_b. In the first instance, the formulae for these statistics take ties into account by a process of averaging ranks (Kendall, 1970). For example, if two data tie for rank 4 where ranks 3 and 4 would have been assigned in the untied case, they are each given a rank of 3,5. With this modified form of ranking in the case of ties, *S* and $\Sigma\, d_i$ are calculated as previously. t_a is then able to be computed from the formula

$$t_a = \frac{2S}{n(n-1)}$$ f g.3

(Kendall, 1970)

In a case (b) situation, the alternative statistic for t is

$$t_b = \frac{S}{\sqrt{\{\tfrac{1}{2}n(n-1) - U\}}\sqrt{\{\tfrac{1}{2}n(n-1) - V\}}}$$

f g.4

where $U = \tfrac{1}{2} \sum_u u(u-1)$ and $V = \tfrac{1}{2} \sum_v v(v-1)$ for all consecutive ties u in the first ranking and all consecutive ties v in the second ranking.

Also, $\sum_u$ represents the summation over various sets of ties in the first ranking, and $\sum_v$ is similarly defined for various sets of ties in the second ranking.

(Kendall, 1970)

The analogous results for r_s make use of the factors U' and V', where $U' = {}^1/_{12} \sum_u (u^3 - u)$ and $V' = {}^1/_{12} \sum_v (v^3 - v)$.
Hence,

$$r_a = 1 - \frac{6\,\{\Sigma\, d_i^2 + U' + V'\}}{n^3 - n}$$ f g.5

$$r_b = \frac{{}^1/_6\,(n3 - n) - \Sigma\, d_i^2 - U' - V'}{2\sqrt{[\{{}^1/_6(n^3 - n) - 2\,U'\}\{{}^1/_6(n^3 - n) - 2\,V'\}]}}$$

f g.6

(Kendall, 1970)

Formulae for testing the significance of associations

The formulae for the variances of S, t_a and t_b, required to test the associations at certain levels of significance are given by Kendall (1970) and Liebetrau (1983) as follows:

$$\sigma^2(S) = {}^1/_{18}\,[n(n - 1)(2n + 5) - A' - B'] + \frac{A\,B}{9n\,(n - 1)\,(n - 2)} + \frac{2\,U\,V}{n\,(n - 1)}$$

f g.7

where $A = \sum_u u(u - 1)(u - 2)$, $B = \sum_v v(v - 1)(v - 2)$,

$A' = \sum_u u(u - 1)(2u + 5)$, and $B' = \sum_v v(v - 1)(2v + 5)$.

From f g.7, $\sigma^2(t_a)$ and $\sigma^2(t_b)$ may be expressed as:

$\sigma^2(t_a) = \sigma^2(S) / ({}_nC_2)^2$ f g.8

$\sigma^2(t_b) = \sigma^2(S) / \{[{}_nC_2 - U][{}_nC_2 - V]\}$ f g.9

These formulae hold only for the null hypothesis (Liebetrau, 1983). However, as previously noted (Section 5.3), this is entirely satisfactory for the current study. If the null hypothesis of independence is to be tested using the standard normal (z) distribution, the z-statistic needs to be computed for t_a or t_b, so that the tail area can be determined from tables. The corresponding z-statistics are given by the formulae

$z(t_a) = t_a / \sigma(t_a) = S / \sigma(S)$ f g.10

and

$z(t_b) = t_b / \sigma(t_b) = S / \sigma(S)$ f g.11

It will be noticed that both f g.10 and f g.11 give the same result, hence where only significance is to be tested, it makes no difference whether t_a or t_b be used as the measure of association.

Turning next to the significance of r_s, Glasser and Winter (1961) suggested that the statistic

$t = r_s\sqrt{[(n - 2)/(1 - r_s^2)]}$ f g.12

which has an approximate Student's *t-distribution* with $n - 2$ degrees of freedom, be used for testing of the null hypothesis of independence. However, Liebetrau (1983) claims that unless n is *extremely large* (presumably larger than 34), this statistic is quite inaccurate, especially if significant ties occur in the data. He recommends normal approximations based on the equations below for significance-testing in smaller samples:

$$\sigma^2(r_s) = 1/(n - 1) \qquad \text{f g.13}$$

$$\sigma^2(r_a) = \frac{[n(n^2 - 1) - 12\ U'][n(n^2 - 1) - 12\ V']}{n^2(n^2 - 1)2\ (n - 1)} \qquad \text{f g.14}$$

$$\sigma^2(r_b) = 1/(n - 1) \qquad \text{f g.15}$$

For the calculation of the corresponding z-statistics, the formulae, analogous to those for the Kendall statistics, are as follows:

$$z(r_s) = r_s / \sigma(r_s) \qquad \text{f g.16}$$

$$z(r_a) = r_a / \sigma(r_a) \qquad \text{f g.17}$$

and

$$z(r_b) = r_b / \sigma(r_b) \qquad \text{f g.18}$$

It should also be noted that

$$z(r_a) = z(r_b) \neq z(r_s) \qquad \text{f g.19}$$

As the sample sizes in this study were all greater than 10 or 20 but not extremely large ($n = 34$), the standard normal distribution was used in the calculation of all required significance levels, using the formulae f g.7 to f g.18.

The associations were first computed as Kendall's rank correlation coefficients, t_a, using formula f g.3. Formula f g.8 was then applied to determine the variances of these statistics and hence their standard deviations. In order to measure the significance of each association t_a, the standard normal statistic for zero association, $z(t_a)$, was calculated using formula f g.10. The significance of t_a was then determined from standard normal tables (Huntsberger et al, 1973), as a tail area. The results of this procedure for each hypothesis have been summarized in Table I-1 (a) of Appendix I. The analysis was repeated for t_b, using formulae f g.4, f g.9 and f g.11. The results for t_b are summarized in Table I-1 (b).

The same tests were repeated using the Spearman rank order correlation co-efficients r_a, r_b and r_s for the purposes of verification. These results are summarized in Tables I-2 (a), (b) and (c) of Appendix I respectively. The appropriate formulae are f g.5, f g.6 and f g.2 for the calculation of r_a, r_b and r_s respectively, f g.14, f g.15 and f g.13 for their variances, and f g.17, f g.18 and f g.16 for their z-statistics. Table I-2 (c) also gives parallel results for the Student t-statistic, calculated using f g.12. It will be noted, however, that complete agreement was obtained with the z-statistic on the matter of the significance for all the associations recorded in Table I-2 (c).

An examination of the Tables I-1 (a) to I-2 (c) inclusive reveals that the four tie-case statistics t_a, t_b, r_a and r_b agree very nearly in respect of the significances of all the associations tested. The formulae associated with r_s, however, yield differing results in the case of three of the research hypotheses (see Table I-2 (c)). As previously discussed, the tie-case statistics are theoretically more correct, and are thus assumed more reliable. Consequently, only these are considered further. Table G-1 is a summary of Tables I-1 (a) to I-2 (b).

Table G-1

Tests of hypotheses: Summary of relevant statistics

Hypothesis	t_a	t_b	p_t	r_a	r_b	p_r
H_1	,2888	,2981	,008 (s**)	,4017	,4031	,010 (s**)
$H_{2(a)}$	,1747	,1944	,068 (?)	,2654	,2721	,059 (?)
$H_{2(b)}$	,1070	,1253	,171 (x)	,1508	,1602	,179 (x)
$H_{2(c)}$	-,2389	-,3036	,014 (s*)	-,3539	-,3915	,012 (s*)
$H_{2(d)}$	-,1016	-,1142	,192 (x)	-,1598	-,1646	,171 (x)
$H_{2(e)}$	,0695	,0853	,264 (x)	,1011	,1092	,264 (x)
$H_{2(f)}$	,0036	,0043	,488 (x)	-,0063	-,0066	,484 (x)
$H_{2(g)}$	-,0998	-,1180	,189 (x)	-,1546	-,1629	,174 (x)
$H_{3(a)}$	-,3387	-,3922	,002 (s**)	-,4712	-,4916	,002 (s**)
$H_{3(b)}$	-,2478	-,2924	,015 (s*)	-,3518	-,3702	,017 (s*)
$H_{3(c)}$	-,0196	-,0219	,433 (x)	-,0184	-,0188	,456 (x)
$H_{3(d)}$	-,1693	-,2025	,067 (?)	-,2440	-,2587	,068 (?)
$H_{3(e)}$	-,1818	-,2156	,055 (?)	-,2618	-,2760	,056 (?)
$H_{4(a)}$	,0749	,0773	,264 (x)	,0860	,0864	,309 (x)
$H_{4(b)}$	,0909	,0943	,224 (x)	,1269	,1274	,233 (x)
$H_{4(c)}$	,1462	,1521	,111 (x)	,1804	,1812	,149 (x)
$H_{4(d)}$	,1159	,1208	,166 (x)	,1537	,1546	,187 (x)

p_t p determined using either t_a or t_b

p_r p determined using either r_a or r_b

(s**)	"significant"	$p \leq 0,010$
(s*)	"significant"	$p \leq 0,020$
(s)	"significant"	$p < 0,050$
(?)	"indecisive significance"	$0,050 \leq p \leq 0,100$
(x)	"not significant"	$p > 0,100$

Sample Size: 34

N. B. All subjective assessments of p are as per **Table 5-2**

Appendix H

Tables of the Raw Data and their Descriptive Statistics

Table H-1

R-scores and KAI scores

System No.	R-score	Analyst KAI	User KAI	Mean KAI	ΔKAI	|ΔKAI|
1	8	119	107	113	12	12
2	2	78	81	80	-3	3
3	12	106	100	103	6	6
4	5	105	116	111	-11	11
5	5	114	115	115	-1	1
6	20	92	96	94	-4	4
7	4	83	82	83	1	1
8	23	94	119	107	-25	25
9	11	103	98	101	5	5
10	20	85	97	91	-12	12
11	30	119	81	100	38	38
12	21	107	87	97	20	20
13	16	107	113	110	-6	6
14	16	123	96	110	27	27
15	19	111	127	119	-16	16
16	33	108	93	101	15	15
17	10	121	88	105	33	33
18	12	121	84	103	37	37
19	32	121	117	119	4	4
20	14	103	95	99	8	8
21	14	100	105	103	-5	5
22	21	94	110	102	-16	16
23	14	93	103	98	-10	10
24	9	93	115	104	-22	22
25	21	93	108	101	-15	15
26	16	87	76	82	11	11
27	17	117	93	105	24	24
28	10	94	119	107	-25	25
29	14	110	104	107	6	6
30	9	110	101	106	9	9
31	7	109	98	104	11	11
32	25	88	135	112	-47	47
33	5	95	89	92	6	6
34	27	94	107	101	-13	13
Mean	15,4	102,9	101,6	102,5	1,2	14,8
Std Dev	8,06	12,55	14,09	9,34	18,88	11,47

Table H-2

Users' opinions of the analysts and their problem-solving styles

(Seven-point scales: Scoring from 1 to 7§)

System No.	Speed of Comprehension	User Ignored	Time Wasted	Limited Area	Design Detail	Contingency Coping	Dissonance with analyst	Debugging Effort	Enhancing Effort	Manual Detail
1	4	2	1	3	3	6	1	4	1	3
2	3	2	1	4	4	6	1	2	3	4
3	6	5	1	1	2	2	1	4	1	2
4	4	5	4	1	4	4	1	2	5	6
5	5	5	2	2	4	4	1	3	2	1
6	3	6	2	2	6	2	2	4	3	1
7	4	6	1	3	5	5	1	1	4	7
8	5	2	2	5	4	2	2	4	3	1
9	6	5	2	4	4	6	1	4	5	2
10	5	5	1	1	4	6	1	4	2	4
11	4	1	1	5	4	6	1	5	4	1
12	5	6	1	1	2	4	1	2	6	1
13	2	5	3	6	5	6	1	3	4	3
14	7	2	2	2	4	6	1	5	3	4
15	4	5	3	5	2	1	4	4	4	4
16	6	7	5	1	4	2	6	3	6	4
17	7	7	1	5	4	6	1	2	4	1
18	6	6	2	2	1	6	2	3	1	4
19	4	5	2	6	5	6	2	6	3	4
20	2	5	2	2	1	4	5	6	6	4
21	7	5	2	5	4	7	5	4	3	4
22	4	4	2	5	1	4	6	4	3	4
23	5	2	2	2	4	6	2	2	3	1
24	4	5	2	2	4	3	1	2	2	4
25	2	1	2	2	4	2	5	3	2	4
26	4	3	2	2	4	4	2	4	3	4
27	5	5	1	2	4	1	1	4	1	5
28	6	5	2	2	2	5	5	4	3	4
29	7	5	1	1	4	3	5	6	4	4
30	6	5	2	5	4	6	1	3	6	4
31	6	1	2	4	4	7	2	3	6	4
32	6	2	2	4	4	4	2	7	4	1
33	6	1	1	1	4	3	1	3	1	4
34	5	5	4	5	3	3	6	4	4	4
Mean	4,9	4,1	1,9	3,0	3,6	4,4	2,4	3,6	3,4	3,3
Std Dev	1,44	1,83	,95	1,68	1,18	1,79	1,82	1,35	1,56	1,55

§Score 7 implies:

Comprehension far quicker than expected	User ignored most	Most time wasted	Most limited	Far too much	Excellent	Extreme	Extreme	Extreme	Far too much

Table H-3

User Satisfaction Factor Ratings

(Seven-point scales: Scoring from 1 to 7§)

System No.	Accuracy of Output	Reliability of System	Efficiency Improvement	Relationship with Analyst	Attitude of Analyst
1	4	5	3	6	6
2	7	7	7	7	7
3	7	5	2	7	7
4	7	7	7	7	6
5	7	6	4	6	6
6	6	6	7	6	6
7	7	7	4	5	6
8	6	7	5	6	5
9	3	6	5	6	6
10	4	6	7	7	7
11	6	6	6	7	7
12	6	7	7	7	6
13	6	6	4	7	7
14	4	6	6	7	7
15	6	6	5	6	6
16	5	6	1	2	3
17	5	6	7	6	6
18	7	5	5	6	5
19	1	1	4	5	5
20	6	6	7	4	1
21	7	7	4	6	7
22	2	1	4	3	5
23	6	5	2	5	6
24	5	5	4	5	5
25	6	6	7	5	6
26	5	5	1	5	5
27	7	4	5	6	4
28	6	7	6	6	7
29	6	7	6	6	6
30	6	6	6	6	6
31	6	6	6	6	5
32	2	2	5	5	6
33	7	7	6	6	7
34	5	4	7	2	2
Mean	5,5	5,6	5,1	5,6	5,6
Std Dev	1,58	1,58	1,77	1,30	1,41
§Score 7 implies:	**Excellent**	**Excellent**	**Outstanding**	**Excellent**	**Excellent**

Table H-4

Ages and Lengths of Service (LOS) in Years

System No.	Analyst Age	User Age	ΔAge	|ΔAge|	Analyst LOS	User LOS	ΔLOS	|ΔLOS|
1	31	35	-4	4	6	3	3	3
2	44	55	-11	11	9	35	-26	26
3	48	37	11	11	6	17	-11	11
4	45	41	4	4	28	18	10	10
5	25	33	-8	8	2	6	-4	4
6	34	28	6	6	6	5	1	1
7	38	35	3	3	6	10	-4	4
8	32	34	-2	2	5	5	0	0
9	31	41	-10	10	9	16	-7	7
10	37	39	-2	2	8	17	-9	9
11	34	50	-6	6	3	18	-15	15
12	28	53	-25	25	3	26	-23	23
13	28	50	-22	22	3	27	-24	24
14	33	31	2	2	4	7	-3	3
15	46	33	13	13	6	3	3	3
16	37	62	-25	25	5	37	-32	32
17	53	48	5	5	25	27	-2	2
18	42	36	6	6	3	17	-14	14
19	42	52	-10	10	3	18	-15	15
20	25	38	-13	13	4	8	-4	4
21	31	47	-16	16	1	6	-5	5
22	28	27	1	1	10	6	4	4
23	47	38	9	9	5	8	-3	3
24	47	30	17	17	5	2	3	3
25	47	35	12	12	5	14	-9	9
26	29	60	-31	31	5	40	-35	35
27	38	32	6	6	1	10	-9	9
28	36	35	1	1	15	11	4	4
29	25	30	-5	5	3	11	-8	8
30	25	35	-10	10	3	8	-5	5
31	37	42	-5	5	3	22	-19	19
32	43	28	15	15	5	7	-2	2
33	25	21	4	4	2	1	1	1
34	32	36	-4	4	5	17	-12	12
Mean	36,0	39,0	-2,8	9,5	6,2	14,2	-8,0	9,7
Std Dev	8,06	9,82	11,91	7,49	5,86	10,22	10,71	9,14

Appendix I

Tests of the Research Hypotheses using both Kendall and Spearman Rank Correlation Co-efficients

Table I-1 (a)

Associations as Kendall Rank Correlation Coefficients, t_a

Hypothesis	S	t_a	$s(t_a)$	$z(t_a)$	p	
H_1	162	,2888	,1197	2,41	,008	(s)
$H_{2(a)}$	98	,1747	,1169	1,49	,068	(?)
$H_{2(b)}$	60	,1070	,1128	,95	,171	(x)
$H_{2(c)}$	-134	-,2389	,1082	-2,21	,014	(s)
$H_{2(d)}$	-57	-,1016	,1163	-,87	,192	(x)
$H_{2(e)}$	39	,0695	,1108	,63	,264	(x)
$H_{2(f)}$	2	,0036	,1130	,03	,488	(x)
$H_{2(g)}$	-56	-,0998	,1137	-,88	,189	(x)
$H_{3(a)}$	-190	-,3387	,1148	-2,95	,002	(s)
$H_{3(b)}$	-139	-,2478	,1138	-2,18	,015	(s)
$H_{3(c)}$	-11	-,0196	,1171	-,17	,433	(x)
$H_{3(d)}$	-95	-,1693	,1129	-1,50	,067	(?)
$H_{3(e)}$	-102	-,1818	,1136	-1,60	,055	(?)
$H_{4(a)}$	42	,0749	,1196	,63	,264	(x)
$H_{4(b)}$	51	,0909	,1196	,76	,224	(x)
$H_{4(c)}$	82	,1462	,1195	1,22	,111	(x)
$H_{4(d)}$	65	,1159	,1194	,97	,166	(x)

(s) "significant" $p < 0,050$
(?) "indecisive significance" $0,050 \leq p \leq 0,100$
(x) "not significant" $p > 0,100$

Sample Size: 34

N. B. All subjective assessments of *p* are as per **Table 5-2**

Table I-1 (b)

Associations as Kendall Rank Correlation Coefficients, t_b

Hypothesis	S	t_b	$s(t_b)$	$z(t_b)$	p	
H_1	162	,2981	,1235	2,41	,008	(s)
$H_{2(a)}$	98	,1944	,1301	1,49	,068	(?)
$H_{2(b)}$	60	,1253	,1322	,95	,171	(x)
$H_{2(c)}$	-134	-,3036	,1375	-2,21	,014	(s)
$H_{2(d)}$	-57	-,1142	,1307	-,87	,192	(x)
$H_{2(e)}$	39	,0853	,1358	,63	,264	(x)
$H_{2(f)}$	2	,0043	,1347	,03	,488	(x)
$H_{2(g)}$	-56	-,1180	,1344	-,88	,189	(x)
$H_{3(a)}$	-190	-,3922	,1330	-2,95	,002	(s)
$H_{3(b)}$	-139	-,2924	,1343	-2,18	,015	(s)
$H_{3(c)}$	-11	-,0219	,1308	-,17	,433	(x)
$H_{3(d)}$	-95	-,2025	,1350	-1,50	,067	(?)
$H_{3(e)}$	-102	-,2156	,1347	-1,60	,055	(?)
$H_{4(a)}$	42	,0773	,1236	,63	,264	(x)
$H_{4(b)}$	51	,0943	,1240	,76	,224	(x)
$H_{4(c)}$	82	,1521	,1244	1,22	,111	(x)
$H_{4(d)}$	65	,1208	,1245	,97	,166	(x)

(s) "significant" $p < 0{,}050$
(?) "indecisive significance" $0{,}050 \leq p \leq 0{,}100$
(x) "not significant" $p > 0{,}100$

Sample Size: **34**

N. B. All subjective assessments of *p* are as per **Table 5-2**

Table I-2 (a)

Associations as Spearman Rank Correlation Coefficients, r_a

Hypothesis	Σd_i^2	r_a	$s(r_a)$	$z(r_a)$	p	
H_1	3892	,4017	,1735	2,32	,010	(s)
$H_{2(a)}$	4649	,2654	,1698	1,56	,059	(?)
$H_{2(b)}$	5186	,1508	,1639	,92	,179	(x)
$H_{2(c)}$	8262	-,3539	,1574	-2,25	,012	(s)
$H_{2(d)}$	7401	-,1598	,1690	-,95	,171	(x)
$H_{2(e)}$	5411	,1011	,1611	,63	,264	(x)
$H_{2(f)}$	6225	-,0063	,1642	-,04	,484	(x)
$H_{2(g)}$	7231	-,1546	,1652	-,94	,174	(x)
$H_{3(a)}$	9361	-,4712	,1668	-2,82	,002	(s)
$H_{3(b)}$	8528	-,3518	,1654	-2,13	,017	(s)
$H_{3(c)}$	6518	-,0184	,1701	-,11	,456	(x)
$H_{3(d)}$	7778	-,2440	,1642	-1,49	,068	(?)
$H_{3(e)}$	7930	-,2618	,1651	-1,59	,056	(?)
$H_{4(a)}$	5955	,0860	,1734	,50	,309	(x)
$H_{4(b)}$	5687	,1269	,1734	,73	,233	(x)
$H_{4(c)}$	5333	,1804	,1733	1,04	,149	(x)
$H_{4(d)}$	5502	,1537	,1731	,89	,187	(x)

(s)	"significant"	$p < 0{,}050$
(?)	"indecisive"	$0{,}050 \le p \le 0{,}100$
(x)	"not significant"	$p > 0{,}100$

Sample Size: 34

N. B. All subjective assessments of *p* are as per **Table 5-2**

Table I-2 (b)

Associations as Spearman Rank Correlation Coefficients, r_b

Hypothesis	Σd_i^2	r_b	$s(r_b)$	$z(r_b)$	p	
H_1	3892	,4031	,1741	2,32	,010	(s)
$H_{2(a)}$	4649	,2721	,1741	1,56	,059	(?)
$H_{2(b)}$	5186	,1602	,1741	,92	,179	(x)
$H_{2(c)}$	8262	-,3915	,1741	-2,25	,012	(s)
$H_{2(d)}$	7401	-,1646	,1741	-,95	,171	(x)
$H_{2(e)}$	5411	,1092	,1741	,63	,264	(x)
$H_{2(f)}$	6225	-,0066	,1741	-,04	,484	(x)
$H_{2(g)}$	7231	-,1629	,1741	-,94	,174	(x)
$H_{3(a)}$	9361	-,4916	,1741	-2,82	,002	(s)
$H_{3(b)}$	8528	-,3702	,1741	-2,13	,017	(s)
$H_{3(c)}$	6518	-,0188	,1741	-,11	,456	(x)
$H_{3(d)}$	7778	-,2587	,1741	-1,49	,068	(?)
$H_{3(e)}$	7930	-,2760	,1741	-1,59	,056	(?)
$H_{4(a)}$	5955	,0864	,1741	,50	,309	(x)
$H_{4(b)}$	5687	,1274	,1741	,73	,233	(x)
$H_{4(c)}$	5333	,1812	,1741	1,04	,149	(x)
$H_{4(d)}$	5502	,1546	,1741	,89	,187	(x)

(s) "significant" $p < 0,050$
(?) "indecisive" $0,050 \leq p \leq 0,100$
(x) "not significant" $p > 0,100$

Sample Size: 34

N. B. All subjective assessments of *p* are as per **Table 5-2**

Table I-2 (c)

Associations as Spearman Rank Correlation Coefficients, r_s

Hypothesis	Σd_i^2	r_s	$s(r_s)$	$z(r_s)$	p(z)	$t(r_s)$	p(t)	
H_1	3892	,4053	,1741	2,33	,010	2,508	<,01	(s)
$H_{2(a)}$	4649	,2897	,1741	1,66	,048	1,712	<,05	(*)
$H_{2(b)}$	5186	,2076	,1741	1,19	,117	1,201	>,10	(x)
$H_{2(c)}$	8262	-,2623	,1741	-1,51	,066	-1,538	>,05	(§)
$H_{2(d)}$	7401	-,1309	,1741	-,75	,227	-0,748	>,10	(x)
$H_{2(e)}$	5411	,1733	,1741	1,00	,159	0,995	>,10	(x)
$H_{2(f)}$	6225	,0489	,1741	,28	,390	0,277	>,10	(x)
$H_{2(g)}$	7231	-,1048	,1741	-,60	,274	-0,596	>,10	(x)
$H_{3(a)}$	9361	-,4303	,1741	-2,47	,007	-2,697	<,01	(s)
$H_{3(b)}$	8528	-,3031	,1741	-1,74	,041	-1,799	<,05	(s)
$H_{3(c)}$	6518	,0041	,1741	,02	,492	0,023	>,10	(x)
$H_{3(d)}$	7778	-,1885	,1741	-1,08	,140	-1,086	>,10	(#)
$H_{3(e)}$	7930	-,2116	,1741	-1,22	,111	-1,225	>,10	(#)
$H_{4(a)}$	5955	,0901	,1741	,52	,302	0,512	>,10	(x)
$H_{4(b)}$	5687	,1310	,1741	,75	,227	0,748	>,10	(x)
$H_{4(c)}$	5333	,1851	,1741	1,06	,145	1,066	>,10	(x)
$H_{4(e)}$	5502	,1594	,1741	,92	,179	0,913	>,10	(x)

p(z) p based on z-statistic
$t(r_s)$ Student t-Statistic (See Section 5.5)
p(t) p based on Student t-Statistic

(s) "significant" $p < 0,050$
(?) "indecisive significance" $0,050 \leq p \leq 0,100$
(x) "not significant" $p > 0,100$
(*) "significant" for r_s only
(§) "indecisive" for r_s only
(#) "insignificant" for r_s only

Sample Size: 34

N. B. All subjective assessments of *p* are as per **Table 5-2**

Appendix J

Derivation of Confidence Interval Formula for Ratio r/k

In the first instance a model is developed to show that if k and r are normal it is reasonable to test $\ell n(k/r)$ for normality, and should it so be, to make use of its descriptive statistics. Secondly, the formula for the standard normal statistic required to compute the confidence intervals is derived. The model falls short of being a rigorous mathematical proof. However, it demonstrates that if sample measurements k and r are approximately normal, then it is *reasonable to test* the statistic $\ell n(k/r)$ for normality. What is actually demonstrated, is the approximate *symmetry* of the distribution of $\ell n(k/r)$ when k and r are normally distributed, and have similar coefficients of variation.

Let (R, K) represent a bivariate population, in which R and K are positive and normally distributed, and where $R \propto K$. Then

$$R = cK$$

where c is the constant of proportionality.

Quite clearly, cK itself is normal, with the same mean and standard deviation as R, since it equals R. Now suppose that an attempt is made to measure the values of R and K for one member of the population, and measurements r; k are obtained respectively. Then the ratio ck/r estimates cK/R, and hence, but for experimental error, $ck/r \approx 1$.

More specifically, as a result of experimental error, either $ck/r \leq 1$ or $ck/r \geq 1$. Without loss of generality, only the case $ck/r \geq 1$ is considered.

To proceed further, an assumption is required; namely, that the *repeated* measuring of *cK* and *R* for *one member* of the population yields univariate populations of values for *ck* and *r*, which have the same normal distribution. In other words, the assumption is to be made that the errors of measurement of *cK* and *R* are normally distributed with equal means and standard deviations. As the means are respectively the true values for *cK* and *R* (which are equal), the assumption reduces to one of normal populations with equal standard deviations. This is not easily justified.

If the above assumption were made then this reservation would dictate the empirical verification of the resulting distribution. The assumption that *ck* and *r* (as a result of repetition of the same measurements) have equal normal distributions is made subject to this proviso. Then any *measured* values for *ck* and *r* have the same small probability of estimating either *cK* or *R*. This means that the ratios for any *practically determined* values of these variables, *ck/r* and *r/(ck)* have the same, small chance of occurring during the measurement of *cK/R*. Put more rigorously, the ratio *ck/r* has the same probability of falling into either one of the intervals [p, q] or [1/q, 1/p] for any p, q chosen such that $q \geq p \geq 1$. Put in symbolic terms,

$$P(ck/r \in [p, q]) = P(ck/r \in [1/q, 1/p])$$

$$\Rightarrow \quad P(\ln(ck/r) \in [\ln p, \ln q]) = P(\ln(ck/r) \in [-\ln q, -\ln p]) \qquad \text{f J.1}$$

By writing $a = \ln p$ and $b = \ln q$, f J.1 reduces to

$$P(\ln(ck/r) \in [a, b]) = P(\ln(ck/r) \in [-b, -a]) \qquad \text{f J.2}$$

This holds for all class intervals [a, b] and [-b, -a], which have the same size and occur symmetrically about zero. Hence $\ell n(ck/r)$ has a symmetrical distribution with mean (and median) zero.

An immediate difficulty in making use of f J.2 is in the computation of the ratio *ck/r*, since *c* is an unknown constant. However, by making use of the laws of logarithms, $\ell n(ck/r)$ may be expressed as

$$\ell n(k/r) + \ell n\ c$$

By substituting *m* for ℓn c,

$$\ell n(ck/r) = \ell n(k/r) + m \qquad \text{f J.3}$$

where *m* is a constant. Hence under the same assumptions which gave rise to f J.1, $\ell n(k/r)$ is symmetrically distributed about *m*, with mean (and median) *m*. Now, if values of $\ell n(k/r)$ were *measured*, and shown to exhibit *symmetrical* distribution, the proviso of an empirical test made earlier would be satisfied. An approximately normal distribution is a common case of a symmetrical distribution, hence it would be an obvious step to compute values for $\ell n(k/r)$ and to test them for normality.

R-scores and $|\Delta KAI|$ values tested normal at the 0,1 significance level (see Table 5-4). The above model was thus applied with *r* and *k* representing corresponding measurements in these samples; that is, of measured R-scores and absolute KAI score differences respectively. The values k/r and $\ell n(k/r)$ were then determined, as listed in Table J-1.

Table J-1

R-scores and KAI scores: Ratios and Natural Logarithms of Ratios

System No.	R-score(r)	|ΔKAI|(k)	k/r	ℓn(k/r)
1	8	12	1,5000	,4055
2	2	3	1,5000	,4055
3	12	6	,5000	-,6931
4	5	11	2,2000	,7885
5	5	1	,2000	-1,6094
6	20	4	,2000	-1,6094
7	4	1	,2500	-1,3863
8	23	25	1,0870	,0834
9	11	5	,4545	-,7885
10	20	12	,6000	-,5108
11	30	38	1,2667	,2364
12	21	20	,9524	-,0488
13	16	6	,3750	-,9808
14	16	27	1,6875	,5232
15	19	16	,8421	-,1719
16	33	15	,4545	-,7885
17	10	33	3,3000	1,1939
18	12	37	3,0833	1,1260
19	32	4	,1250	-2,0794
20	14	8	,5714	-,5596
21	14	5	,3571	-1,0296
22	21	16	,7619	-,2719
23	14	10	,7143	-,3365
24	9	22	2,4444	,8938
25	21	15	,7143	-,3365
26	16	11	,6875	-,3747
27	17	24	1,4118	,3448
28	10	25	2,5000	,9163
29	14	6	,4286	-,8473
30	9	9	1,0000	,0000
31	7	11	1,5714	,4520
32	25	47	1,8800	,6313
33	5	6	1,2000	,1823
34	27	13	,4815	-,7309
Mean	15,4	14,8	1,09712	-,20503
Std Dev	8,14	11,47	,834640	,824171
χ^2	,412	3,647	5,118	,118
p >	0,800	0,100	0,050	0,900

R-score (r): User R-score
|ΔKAI| (k): Absolute KAI difference
k/r: Ratio: Absolute KAI difference / User R-score
ℓn(k/r): Natural logarithm of *k/r*

The goodness-of-fit test described in Appendix F was applied to the values obtained for ℓn(k/r). The χ^2 statistic for this test was found to be 0,118, for which $p = 0,9$ (2 degrees of freedom). This suggests strong normality, and hence the feasibility of determining confidence intervals for *k/r* (and, of course, for *r/k*).

The method used to estimate these ratios was as follows:
firstly, in the light of the above analysis, $\ell n(k/r)$ was taken to be normally distributed with mean -0,20503 and standard deviation 0,824171. If these are assumed to be precise estimates of the population parameters, then the statistic

$$z(\ell n(k/r)) = \frac{\ell n(k/r) + 0,20503}{0,82417} \qquad \text{f J.4}$$

has an approximately standard normal distribution with mean zero and standard deviation 1.
Evaluating $e^{0,20503}$ as 1,22756 makes it evident that 0,20503 can be expressed as ℓn 1,22756. f J.4 then reduces, with the aid of the laws of logarithms, to

$$z(\ell n(k/r)) = \frac{\ell n(1,22756\ k/r)}{0,82417} \qquad \text{f J.5}$$

Suppose the *p* confidence interval is required for *k/r*. Then, by writing the lower and upper limits for $z(\ell n(k/r))$ as $-z(p/2)$ and $+z(p/2)$ respectively, the following formula for the confidence interval of $z(\ell n(k/r))$ is obtained:

$$-z(p/2) \leq \frac{\ell n(1,22756\ k/r)}{0,82417} \leq z(p/2) \qquad \text{f J.6}$$

From this it follows that

$$-z(p/2)\ 0,82417 \leq \ell n(1,22756\ k/r) \leq z(p/2)\ 0,82417$$

$$\Rightarrow \quad e^{-z(p/2)\ 0,82417} \leq 1,22756\ k/r \leq e^{z(p/2)\ 0,82417}$$

$$\Rightarrow \quad e^{-z(p/2)\ 0,82417}/1,22756 \leq k/r \leq e^{z(p/2)\ 0,82417}/1,22756 \qquad \text{f J.7}$$

Confidence intervals for *r/k* are more convenient in situations where *r* (that is, the R-score) is to be forecast from *k* (the absolute KAI difference). The formula for these confidence intervals is easily derived from f J.7 as

$$1{,}22756\ e^{-z(p/2)\ 0{,}82417} \leq r/k \leq 1{,}22756\ e^{z(p/2)\ 0{,}82417}$$

f J.8

Using f J.8 and standard normal distribution tables (Huntsberger et al, 1973), Table 5-11 was produced. This gives approximate confidence intervals for the ratios *r/k* at the confidence levels specified.