CREATIVITY IN LIFE SCIENCES R & D

A study employing Adaption-Innovation Theory

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SUMMARY

This research is concerned with the question of performance in scientific research, and focusses on the potential of Adaption-Innovation theory (Kirton, 1976) for providing insights into individual innovativeness. Using empirical data from four large research organisations, a taxonomy of scientists is developed using the Kirton Adaption-Innovation (KAI) inventory. This taxonomy breaks new ground in its use of the sub-scales of KAI. It shows that the use of the total KAI scale, as in previous research in the literature, is a conflation which conceals important insights. The research also breaks new ground in its conceptualisation of research performance. Two dimensions of performance are hypothesised: creative performance and skills performance. The evidence suggests that the distinction is meaningful and that the two dimensions are essentially orthogonal.

The taxonomy developed in this research identifies four types of scientists according to their location on the 'O' and 'E' sub-scales of the KAI. It is in the distinction between two types possessing similar mid-range KAI scores that the research makes a notable contribution to the literature. These two types are shown to be very different in terms of their performance, job satisfaction and other characteristics. It is through these insights that the research offers the prospect of an instrument of value in the deployment of research scientists.

Finally, concerns about the conceptual status of the KAI are developed. The KAI is critically reviewed, and the evidence presented seriously challenges the claim that the KAI is purely a measure of cognitive style. Criticism is focussed on the 'O' sub-scale which, it is argued, contains items measuring level of cognitive ability. A refined KAI is developed and evaluated using a sample of post-graduate students of management. It is demonstrated that sub-scales can be derived which are more homogeneous conceptually and give nearly orthogonal measures.

ACKNOWLEDGEMENTS

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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

The future of the chemical industry as a whole depends primarily on successful research and development (R&D) to provide both new products and processes. Nowhere within this industry however, is the research function of more critical importance than in those areas whose business is based on the fast evolving life sciences, such as in the pharmaceutical sector. The intense competition and the potential rewards of a significant advance in the treatment of important disease states give such companies a great incentive to engage in research. A successful product can generate world-wide sales of well over $100 million per annum. During the past decade it has been the norm for large firms in this sector to commit around 10 per cent of their sales income to R&D, and in a recent review (Rapoport, 1983) several firms were quoted as spending more than 15 per cent of sales on R&D. During 1983 a leading drug company announced plans to build a £16 million neuro-sciences research centre in the U.K., and in 1985 another company announced a £20 million expansion in the U.K. on new laboratories and research staff for its agrochemicals business.

Nevertheless, the risks are also very great. The cost of bringing a single major drug innovation to the market is now in the range £65-100 million (Fishlock, 1985), and the time taken for the research and development is something in excess of ten years. Furthermore, the mortality rate of candidate drugs is very high. It has been estimated that for every new drug launched on the market, some 8,000 to 10,000 are subjected to initial screening (Cox and Neuwirth, 1979). Moreover project mortality is not restricted to the early stages of research, and in recent years several companies have had to abandon promising new drugs which had progressed as far as clinical trials. It is not surprising therefore that the efficacy of R&D in the life sciences has come under close scrutiny by top management (Fishlock, 1985).

A further aspect of pharmaceutical research which has led to increased attention to its management, is the change during the last decade or so of disciplinary emphasis. Prior to 1970, pharmaceutical research was essentially the province of the chemist. Vast numbers of chemical compounds would be synthesised and then screened by means of a model which simulated the particular disease state in man that was under investigation. During the past decade, advances in the biological sciences and biochemistry have made it possiblo to define disease states more accurately, and there is far greater selectivity in the choice of compounds for synthesis and screening. The emphasis now is on a whole range of disciplines known collectively as the life sciences. In addition there have been major advances in instruments and measuring systems which have extended further the range of specialists involved in pharmaceutical research.

In seeking to co-ordinate and control complex long-term projects involving highly trained reseach staff from a variety of scientific disciplines, organisation structures have undergone significant change. As noted by a NEDO report as long ago as 1972, there is increasing use of multi-disciplinary project teams in addition to the traditional grouping of staff into departments based on the various scientific disciplines. This so called matrix organisation has received attention from researchers into R&D and it is apparent that there are variants of this structure in use (Gunz and Pearson, 1977). One recent paper (Stucki, 1980) describes the evolution of matrix organisation over an eleven year period in a U.S. pharmaceutical R&D unit. During discussions with directors of research of four R&D organisations in the life sciences, which formed the preliminary phase of this work, it was apparent that there were differences in the way a matrix structure was used, and in views about its efficacy. This observation is in keeping with the findings of a study of about forty R&D organisations in the U.K. (Gunz and Pearson, 1977a).

The style of management exercised within R&D has been held, for many years, to influence creativity. In their extensive study, Pelz and Andrews challenged the widely held view that individual freedom and managerial coordination were incompatible. They concluded from their data that a combination of both was needed (Pelz and Andrews, 1976). Several studies have demonstrated the influence of leadership style on the innovative performance of R&D groups. Farris, for example, discussed the importance of the integrative function of the supervisor (Farris, 1972).

1.2 PERFORMANCE, PERSONALITY, AND ORGANISATION ENVIRONMENT.

From the background notes, it is apparent that many factors impinge on the performance of scientists employed in life-sciences research. Yet in spite of the importance of harnessing the creative abilities of a variety of scientists in the pursuit of organisational goals, only a few empirical studies are reported in the literature. One such research project was carried out in the research unit of a U.K. pharmaceutical company (Osbaldeston et al., 1978). This work sought to evolve a methodology capable of identifying and measuring facilitatory and inhibitory influences on creativity in R&D. Comparisons were drawn between environmental influences in different parts of the same organisation, and although the research was regarded as a pilot study, the authors concluded that interaction between organisational climate and creativity was confirmed. The present research aims to develop the methodology of Osbaldeston and others who have been concerned with team collaboration (e.g. Aram and Morgan, 1976). Nevertheless we feel that these and other studies have a serious omission in failing to consider the question of individual personality.

The preliminary phase of the present research involved discussions with fourteen directors and senior managers in six large organisations. Four of these companies have R & D budgets in excess of '1 million per annum. When seeking to identify areas of particular interest to senior management, issues of creativity, morale and motivation were raised by them. The view was expressed that personality characteristics need to be taken into account when setting up project teams. In one of these discussions, the director referred to 'managing the prima donna tendencies of some scientists' (Unpublished notes on discussions, Lowe E. A. and Taylor W.G.K., June 2, 1982; Appendix A). He commented that some scientists seem able to collaborate readily, others do not get on at all well together. These views led us to consider the work of Kirton on the Adaption-Innovation (A-I) theory. This theory, first propounded in 1976, is based on the concept of a bipolar dimension of cognitive style (Kirton, 1976, 1980). Earlier literature concerned with creativity had concentrated on defining and assessing level rather than style, and measures of level had received much criticism in terms of their reliability and validity. It is generally held that such measures are contaminated by factors such as intelligence and know-how (Freeman et al., 1968) whereas a measure of style can be unaffected by these factors (Kirton, 1984b).

The A-I theory postulates that everyone can be located on a continuum ranging from highly adaptive to highly innovative according to their score on the A-I inventory (Kirton, 1977). In the general population the score exhibits a variability characterised by a normal distribution, and reliability coefficients approaching 0.9 have been reported. Kirton describes the highly adaptive as inclined to produce a sufficiency of ideas, but ideas which are based closely on agreed definitions of the problems. They are inclined to look at these in detail and proceed within the established norms of their organisations and disciplines. Their attitude towards change is characterised by doing things better. In contrast, those who are highly innovative are more likely in the pursuit of change to reconstruct the problem, separating it from its customary viewpoints. Innovators are likely to produce less acceptable solutions. They are more concerned with doing things differently rather than doing things better. Both may be equally creative in their different ways. There is a superficial resemblance between A - I theory and some ideas described a decade earlier by McPherson (1965), who developed the idea of a productive partnership between those he described as 'Ideators' and the 'Sifters'. According to McPherson the Ideator produces the ideas and the Sifter picks out the best of them, gets them developed and protects the Ideator from criticism. However, while McPherson saw a partnership between his two types based on mutual respect, Kirton sees a tension between his two types owing to substantially different cognitive styles.

The behavioural differences given in A -I theory between Innovators and Adaptors are important in the context of collaboration between individuals in a variety of work situations. Innovators tend to be seen by Adaptors as being abrasive and insensitive. The Adaptor may feel threatened because his/her therories and assumptions are implicitly attacked by the Innovator's disregard for customs. Adaptors tend to be seen by Innovators as unenterprising. Adaptors tend to find it more easy to collaborate with other Adaptors, whereas Innovators may often appear abrasive even to each other.

The A-I theory postulates that both Adaptors and Innovators have their characteristic strengths and weaknesses, and that both types are needed by organisations. The potential value of A-I theory in understanding what makes for effectiveness in research groups in the life sciences is obvious in view of the extensive collaboration necessary. As far as the author is aware, none of the reported work on R&D team collaboration has made use of A-I theory. This is not to say that A-I theory has not been tested in the R&D context. Keller and Holland (1978) carried out a study in three American R&D organisations (none were engaged in the life sciences) and concluded that the KAI (Kirton Adaption-Innovation) score correlated well with several direct measures of innovativeness. The considerable data on KAI measurements accumulated by researchers in several countries in the past six years indicates that in most groups of individuals there is a substantial range of scores. This implies that we might expect to find that many R&D scientists are part of a group whose mean KAI score is markedly different from their own. Such a situation is potentially stressful, yet it may at the same time help to provide the very environment which is needed for successful scientific research.

1.3 THE STRUCTURE OF THE THESIS.

The overall goal of the present work was to contribute to the task of managing the R & D function and to its scholarly literature. From the outset it was the intention to carry out research that would be of interest and potential value to practising R & D managers and improve research activity by furthering understanding of significant factors that have a bearing on research effectiveness, and on their inter-relationships. As the research progressed, there was increased interest in the potential of A - I theory because of some observations which appeared to have been overlooked in earlier work reported in the literature, and this became the principal focus of the work. These observations, and developments stemming from them, offered the prospect of valuable insights into the question of individual creativity in scientific research, and of an instrument to provide guidance in the deployment of research staff. Although it was anticipated that the research would draw on and, hopefully, contribute to behavioural theory, the end in view was to contribute to the management of research staff by providing insights into differences in cognitive style as identified by A - I theory and the implications for effective working.

The thesis proper begins with a selective review of a vast literature which has a bearing on the inter-disciplinary subject of R & D management. Firstly, reference is made to some of the concepts emerging from work on creativity during the past three decades. The importance of creativity to R & D effectiveness can hardly be overstressed. This review leads to a detailed study of recent work concerned with measuring a person's style of creativity, the A-I theory of Kirton, already referred to. Secondly, the literature concerned with the difficult task of measuring research performance is discussed. This is a particularly important issue in the present context since it constitutes the dependent variable in an overall sense. A considerable variety of methods are reviewed but, as will be described subsequently, the opportunities available for performance measurement at the research sites were severely restricted. Thirdly, reference is made to the literature concerned with the concepts of organisation environment and job satisfaction, since earlier work in the literature has identified the importance of these aspects. Although the main thrust of the present work is not concerned with organisational climate, reference to certain aspects, particularly collaboration, was felt to be essential and an attempt has been made to review the rather diffuse literature.

Chapter Three contains a detailed account of the methodology used in the research, the underlying thinking and the literature reflected in the methodology. This chapter presents a frank account of the difficulties experienced in gaining access to research workers, and of the way the methodology was to some extent shaped by the constraints imposed by the senior management at the research sites. One of the aims of the methodology was to provide an inter-firm comparison, and indeed this has been achieved within the limitations that will subsequently described. The dearth of inter-firm comparisons in R & D management to be found in the literature suggests that the difficulties experienced in the present research are far from unique, yet the importance of such comparisons is patently clear. The difficulties stem from the highly confidential nature of work which underpins the long term future of a company's commercial operations, and the sensitive way that a community of creative workers needs to be managed. Nevertheless, these facets make for not only difficulties but also the fascination that such work holds for a researcher in management.

Chapter Four presents the basic data stemming from the research. The three company sub-samples are first characterised using classificatory variables such as age, sex, etc. Then follows data on KAI measurements, with particular reference to the sub-scales of KAI, and data on the two dimensions of research performance, creative performance and skills performance. Finally the data on job needs, job satisfaction and organisation environment is summarised. Reference is made in this chapter to the observation that these R & D samples exhibit relative levels of the 'O' and 'E' sub-scales which are slightly different to the to those in general population as reported in the literature. A suggestion is made to account for this observation, and this leads to the idea that the total KAI score may be much less appropriate a measure than the separate sub-scales.

Chapter Five is concerned with the preliminary analysis of the data using correlation methods. Following the lead from Chapter Four, intriguing patterns in the correlatives of the 'O' and 'E' sub-scales were identified. From this point in the research, relatively little use was made of the total KAI score, and attention was focussed on the possibility of deriving a more insightful analysis using the sub-scales. Indeed, it was concluded that the total KAI score concealed important differences as far as a community of scientific researchers was concerned.

Chapter Six describes several possible taxonomies using the KAI sub-scales. The method ultimately chosen was a characterisation of researchers using a four way classification based on the 'O' and 'E' sub-scales. Using the mean levels of 'O' and 'E' in the general population as the boundary lines, the respondents were classified according to which quadrant in the O-E plane they belonged. These four categories were dubbed Types I, II, III, and IV. Reference is made to a paper published subsequently by Davies (1985) which provides some independent validation of this model.

Chapter Seven develops the model introduced in Chapter Six. Reference is made to job needs and job satisfaction, and to data on organisation environment, particularly that concerned with collaboration. Although not all of the data fits comfortably into the model, a substantial amount forms a coherent pattern. By virtue of the fact that A - I theory makes postulates about the question of collaboration, there was an opportunity to check the validity of these aspects of A - I theory.

Chapter Eight introduces further empirical data obtained from a Danish pharmaceutical company. By the time this data was available, analytical work on the British data and the thesis stemming from that analysis were at an advanced stage. There were also concerns about how well this small sample represented the R & D unit as a whole.

In Chapter Nine, an attempt is made to draw together the several strands of the research so far with reference to the original aim of contributing to the management of R & D. A tentative model of research performance is proposed and some implications for the management of R & D are discussed.

Chapter Ten is directed to a review of the major tenets of A - I theory, which has been a major theoretical concept underlying much of the thesis. The issue of whether the KAI is a measure of cognitive style, as asserted by A-I theory, is critically reviewed, as are the concepts underlying the three sub-scales. Through factor analytic studies the homogeneity of the sub-scales is investigated, and concern about the sufficiency of three factors is developed.

Finally, in Chapter Eleven, work towards refining the KAI is described. It is demonstrated how sub-scale reliability can be maintained with a reduced number of items, and how an extremely clear cut factor structure giving near orthogonal sub-scales can be obtained. A reduced KAI inventory is evaluated using the empirical data already presented. Given the encouraging results, a revised KAI using new items is evaluated by means of fresh data obtained from management students.

During the final stage of the research, interest has been shown in the method of characterising researchers which has been developed in this thesis. Papers based on this research have been presented at a R & D Conference at Manchester Business School (Lowe and Taylor, 1985a) and at a KAI Users Seminar (Lowe and Taylor, 1985b), and an article based on the Manchester paper has been recently published (Lowe and Taylor, 1986). There has been particular interest in the use of the separate KAI sub-scales (Payne, 1987), which until the present research, had remained virtually uninvestigated compared with the total KAI scale.

CHAPTER 2 A LITERATURE REVIEW

2.1 CREATIVITY

To the population at large there has been, and perhaps still is, a sense of mystery surrounding highly creative work. A fascinating personal account of the creative process by one of the outstandingly creative geniuses of all time, Wolfgang Amadeus Mozart, reveals that the creative process can also remain mysterious to the creative person. In a letter believed to have been written in 1789, Mozart describes the process in the following way (Holmes, 1878).

"When I am, as it were, completely myself, entirely alone, and of good cheer - say travelling in a carriage, or walking after a good meal, or during the night when I cannot sleep; it is on such occasions that my ideas flow best and most abundantly. Whence and how they come, I know not; nor can I force them. . . . . All this fires my soul, and, provided I am not disturbed, my subject enlarges itself, becomes methodised and defined, and the whole, though it be long, stands almost complete and finished in my mind, so I can survey it, like a fine picture or a beautiful statue, at a glance. Nor do I hear in my imagination the parts successively, but I hear them, as it were, all at once. . . . . When I proceed to write down my ideas, I take out of the bag of my memory, if I may use the phrase, what has been previously collected into it in the way I have mentioned. For this reason the committing to paper is done quickly enough, for everything is, as I have said before, already finished . . . . . . But why my productions take from my hand that particular form and style that makes them Mozartish, and different from the works of other composers, is probably to the same cause which renders my nose so large or so aquiline, or in short, makes it Mozart's, and different from those of other people. For I really do not study or aim at any originality."

To read that one of the most creative minds known to mankind, certainly as far as the sphere of art is concerned, sought no originality, is bound to promote a sense of mystery.

There can be no doubt about the social and commercial need for creative work, and a vast literature on the subject has accumulated mainly since 1950. The starting point for the surge of interest seemed to coincide with the inaugural address to the American Psychological Association in 1950 by Guilford, who drew attention to 'education's appalling neglect of the study of creativity' (Guilford, 1950). Since that time there has been a great deal of research by psychologists, mainly in America. A thorough review of that literature would be inappropriate in this thesis, but some of the themes are relevant to the methodology that will be described subsequently. There have been several reviews of research on creativity. An example is that by Freeman, Butcher and Christie (Freeman, 1968). A British publication of readings in creativity edited by Vernon (1970), has also attracted much interest, judging by the regularity with which the book has been reprinted since its first publication in 1970. In the present notes the aim will be to identify strands of thinking which are related to our research from among the diverse theoretical material available.

The measurement of creativity

There has been a very prolonged debate about the measurement of creativity. American psychologists have shown much ingenuity in devising a wide range of tests to purportedly measure creativity or original thinking. The names of Guilford, Torrance, Messick and Mednick are associated particularly with such tests. A test by the Swiss psychiatrist, Rorschach, the Ink-blot test, has achieved considerable fame, though much criticism. In reviewing such tests, Barron (1969), has listed three general criticisms. Firstly, the tests are superficial and in no sense do they engage the subject's deepest being, as creative work in the real world does. Secondly, because they measure creative ability in fragments, they provide no opportunity for the integral quality of intellect to manifest itself. Thirdly, the short and closely timed tests violate the essence of the creative process, which goes at its own pace, and "is easily aborted if someone is always blowing a whistle on it."

The question of the connection between creative ability as measured by the many available tests and intelligence has also been subjected to prolonged debate. On the face of it, many tests of originality do seem to call for what one thinks of as intelligence. In summarising the position, Freeman et al. (1968) concluded that in any group of people covering the usual range of ability, creativity as assessed by the Guilford / Torrance / Messick tests of divergent thinking overlaps very considerably with intelligence as assessed by conventional tests. Most of the studies in which the two traits have been clearly separable have been based on selected groups of high ability.

Creativity and personality

There is also a considerable literature on the connection between creative ability and personality. Freeman et al. (1968) concluded that the considerable evidence of the literature suggested that differences in creativity were more related to non-cognitive than to cognitive traits. In the area of personality study the work of four American psychologists, Roe, MacKinnon, Barron and Cattell is prominent. Roe (1952) was a pioneer in the study of the personality traits of scientists. She studied a wide variety of attributes of 64 eminent scientists by long personal interviews and many tests. She sought to identify any information that might have a bearing on the subject's choice of vocation and success in it. Roe found that personality differences were more crucial than differences in intelligence, and concluded that fairly high intelligence with a very high degree of persistence and motivation were more characteristic of the most eminent scientists than very high intelligence with rather less persistence. Another clear finding from her research was the marked independence of mind and self-sufficiency of these scientists. Although not overtly dominant, they showed considerable stubborness and autonomy of judgement.

MacKinnon has published several papers in this area, though some of them are inaccessible. He concluded that cognitive tests of divergent thinking such as those of Guilford and Torrance are not adequate to distinguish creative and non-creative people in terms of real-life achievement. He is best known for his study of 124 American architects. They were rated and classified into three groups by eminent colleagues according to creative talent, and MacKinnon (1963) has presented many interesting results. Among the characteristics of the most creative architects revealed by his extensive tests were dominance, low sociability, freedom from conventional restraints and inhibitions, readiness to admit views that were unusual and unconventional, and relatively high femininity of interests.

Cattell and Drevdahl (1955) studied 140 eminent research scientists and compared their personality profiles with those of the general population and with those of eminent teachers and administrators. Interesting similarities and differences were found between the scientists and the teachers / administrators. Both scored well above average in ego-strength, intelligence, dominance, and strength of self sentiment. Regarding differences, the scientists were characterised by high radicalism, self-sufficiency and by low surgency and cyclothymia. The creative scientists were uniformly lower on almost all the elements of extraversion.

The question of introversion - extroversion was dealt with in greater detail by Cattell and Butcher (1968). They noted that the broad second-order concepts of introversion and extraversion were useful only as a first approximation, and that a description in terms of primary factors was needed to make the picture more consistent. The general tendency to introversion did not apply to all the components, but was largely concentrated in the 'A' factor, ie the scientists were skeptical, withdrawn, unsociable, critical and precise. Regarding factor 'H' however, the eminent scientists were well up on the scale, displaying a characteristic resourcefulness, adaptability and adventureness. On factor 'F' however, (surgency - desurgency) eminent scientists tend to be low, ie desurgent, having the characteristics of restraint, brooding and solemnity. Cattell and Butcher comment on the fact that scientific research today is increasingly a matter of teamwork, and there could be value in conventional social skills. Nevertheless they are inclined to the view that the individual, fertile, originator remains the crucial factor in scientific progress.

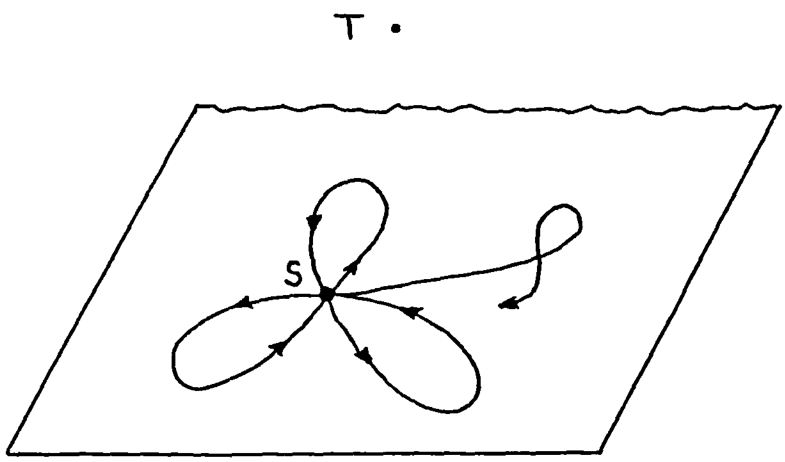
The work of Koestler (1969)

Koestler developed a psychological theory of creative thinking which he termed the 'bisociative response'. His monumental work contains a rich store of anecdotal material, but one particular anecdote is used to illustrate his central thesis. It is the story of the discovery of the principle of Archimedes.

"Hiero, tyrant of Syracuse and protector of Archimedes, had been given a beautiful crown, allegedly of pure gold, but he suspected that it was adulterated with silver. He asked Archimedes's opinion. Archimedes knew, of course, the specific gravity of gold (mass per unit volume related to that of water). If he could measure the volume of the crown he would know immediately whether it was pure gold or not; but how on earth is one to determine the volume of a complicated ornament with all its filigree work? If only he could melt it down . . . . ".

One can imagine Archimedes's thoughts moving round in circles within the frame of his geometrical knowledge; and finding all approaches to the target blocked, returning again and again to the starting point. The frustrating situation, familiar to everybody trying to solve a difficult problem, may be represented as in Figure 2.1. The point 'S' represents the starting point, the loops are trains of thought within the blocked matrix of geometrical concepts, and 'T' represents the target, ie a method for measuring the volume of a highly complex geometrical shape. Unfortunately, the point 'T' is located outside the plane of the matrix.

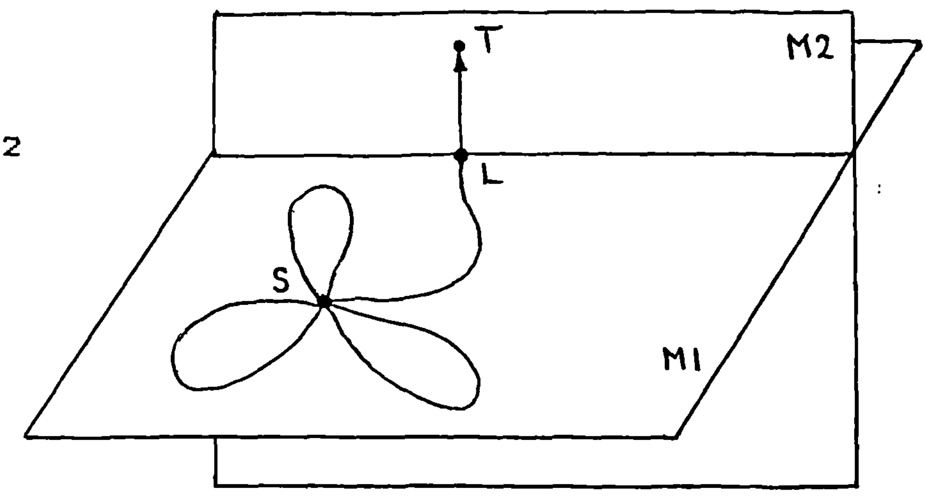
Figure 2.1



"One day, while getting into his bath, Archimedes watched absent-mindedly the familiar sight of the water level rising from one smudge on the basin to the next as a result of the immersion of his body, and it occurred to him in a flash that the volume of water displaced was equal to the volume of the immersed parts of his own body, which therefore could be simply measured by the pint. He had melted his body down, as it were, without harming it, and he could do the same with the crown."

The experiences and ideas associated with the daily bath moved along habit-beaten tracks. They were the sensations of hot and cold, of fatigue and relaxation, and a pretty slave girl to massage his limbs. Neither to Archimedes nor to anyone else before him had it ever occurred to connect the trivial and sensuous experience of taking a hot bath, with the scholarly pursuit of geometrical measurement. No doubt he had observed many times that the level of the water rose whenever he got into it, but this fact, and the distance between the two levels, was totaly irrelevant to him until it suddenly became bisociated with his problem. The discovery can be represented by Figure 2.2.

Figure 2.2



Matrix 'M1' is the same as in the previous diagram, governed by the well-known rules of geometry, by means of which Archimedes originally had tried to solve the problem. 'M2' is the matrix of associations related to taking a bath. The link 'L' may have been simply a visual impression (the image of the crown was lurking on the fringe of his conciousness) or it may have been a verbal concept (rise of water level equals melting down volume of my body). The essential point is that at the critical moment <u>both</u> matrices 'M1' and 'M2' were simultaneously active in Archimedes's mind. The creative stress resulting from the blocked situation had kept the problem on the agenda even while the beam of conciousness was drifting along quite another plane. Without the constant pressure, the favourable conjunction would have been missed. No doubt Archimedes's knew that the water level rose when he climbed into his bath but there had not previously been the crucial association. Once the association has been made the two matrices can never be separated. That is why, asserts Koestler, the discoveries of yesterday are the commonplace of today.That is why we always marvel how stupid we were not to see what <u>post factum</u> appears to be so obvious.

There are interesting connections between Koestler's theory of scientific creativity and the work of Kuhn, the physicist and scientific historian. In a paper presented to a conference mainly of psychologists, Kuhn (1963) cautioned against equating divergent thinking with creativity. He readily acknowledged that some divergent thinking characterised all scientific research, and that gigantic divergencies lie at the core of most significant episodes of scientific development. Nevertheless he questioned whether flexibility and open-mindedness had not been too exclusively emphasised as the characteristics requisite for basic research. He suggested that convergent thinking is just as essential to scientific advance as divergent thinking. Since these two modes of thought are in conflict, it can be expected that an ability to support such a tension would be a prime requisite for first class scientific research.

Kuhn made the point that almost none of the research undertaken by even great scientists is <u>designed</u> (my italics) to be revolutionary, and very little of it had any such effect. On the contrary, Kuhn argues, normal research, even the best of it, is a highly convergent activity, based firmly upon a settled consensus. Nevertheless, this convergent or consensus-bound research ultimately results in revolution when a point is reached where traditional techniques and beliefs need to be abandoned. Kuhn's work as a historian of science led him to suggest that only investigations firmly rooted in the contemporary scientific tradition are likely to break that tradition and give rise to a new one. This idea finds an echo in Koestler's writings. It led Kuhn to the view that the successful scientist must simultaneously display the characteristics of the traditionalist and of the iconoclast. Kuhn was seeking to discredit the stereotype of the research scientist which he perceived to be held by the community of psychologists concerned with creativity. "Most important of all", he concluded, "we must seek to understand how these two superficially discordant modes of problem solving can be reconciled both within the individual and within the group".

Some years before Koestler's work, Rogers (1959) had suggested that there were several conditions <u>within</u> the individual which are closely associated with creativity. One of these was an openness to experience, or extensionality in Rogers's terminology. This is the opposite of psychological defensiveness. Rogers argued that in a person open to experience, each stimulus is freely relayed through the nervous system. In such a person there is a lack of rigidity and a permeability of boundaries in concepts, beliefs, perceptions, and hypotheses. It means a tolerance for ambiguity where ambiguity exists; it means the ability to receive much conflicting information without forcing closure upon the situation. Another of Rogers's conditions was the ability to play spontaneously with ideas, 'to juggle elements into impossible juxtapositions, to make the given problematic, to express the ridiculous, to translate from one form to another'. In this way he envisaged that out of the wasteful spawning of vast numbers of possibilities, there would emerge one or two evolutionary forms with qualities of special value.

Green (1964), who wrote with the experience of R & D management (he was Vice President of Bell Telephone Laboratories at that time), provided an interesting schema of the creative process. He proposed that creative thinking in science can be typified as in Figure 2.3.

Figure 2.3 Green's Typology

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                    Technolgical thinking
                              !
           _________________!_________________
          !                                   !
          !                                   !
      Systematic                          Intuitive
          !                                   !
  ________!_________                          !
 !                  !                         !
Empiricism     Omphaloskepsis  <---->  Flash of genius/hunch
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On the horizontal or lateral dimension, there is a continuum of styles of thinking from systematic thinking to intuitive thinking. As Green put it, "The one is a deliberate act of the concious mind, the other the gracious gift of the sub-concious in return for the previous labours of the concious mind." He suggested that systematic thinking is a combination of empiricism and omphaloskepsis. The first term is self explanatory; the second describes a process of oriental meditation. Green used the latter to describe the contemplative process of the rational formulation of a theory, tested by guided empiricism, and sometimes supplemented by serendipitous outcomes. Intuitive thinking yields the sudden flash of insight.

Green formulated the creative process as consisting of eight stages.

(1) The individual develops at least one **preliminary conception** of the problem.

(2) **Accumulation** of data and ideas through reading, discussion and experiment takes place.

(3) **Incubation** occurs when the concious and non-concious mind assimilate the information.

(4) **Intensive thinking** next occurs, when the individual seeks a solution by weaving ideas in different ways, but in spite of intense effort, fails.

(5) **Frustration** and fatigue result, and the individual abandons concious concern with the problem.

(6) Thus **relaxation** follows, he sleeps on it.

(7) **Illumination** or sudden inspiration occurs.

(8) A **solution** is to hand, and is verified.

There is much in common between Green and Koestler. With both viewpoints, inspiration only occurs after the researcher has undergone the perspiration of extensive and frustrating concious effort. Koestler suggested that creative people soak themselves in the subject matter of the problem and then cogitate. To cogitate means to shake together hitherto separate entities. This process of cogitation can occur at two levels of thinking. There is the linguistic and logical level of systematic thought, but there is also the non-linguistic, dreamlike level which provides the 'flash of genius' in Green's typology, and the 'bisociation' of Koestler.

Since cogitation involves a combination of non associated matrices, perhaps in a random way, the more matrices there are present in the mind potentially to combine, the more likely is a creative combination to be found. Hence a creative individual is likely to be one with wide as well as specialist scientific interest, someone with intellectual curiosity. Such a person will be an inveterate idea collector, immersed in his/her specialist literature, but curious about everything else too. However, the creative individual also needs the persistence and tenacity to generate the perspiration that precedes the inspiration. It would seem that the case of Mozart does not fit the model and, as many commentators have suggested, he is perhaps best regarded as a unique phenomenon.

It is not difficult to identify relationships between the works of other writers mentioned earlier. There is a connection between the 'permeable boundaries' of Rogers and the 'bisociation' of Koestler. Furthermore, there is the 'marked independence of mind' of Roe, the 'freedom from conventional restraints and inhibitions' of MacKinnon, the 'high radicalism' of Cattell, which can be seen to be traits tending to facilitate the bisociate response. In the Section which follows, concerning the work of Kirton on the Adaption-Innovation theory, the verbal portrait of the Kirton Innovator will be recognised in some of the above descriptions.

2.2 ADAPTION - INNOVATION THEORY

Adaption - Innovation theory is organised around the concept of a bipolar dimension of cognitive style (Kirton, 1976). The extremes of this continuum, contrast two distinct modes of creative, problem solving, and decision-making behaviour. The measure of this style, the Kirton Adaption - Innovation Inventory (KAI), based on developmental work involving more than 2,000 subjects in eight countries, has shown that KAI scores are distributed normally in the population (Kirton, 1977a). The continuum underlying that distribution is inferred to be a basic dimension of human personality. It has relationships with other personality characteristics which will be reviewed subsequently. The A - I property of cognitive processes is not context specific, according to Kirton. There is no suggestion, for example, that artists are innovative and engineers are not. The KAI is not a measure of cognitive or intellectual level. It is the manner of performance, not the level of effectiveness of performance, that KAI is purported to measure.

The Inventory consists of 32 items, each of which is scored by the subject on a scale from 1 to 5, giving a theoretical range of total scores from 32 to 160. The range of a general population, appears to be from 46 to 146, with a mean fractionally below 96. Internal reliability coefficients have been estimated by several researchers as follows : Cronbach Alpha = .88 for two combined U.K. general population samples, n=562 (Kirton, 1976); Cronbach Alpha = .85 for New Zealand students, n=412 (Kirton, 1978a) K-R20 =.88 for U.S. managers, n=256 (Keller and Holland, 1978a); K-R20 = .86 for a U.S. general population sample, n=214 (Goldsmith, 1985a); Cronbach Alpha = .87 for a general Italian population sample, n=835 (Prato-Previde 1985, unpub.). This data appears to have led many researchers to the conclusion that the KAI has good psychometric properties, and a substantial volume of publications involving KAI has appeared within the past five years.

Factor components of the KAI

Repeated factor analyses of the KAI (Kirton, 1976; Keller and Holland, 1978a; Mulligan and Martin, 1980; Goldsmith, 1985a; Prato-Previde, 1985, unpub.) using large samples in four countries, U.K., U.S.A., New Zealand and Italy, have demonstrated three stable, reliable factor traits with internal reliabilities around .8. The stability of the concept is seen in the percentage of items in each of the studies which load maximally on the same factor as that found in the original study. The average percentage of terms correctly classified across all studies was 83 per cent.

The first factor is labelled Originality. A number of the items loading heavily on this factor have a close similarity to the descriptions referred to earlier in the work of Rogers (1959). A person scoring high on the 'O' scale would seem to correspond closely to the 'creative loner' of Rogers' theory. Rogers suggests that his creative loner compulsively toys with ideas. Adaptors seem to prefer the production of (as distinct from being capable of producing) fewer original ideas in a given situation. In contrast Innovators proliferate ideas, by preference. Hence when extremes of each type are in conflict, it is likely that the Innovator sees the Adaptor as one who originates with his/her finger on the stop button. Equally, the Adaptor sees the Innovator as one who cannot find such a button. Most of the idea output of the Innovator can be expected to be discarded though a small proportion may be spectacularly successful. Kirton emphasises that the 'O' factor must not be confused with level or capacity to produce ideas. Adaptors tend to produce few ideas unless pressed to produce more than they would prefer to, the limit for anyone, Adaptor or Innovator, being the level of their capacity.

The second factor is labelled Efficiency. It has a parallel with Weber's (1970) analysis of the aims of bureaucratic structure. Weber describes bureaucrats as concerned with precision, reliability and efficiency. In A - I theory this is a description of an Adaptor, high Weberian efficiency being associated with a low 'E' score (negative scoring). Kirton suggests that the opposite, innovation, is essentially a discontinuity, and can rarely be expected to be immediately efficient. Efficiency is usually achieved by development, which is an adaptive process.

The third factor is labelled Rule / Group Conformity. This factor relates to Merton's (1957) analysis of bureaucratic structure which ".... exerts a constant pressure on officials to be methodical, prudent, disciplined, ... and an unusual degree of conformity. These qualities make for adaption rather than innovation. Kirton suggests that Innovators seem more able and willing to resist such pressures, because of the value they place on freedom to develop ideas. (The KAI 'R' scale is negatively scored.)

Personality differences between Adaptors and Innovators

Kirton and several other researchers independently, in several countries, have attempted to correlate KAI scores with other measures of personality. The aim, clearly, has been to identify a pattern of correlations so that the A-I theory can be located in relation to other established personality measures. Numerous studies have been reported during the past seven years, and it is beyond the scope of the present study to review in detail the work in this specialist area. Particularly wide-ranging work was reported by Gryskiewicz (1982), who related KAI to the California Psychological Inventory, the Strong Campbell Inventory and the Myers-Briggs Type Indicator. Also important are papers by Torrance and Horng (1980) and Torrance (1982). Kirton (1984b) has produced a recent summary. Several differences between Adaptors and Innovators seem to be well substantiated. The Adaptor is more left brain dominated, less creatively motivated, perceives himself/herself as less creative, is more dogmatic, intolerant of ambiguity and inflexible. The Adaptor is also more introverted, humble, conscientious, controlled, subdued and emotionally tender. Adaptors are lower in self-esteem and prefer to take fewer risks.

A - I theory has stressed the distinction between cognitive style and cognitive level, and purports to measure style. Accordingly, KAI scores should not correlate significantly with IQ, achievement tests, nor with tests measuring level of creativity. There is considerable support for this view in the work of Gryskiewicz (1982), Goldsmith (1984) and Kirton (1978), none of whom found significant correlations with a variety of IQ tests. Only one of five tests measuring level of creativity (Cattell 16PF Second Order Factor X) gave a significant correlation with KAI (r=.28), and it has been suggested that this measure mixes style with level. Education is another factor which could be expected to be unrelated to style. Two findings bear this out (Kirton, 1976 r=.14 and Ettlie & O'Keefe, 1982 r=.13). One factor, not previously discussed, which does have a small but significant correlation with KAI is sex. Studies covering several countries indicate that women are in general slightly more adaptive than males.

Adaptors and Innovators in collaboration

From the outset, A -I theory has led to hypotheses about the nature of collaboration and communication between people with similar KAI scores and those with dissimilar KAI scores. In Kirton's initial paper on A-I theory (Kirton 1976), behaviour descriptions are given of Adaptors and Innovators and there is particular reference to the question of collaboration (see Figure 2.4). Nevertheless, documentary evidence in the literature concerning relationships between KAI scores and issues of collaboration is hard to find. Much of the material is speculative and is unreferenced. A typical example is the following (Kirton, 1984b). "Experience is accumulating from the use of KAI in industry, both from consultants and in-house observations, that large differences in scores between individuals (and groups) leads to increased difficulties in collaboration and even communications..... While Innovators find it difficult to combine with others, Adaptors find it easier. The latter will more rapidly establish agreed ground, assumptions, guidelines, and accepted practices on which to found their collaboration".

Figure 2.4 Behaviour descriptions of Adaptors & Innovators
(Kirton, M.J., J. App. Psych., 1976, 61, 622)

Adaptor	Innovator
Characterised by precision, reliability, efficiency, prudence, conformity	Seen as undisciplined, thinking tangentially, approaches tasks from unsuspected angles
Concerned with resolving problems	Could be said to discover problems
Seeks solutions to problems in tried & understood ways	Queries problems' concomitant assumptions
Reduces problems by improved efficiency, with maximum continuity and stability	Is catalyst to settled groups irreverent of consensual view abrasive, causes dissonance
Seen as sound, safe, and dependable	Seen as unsound, impractical, often shocks his opposite
Liable to make goals of means	Treats accepted means with little regard
Seems impervious to boredom able to maintain accuracy in long spells of detailed work	Capable of detailed routine work for only short periods, quick to delegate routine
Is an authority within given structures	Tends to take control in unstructured situations
Challenges rules rarely; when assured of support	Often challenges rules, has little respect for custom
Tends to high self-doubt; vulnerable to social pressure & authority; compliant	Tends to low self-doubt when forming ideas; does not need consensus given opposition
Essential to the functioning of the institution; at times must be 'dug out'	Ideal in unscheduled crises and better in avoiding them if he can be controlled
When collaborating with Innovators: supplies order stability & continuity to the partnership	When collaborating with Adaptors: supplies task orientations, the break with the past & accepted theory
Sensitive to people, keeps group cohesion & cooperation	Insensitive to people, often threatens group cohesion
Provides a safe base for the Innovator's riskier operations	Catalyses the periodic radical change, without which institutions tend to ossify

A further issue concerning collaboration within groups is the concept of 'bridgers'. Given that a lack of understanding amongst Innovators and between Innovators and Adaptors leads to friction, it has been suggested that some individuals with intermediate scores and other appropriate personal characteristics may act as 'bridgers' between individuals and groups (Kirton, 1984a). It is suggested that the further a person is from the population mean, the more difficulty is encountered with the role of the intermediary. Once again, as Kirton admits, the evidence is anecdotal.

Creativity and A - I literature: a summary

To conclude this selective review of creativity and A - I theory, it is apparent that there are many mutually supportive strands to be found in work spanning three decades in the papers of Roe, Rogers, Koestler, Cattell, Barron, Kirton and Keller & Holland. For example, the Bisociative concept of Koestler is reflected in Rogers' extensionality and in the paradigm-cracking of Kirton. The creative loner of Rogers' can be seen in some of Kirton's descriptions of A - I Innovators; Keller and Holland's most innovative researchers were also A - I Innovators.

Nevertheless, not all is consistent, and inconsistences are perhaps of particular interest in research work. There are two aspects of interest. Firstly, there is the question of personality as related to creativity by several writers in various ways. The work of Kirton leads one to expect that Innovators will tend towards extraversion. In a recent paper (Kirton and de Ciantis, 1985), where the KAI was related to Cattell's 16PF Inventory, the correlation between KAI and Cattell's Introversion - Extraversion (Factor II) was positive but just non-significant. In commenting on this result, Kirton and de Ciantis expected a stronger correlation, and suggest that a surprising factor structure in Cattell's measure (Factor II includes Q2 (Group Dependent/Self-sufficient) scored negatively) reduced the correlation found. On the other hand, the comprehensive work of Cattell & Butcher and Roe (already summarised) with outstandingly creative scientists suggested no tendency to extraversion. At the risk of over-simplifying, the outstandingly creative scientists tended to introversion. Furthermore, although Koestler's concept of Bisociation requires a predisposition to generate ideas, it also requires, perhaps more importantly, a predisposition to persevere with the task of re-arranging ideas. Cattell and Butcher (1968) provide support for this view: "On the whole, therefore, one would expect that the ability, characteristic of introverts, to withdraw, to exclude the outside world in long periods of concentrated thought and speculation, would outway in creative scientists (and even more in creative artists) the superior ability of the extravert to communicate socially. This is indeed what was generally found". It may well be that the A - I Adaptor is at an advantage over the Innovator as far as the Bisociative process is concerned. This conclusion would retain consistency between the work of Cattell & Butcher, Roe and Koestler.

The second and related strand of inconsistency concerns the question of style and level of creativity. Kirton has repeatedly affirmed that KAI measures style and not level. One paper (kirton, 1978) was specifically concerned with the correlation between the KAI and various measures of the level of creativity. His conclusion was that pure measures of level are uncorrelated with KAI and that both Adaptors and Innovators can be equally creative. Given this result one is not forced to postulate an inconsistency between Kirton's work and that of Cattell & Butcher, Koestler and others. There is a problem, however, regarding the nature of the creativity. Kirton (1976) states that Adaptors and Innovators can be equally creative <u>in their different ways.</u> It is suggested that the Innovator is the person most likely to produce the paradigm-cracking solution. Thus one is led to connect the A - I Innovator with the person favoured in the Bisociative act and presumably the person who achieves fame as 'outstandingly creative'. There is also the work of Keller and Holland, reviewed earlier. Why should Keller and Holland's most innovative (presumably most creative) researchers tend to be A - I Innovators and presumably extraverts? The work of Keller and Holland was presented as validatory evidence for A - I theory, yet on this issue it could be regarded as surprising if not discrepant. It is remarkable that the literature contains no reference, as far as the writer is aware, discussing why a measure of level (Keller and Holland) should be correlated with a measure of style (Kirton). It will be an argument to be presented in this thesis that some progress can be made towards resolving this issue by distinguishing between the measures given by the sub-scales of KAI (instead of using the total KAI score), and by treating 'research performance' in a way not previously utilised in the literature, as far as the author is aware.

2.3 THE MEASUREMENT OF R & D PERFORMANCE

In many studies concerned with the management of R & D, performance in one sense or another constitutes the crucial dependent variable. The variety of methods to be found in the literature may reflect different emphases, but more probably the variety indicates that no single approach has a clear superiority. The problem has long been recognised. Shapiro (1968) considered that the criterion problem was the most challenging aspect of all research into creativity. He pointed out that without establishing satisfactory criteria, all endevours at devising predictors, investigating personality and cognitive characteristics and venturing hypotheses about the creative process were of questionable value. Taylor and Holland (1964) had expressed a similar view with the words, "There is no more crucial problem in creativity than the criterion problem". Shapiro (1968) expressed the view that one of the disheartening conclusions emerging from approximately fifteen years of intensive research was that little progress had been made on achieving acceptable criteria of creativity. The position has changed but little since then.

In a review concerned primarily with communication in R & D organisations, Epton (1981) noted that the relationship between communication and performance was the main reason for carrying out research in that area, and of four such studies reviewed, each one had adopted a different performance measure. Both objective and subjective methods have been described in the literature. Among the objective approaches, the number of papers published is a frequently used measure. Examples include Pelz and Andrews (1976), Smith (1971), McCarry and Edwards (1973), Jauch and Glueck (1975) and Birnbaum (1979). In several of these examples the method adopted was to use self-reporting of papers developed or written during the past five years, a logarithmic transformation being applied to reduce the skewness of the distribution owing to a proportion of extreme scores. Similar procedures relating to the number of books published were also used by the above authors. Somewhat arbitrary numerical devices were used to overcome the awkward minus infinity generated by the logarithm of zero, and to avoid the inconvenience of negative scores. The number of patents gained has also been used as a measure in studies in an industrial environment (Pelz and Andrews, 1976; Smith, 1971). In an academic environment, patents are less frequently taken out as Birnbaum (1979) comments, and so in an academic environment they have not been used as output measures.

The use of objective measures of creative output presents many difficulties. As McPherson (1963) pointed out, there are serious flaws in such an approach. As an example, consider the problems relating to the use of number of patents as a criterion of research performance. Some products have creative worth, but are not patentable; quality differs from patent to patent; it is easier to obtain patents in a new field, but difficult in a well-worked field. Furthermore, all three measures, papers, books and patents, are unreliable measures in an industrial setting because publications by research staff are subject to company policy. Such policies may vary from one project to another as well as from one company to another. In an academic environment, papers and books would seem, a priori, to have better validity, though Birnbaum (1979) does comment that in some projects, papers and books were not thought to be necassarily relevant. In addition to the above objective measures, Keller and Holland (1979) also used job level in the organisation hierarchy as a performance measure.

A wide variety of subjective measures have been described. Allen (1979), who dealt with teams carrying out contract research, relied on evaluations made by "competent technical evaluators in the government laboratories that sponsored the projects". What factors they took into account is not recorded. Frost and Whitley (1971) obtained two sets of measurements of individual performance, both provided by the management team of the laboratory. The first was in the form of an unstructured overall rating on a five-point scale; the second, made at a later period, consisted of a set of ratings of each person with respect to nine attributes such as: energy, originality, and experience. It was found that the attribute designated as originality gave the best correlation with the initial overall rating. Hall and Ritchie (1975) relied on assessments made by the person concerned and by his immediate supervisor. Farris (1972) relied on supervisors and other first-level non-supervisors to judge the innovative performance of members of a project group. Smith (1971) evaluated a scientist's technical contribution and his general usefulness to the laboratory by supervisory and peer rankings. The judges made paired comparisons between those scientists with whose work they were personally familiar.

Keller and Holland (1979) used two subjective measures of job-related performance. For the first subjective measure, management rank ordered the professional employees within their work unit on each of five criteria. These were: quality of performance; quantity of performance; ability to get along with other employees; dependability; and total performance. The score on each criterion was the employee's rank order divided by the number of employees in the work unit. Factor analysis of the five performance criteria indicated that only one clear factor existed, and this was called overall performance. The second subjective measure of performance was innovativeness. It was measured by peer nominations. Each subject was asked to nominate up to four co-workers who had contributed to important innovations in their respective organisation. The number of nominations received by each individual became the innovativeness score for that person.

Birnbaum (1979) also used several subjective performance measures. In addition to a self-evaluation performance index, he used three other subjective methods. These were as follows. Firstly, group member's perceptions of effectiveness, obtained by averaging each group member's agreement or disagreement with a statement that their project was very effective. Secondly, a factor scale composed of three indicators: reliability, cooperation and development. Reliability referred to meeting objectives without the necessity of follow up and checking. Cooperation referred to activities scheduled and coordinated with other organisations, and rarely failing to meet responsibilities. The third indicator, development, referred to personnel participating in training and development activities, and having a high level of competence and skill. These three indicators were found to load on a single factor after principal component analysis, and the three items were combined into a factor scale by weighting each of the standardised indicators by its factor score coefficient and summing. The third measure referred to the extent to which organisational goals were attained, specifically the extent to which project goals were attained as reported by project members.

Osbaldeston, Cox and Loveday (1978) relied entirely on self assessment using an arbitrary 1 - 10 scale. They distinguished between creative potential and creative performance, and asked respondents to assess not only their own creativity but also that of their work group and their department. They also asked each respondent to assess how their immediate superior would assess their creative performance. Osbaldeston et al. note that numerous ways have been proposed for measuring creativity. They quoted the work of Mottram (1972) which showed that self ratings of creativity by scientists correlate broadly with external criteria of research output such as publications or inventions, and that highly creative people are probably the best judges of creativity in others.

In view of the widespread use of assessment by peers in one way or another, a review of such methods in general by Kane and Lawler (1978) is of interest. They distinguished between three types: peer nominations, peer ratings and peer rankings. Each method was evaluated in terms of its practicality, reliability, validity, freedom from bias and acceptability. Peer nomination consists in having each member of the group designate a specified number of group members as being the highest in the group on a particular characteristic. Often each group member is also asked to designate some specified number of persons who are the lowest in the group on the rating dimension. Kane and Lawler concluded that peer nominations are effective in serving the limited purpose of discriminating persons with extreme levels of the attribute concerned. This method has been subject to most research and they concluded that it appears to have the highest validity and reliability. Peer rating consists in having each group member rate each other group member on the given characteristic, using one of several possible rating scales. Behaviourally anchored scales appeared to be the most highly regarded. Kane and Lawler concluded that although widely applicable, there was relatively weak empirical support for its effectiveness, and its validity and reliability were the poorest of the three methods. Peer ranking consists in having each group member rank all of the others from best to worst on one or more factors. Kane and Lawler suggested that this method suffered from a lack of research, but from limited evidence it appeared that it may prove to be the best of the three methods for achieving discrimination throughout the entire performance range.

Kane and Lawler (1978) also noted that systematic investigation of the reactions of the subjects in applying such methods was lacking. They added that peer assessment methods seem more prone to failing to obtain cooperation than most other methods. This is because they implicitely request that people divulge privileged information about their peers. The importance of involving those concerned in the design and planning of such methods is stressed.

2.4 ORGANISATIONAL CLIMATE

An exaustive review of the literature on organisational climate is beyond the scope of the present research. Nevertheless, the organisational environment has long been recognised as a potent source of influence on human behaviour and several empirical studies concerned with the performance of research scientists have attempted to measure aspects of organisational climate. Examples include Aram and Morgan (1976) and Osbaldeston, Cox and Loveday (1978). One of the aims of the present work was to build on and extend the work just cited. In a recent review of organisational climate (Payne and Pugh, 1983), it was suggested that the concept of organisational climate stems from the process of discovering how the organisation is a psychologically meaningful environment for individual organisation members. Through a well developed concept of organisational climate it should be possible to measure the interaction of environment and personality, and thus better predict human behaviour. The potential value of a climate concept is clear.

Many definitions of organisational climate can be found in the literature on the subject. Some of the many and varied examples are given below.

(i) "A set of measurable properties of work environment perceived directly or indirectly by the people who

live and work in this environment, and assumed to influence their motivation and behaviour."
(Litwin and Stringer, 1968)

(ii) "A set of attributes which can be perceived about a particular organisation and/or its sub-systems, and that may be induced from the way that organisation and/or its sub-systems deal with their members and environment."
(Hellriegel and Slocum, 1974)

(iii) "A relatively enduring quality of an organisation's internal environment distinguishing it from other organisations; (a) which results from the behaviour and policies of members of the organisation, especially top management; (b) which is perceived by members of the organisation; (c) which serves as a basis for interpreting the situation, and (d) acts as a source of pressure for directing activity."
(Prichard and Karasick, 1973)

(iv) "A molar concept reflecting the content and strength of the prevalent values, norms, attitudes, behaviours and feelings of members of a social system which can be operationally measured through the perceptions of system's members, or observational and other means."
(Payne, 1971; quoted in Payne and Pugh, 1983)

(v) "Those characteristics that distinguish the organisation from other organisations and that influence the behaviour of people in the organisation." (Gilmer, 1971)

From this selection of definitions, substantial variations in rigour are apparent, and this is probably a fair reflection of the literature on organisational climate as a whole. In the valuable review by Payne and Pugh (1983), it is suggested that consistent patterns are difficult to find, particularly when subjective methods are used, and they present two alternative conclusions. In their 'pessimistic conclusion', they stress the problem that different positions in the structural hierarchy have shown systematic differences in measures of perceived organisational climate and structure. Thus past studies which ignored this aspect were probably misleading, and it is understandable why stable relationships between different organisational variables have not been found. Stressing the pitfalls, their pessimistic conclusion is that organisational climate research has been performed largely by the unwary, and that future research needs a fresh start. In their 'optimistic conclusion' some elements of progress, if meagre, are noted by Payne and Pugh. New methods for measuring dimensions of organisational structure and climate have been developed. Although subjective and objective approaches have not apparently produced similar relationships, each of the dimensional measures has discriminated across organisations. Different climates have had predictable effects on satisfaction. There is little doubt about the potential value of research in the area because of the benefit to be gained by the ability to create climates which are appropriate to particular goals and needs.

Campbell, Dunnette, Lawler and Weick (1970) have identified common sets of factors recurring in the literature, but concluded that only a relatively small number of dimensions had so far been isolated. The dimensions identified by Campbell et al with brief definitions are given below.

(i) Individual autonomy. A concept including individual responsibility, independence, orientation towards rules, freedom of individual initiative, i.e. freedom of the individual to have considerable decision-making power and freedom from constant accountability.

(ii) The degree of structure imposed upon the position. A concept concerned with constraints upon direction, the nature of supervision, objectives, i.e. the degree to which superiors established and communicated a job's objectives and methods for accomplishing them.

(iii) Reward orientation. This dimension included a range of reward-related factors, i.e. the question of various types of reward and criteria by which they were gained.

(iv) Consideration, warmth and support. This dimension is concerned with the extent of managerial consideration, support and stimulation and congenial co-operation between colleages.

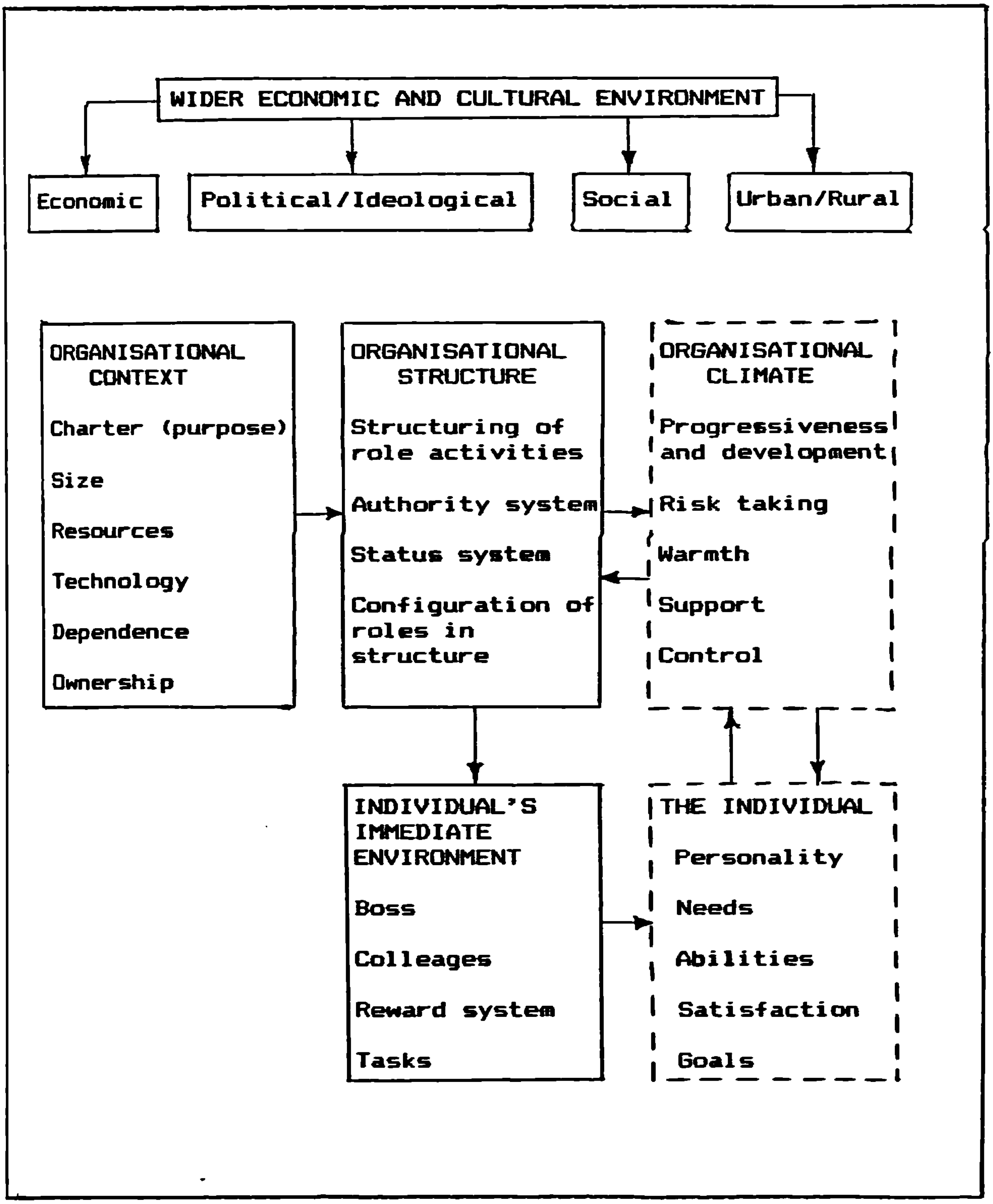
The notion underlying work of this nature is that a large, varied group of social environments can be characterised by a relatively small number of dimensions. Nevertheless, the schema of Campbell et al provided a useful framework to which the work of others could be related in varying degrees. For example, their dimension 'individual autonomy' can be seen to subsume 'individual responsibility' (Litwin and Stringer, 1968), 'agent independence' (Schneider and Bartlett, 1970), and 'opportunities for exercising individual initiative' (Tagiuri and Litwin, 1968). The dimensions of Campbell et al received support from subsequent factor analytic studies (Sims and La Follette, 1975; Waters, Roach and Batlis, 1974), though it was noted that a communality of items might have contributed to the result and that the number of dimensions was perhaps too few. In this connection, Payne and Pugh (1976) suggested a fifth dimension, 'orientation to development and progressiveness'. They noted that several writers had identified climate factors concerned with fostering people's development and encouraging the growth and application of new ideas. Several authors pointed out that specific additional dimensions might be needed to describe particular situations.

Of particular interest in the present work is the aspect of job satisfaction. In Litwin and Stringer's model (1968), the concept of organisational climate is used as an intervening variable, mediating between organisational and motivational factors. They saw "...climate as a filter through which objective phenomena must pass." Lawler, Hall and Oldham (1974) have also used organisational climate as a variable which intervenes between organisational processes and job satisfaction/performance. Schneider and Hall (1972) hypothesised that two important influences upon the kind of experiences an individual has, and thus the climate perceptions he develops, are the formal structure and the administrative processes of the organisation. In this view, climate is again an intervening variable, determined by variables such as job activities and organisational structure, and in turn influencing a number of output variables. Other researchers (Hellriegel and Slocum, 1974; Schneider and Snyder, 1975; and Sims and La Follette, 1975) have made explicit the essential difference between measures of climate and measures of satisfaction, viz. organisational climate attempts to measure properties of the work environment, whereas measures of satisfaction assess the affective response to facets of the work environment. Issues concerning relationships between job satisfaction and organisational climate will be discussed in more detail subsequently.

A simple systems model which depicts these and other relationships was given by Payne and Pugh (1983) in their review (See Figure 2.5). Payne and Pugh (1983) note that because organisational climate is influenced by organisations members' individual perceptions and is, thus, relatively subjective, it occurs in a box with broken lines in Figure 2.5. "Climate describes the characteristic behavioural processes in a social system at one particular point in time. These processes reflect the members' values, attitudes and beliefs, which thus have become part of the construct." Payne and Pugh pursue an interesting geographical analogy. "Climate dimensions such as progressiveness and development, risk taking, warmth, support and control correspond to temperature, rainfall and wind velocity, which have been generated by the interactions of physical features with the sun's energy. Social systems' equivalent energy sources are people who also create and are part of the climate. Although both physical and social climates may affect their respective structures, the content and structure of a social system are more stable than its people, whose energies may not always be spent in predictable cycles." 'The individual' is also placed in

Figure 2.5 Influences on organisational structure & climate

(Payne, R.L. and Pugh, D.S., 1983)



a box with broken lines. A person's personality, needs, abilities, satisfactions and goals affect his perceptions and thus indirectly influence the measure of the climate. As Figure 2.5 indicates, the 'true' climate also influences individual's characteristics and experiences.

The extent of diversity of opinion and contradiction in the literature led Guion (1973) to conclude that organisational climate represents a fuzzy concept, basing his assessment on the observation that researchers have attempted to measure what they believe to be organisational climate, rather than trying to identify the composition of climate. James and Jones (1974) point out that organisational climate has been conceptualised as : a dependent variable; an independent variable; a mediating variable; a set of organisational attributes; a set of perceptual variables; a mixture of perceptual variables and individual attributes. It seems that the confusion was partly attributable to poor definition of the climate construct used in questionnaire formulation and partly to the unit of analysis used. Downey et al (1974), quoting from Schneider (1973), summarise the unit of analysis problem by stating that "if climate is conceptualised as the property of an organisation, then the individual is not the appropriate unit of analysis." Of course it is by no means obvious that climate is <u>simply</u> the property of an organisation. Perhaps an example from the world of art may emphasise the point. Suppose one wishes to evaluate paintings and music. If value resides in that which lies on the canvas and that transmitted via sonic air vibrations one could suggest that reliable and precise measurement of the appropriate unit of analysis will be achieved by using the spectrometer and the audio-coupled oscilloscope, respectively.

The major divergence from the idea of a common core of dimensions appeared when Schneider (1975a) concluded that "climate should refer to an area of research rather than a construct with a particular set of dimensions." He viewed organisations, sub-units, and workgroups as having many climates (e.g. climates for creativity, motivation, etc.) and postulated that the question of dimension salience was relevant only in the context of a particular criterion. In spite of this statement, Schneider's call for criterion-oriented climate studies would not seem to rule out the possibility that a relatively small set of dimensions could describe multiple environments. However, any particular dimension may be positively related to some criteria, unrelated to others, and negatively related to a third set of criteria.

The review by Payne and Pugh (1983), completed in 1976, was organised around a distinction between objective and subjective methods of measurement. Some examples cited of objective methods included: critical incidents, labour turnover, absenteeism and lateness statistics. Payne and Pugh concluded that there had been very few studies which had compared objective and subjective measures. They suggested that this was due partly to the concept's infancy and partly to the high cost of collecting observational data from several organisations. Nevertheless some studies were quoted, though none were post-1970, and all were concerned with educational establishments. Payne and Pugh concluded that perceptual climate measures have some validity and do correlate with objective non-perceptual climate indicators, though they added that theoretically some of the relationships were "pretty tame." For example, to show a positive relationship between staff and students of high intelligence and high resources on the one hand, and a climate seen as intellectual and of high esteem, was almost tautological. It is apparent that the majority of the literature has been concerned with perceptual measures.

To the extent that the individual plays an active role as a perceiver and as a cognitive processor, climate scores will reflect the individual characteristics involved in the processes of perception and concept formation, as well as the characteristics of the situation being perceived. Jones and James (1979) quoted many studies in the period 1967 to 1975 which supported this point. Climate perceptions were shown to reflect differences in personality attributes, cognitive styles, ability, and adaptability, as well as age, race, sex, and intelligence. Therefore to the extent that an organisation or its sub-units contain individuals with a wide range of such characteristics, a greater diversity of perceptions might be expected. This point has implications for the generation of aggregate climate scores to describe situations shared by members of an organisation. James and Jones (1976) showed that where certain kinds of people are assigned to particular organisational groups, a biased aggregate score can result through systematically filtered perceptions. Discussing the group mean as an aggregate measure, Payne et al (1976) concluded that the mean was a legitimate descriptor as long as the perceptual referent was a situation and not an individual (in other words, as long as the item describes what was observed rather than reactions to an event or attribute). Working with Payne, Jabri (1986) has developed an approach termed Climate Mapping which depicts the individual and aggregate profiles of individual perceptions along relevant climate dimensions. As will be seen subsequently, no attempt has been made to use aggregate climate measures in the present research, though this position was imposed on the research when a complete identification of individuals with project teams was denied.

This section of the literature review has attempted to provide a theoretical background to the study of organisational climate. In conclusion, the ideas presented in an exhaustive essay by Schneider (1975) are summarised below.

1. Climate refers to molar perceptions people have of their work settings.
2. These molar perceptions have a psychological unity being based on actual or inferred events, practices and procedures that occur in the daily life of an organisation.
3. People have no choice about developing these psychologically meaningful molar perceptions because they are necessary as a frame of reference for gauging the appropriateness of behaviour.
4. Each work organisation can be seen to create a number of different climates. One way of thinking about these is to consider the kind of outcome behaviour a climate would lead to (e.g. leadership, creativity)
5. Climate perceptions may result in people behaving similarly or differently. When an organisation's practises and policies support and reward individual differences, then individual behaviour will differ, but such differences in behaviour will follow from shared perceptions regarding a climate for the display of individuality.
6. People in a work environment tend to share their perceptions of the work setting's climate, although the degree of sharing is not very great with some climate

measures.

7. Measures of climate have not been sufficiently descriptive nor frequently enough analysed at an organisation level for definitive statements to be made about the validity of climate perceptions. Objective measures of structural characteristics are generally not strongly related to climate measures, suggesting that organisational process, rather than structure, is the main root of climate perceptions.

8. In the best of cases, climate researchers have concentrated on measures that are descriptive of organisational practices and procedures. Assessment of how practices and procedures become climate perceptions is required.

9. Climate, as a perception of the external world, is conceptually different from job satisfaction which should be a study of a person's affective state. Both fall in the domain of 'attitude research', but a clear distinction should be maintained.

10. Climate is important for understanding how practices and procedures in organisations are reflected in human behaviour. The concept falls in the domain of cognitive theory wherein man is conceptualised as a thinking creature who organises his world meaningfully and behaves on the basis of the order he perceives and creates.

Job satisfaction and organisational climate

Reference has already been made to the question of inter-relationships between job satisfaction and organisational climate. After an extensive study comparing and contrasting perceptual measures of organisational climate and job satisfaction, Johannesson (1973) formed the following conclusion: "If it appears as if perceptual climate research is converging upon any domain, job satisfaction seems the likely candidate. Indeed it is hard to imagine how this possibly could have been avoided. Even if researchers had taken the pains to create new items and had adopted different item formats (which they have not) there remains the psychological problem of divorcing description from feelings. Since descriptions of work situations have been operationally defined as indices of job satisfaction, it seems redundant at best to also term such descriptions organisational climate."

Commenting on Johannesson's criticisms of the organisational climate construct, Hellriegel and Slocum (1973) wrote: "At a conceptual level, we would expect and be quite disturbed if the dimensions of climate did not include many of the same categories frequently found in satisfaction scales and instruments.... Climate instruments allege to describe work environments whereas satisfaction instruments serve to evaluate them.... While a number of studies have reported significant correlations between organisational climate and satisfaction, it is premature to assert that satisfaction affects climate or climate affects satisfaction. From a systems point of view it is reasonable to expect considerable interrelationships between the two concepts." Thus Hellriegel and Slocum made explicit the essential difference between measures of climate and measures of satisfaction. Organisational climate attempts to measure properties of the work environment, whereas measures of satisfaction assess the affective response to facets of the work environment.

LaFollette and Sims (1975) carried out research addressing specifically the question of redundancy in the job satisfaction/organisational climate concepts. Using a very large sample (n= 1161) of employees in a major medical complex, they concluded that the claim of redundancy was not supported. Although there were substantial inter-correlations among the several sets of variables measured in their research, they found that organisational climate and organisational practises factors did not relate to performance in the same manner as satisfactions related to performance. Their conclusion against the redundancy hypothesis was based on the logic of transitivity: if A equals B, and B relates to C, then A should also similarly relate to C. The conclusion reached by LaFollette and Sims was a tentative one and they admitted that their research had not resolved the dispute regarding climate.

Considerable progress towards the resolution of the problem was made by Payne, Fineman and Wall (1973). In their paper they re-examined the evidence of Johannesson (1973) and concluded that the levels of correlations presented by Johannesson did not warrant his claim that climate and satisfaction measures were substantially the same. Moreover they pointed out that the low levels of relationships between the satisfaction measures called into question their validity.

However, the main thrust of the paper by Payne et al (1973) was towards a <u>conceptual</u> resolution. Their approach employed facet analysis, the underlying idea being that concepts can be broken down into their component parts. A facet is the name that Guttmann gave to such a component. The researcher's task is to identify the relevant facets, and the categories or elements of which each facet is composed. In this way the structure of relationships that exists among the facets is illuminated. In probing the concepts of job satisfaction and organisational climate, Payne et al used three facets, each having two elements, i.e. three dichotomous facets. These were as follows.

(i) The unit of analysis : an individual or a social collectivity

(ii) The element of analysis : a job or a group/team/ department

(iii) The nature of the measurement : descriptive or affective

It can be seen that these three facets reflect some of the major issues discussed in the literature in the decade to 1975. When these facets are used to explicate the concepts of climate and satisfaction, eight conceptual types result. These conceptual types, their descriptions and facet structure are shown in Figure 2.6.

Figure 2.6 Conceptual types of climate and satisfaction
(Payne, R.L., Fineman, S. & Wall, T.D., 1976)

FACETS			CONCEPT
Unit of analysis	Element of analysis	Nature of measurement	
Individual	Job	Affective	JOB SATISFACTION
Individual	Job	Descriptive	PERCEIVED JOB CHARACTERISTICS
Individual	Dept/Team	Affective	SATISFACTION WITH ORGANISATION
Individual	Dept/Team	Descriptive	PERCEIVED ORGN. CHARACTERISTICS
Social Collectivity	Job	Affective	ROLE MORALE
Social Collectivity	Job	Descriptive	ROLE CLIMATE
Social Collectivity	Dept/Team	Affective	ORGANISATIONAL MORALE
Social Collectivity	Dept/Team	Descriptive	ORGANISATIONAL CLIMATE

On examining the literature with the aid of the analysis shown in Figure 2.6, Payne et al (1976) concluded that some researchers have worked with mixtures of facets that are conceptually questionable, while others have believed they were invoking one conceptual type when they were actually invoking another.

Another point highlighted by Payne et al was that the relationship between climate and satisfaction tended to be higher when the content of an item was valued by the population in question. They suggested that future research should concentrate on finding things about both jobs and organisations that are important to the people being studied. One implication of this is that general measures of satisfaction and climate become less useful since that which is important in one job or one organisation may be quite different from that in another. Payne et al concluded that in any specific case the more important psychological and sociological features may be those that are unique to that case.

CHAPTER 3 METHODOLOGY

3.1 INITIAL CONSIDERATIONS

Broadly structured discussions with senior management in a variety of R & D organisations took place before any attempt was made to formulate specific objectives within the field of research management. These discussions were regarded as very valuable because of the opportunity they gave us to learn of current views and problem issues as perceived by those responsible for directing very substantial industrial research and development budgets. Aside from our research, we saw such discussions as valuable in the context of our management *teaching*. Stemming from these exploratory talks, we sought to formulate research objectives which would be of interest and potential value to several host organisations, as well as being capable of making a contribution to the research literature. Indeed it was hoped that an improved understanding which can be expected to follow from research would readily satisfy both aims.

These early discussions ranged over strategic, economic and personnel issues, but it was in the latter area that it was felt the greatest interest lay. Towards the end of our initial visits in 1983 overall objectives had been defined as being concerned with exploring issues related to creativity on the part of research scientists. Not exactly by design, nor yet by chance, the research had become located in that part of the Chemical Industry based on the life sciences. Previous research experience and continuing interest in the Chemical Industry on the part of the author was mainly responsible for the location of the research in the Chemical Industry. Within that industry, the sector with the greatest investment in R & D (as a percentage of sales, for example), and with perhaps the most crucial need for R & D because of the rate of innovation, is the pharmaceutical one. An interest in inter-disciplinary research was a further factor which influenced the location of the present research. Ultimately four large companies engaged in life-sciences research were willing to allow access to their research staff, but because collaboration with the fourth came much later than that with the other three, this thesis will be based on research in just three companies.

In the early exploratory talks which took place over a period of some two years from 1981-1983, it was anticipated that a variety of data sources would be used to gain an understanding of the complex interaction between individuals and their environment. Some of the possibilities contemplated were as follows.

(i) Data by way of a questionnaire.

(ii) Data from company documentation, particularly regarding organisation structures, performance review data and project review data.

(iii) Data by way of interviews.

(iv) Data by way of peer assessment and managerial assessment.

Because of the highly confidential nature of long term research which underpins a company's survival and growth, we could hardly expect to move freely in the research laboratories as observers of formal and informal discussion, although tentative attempts were made to do so.

In spite of persistent efforts, we were unable to persuade our hosts to allow us access to any data in categories (iii) and (iv), and only data on organisation structures was allowed from category (ii). In all three companies there was a similar response: a cautious interest; a concern to exclude us from direct contact with research staff; a willingness to support a questionnaire provided participation was on a voluntary basis and required little staff time for completion.

Strenuous efforts were made before and after administration of the questionnaire to discern the reasons for the caution, and to gain a fuller participation. It seemed evident in one company that there had been some discontent following structural changes, and the senior management were concerned not to "raise old skeletons". Ultimately we had to accept that our research would have to be based essentially on the questionnaire data. [At the time of writing, December 1985, it seems that a further and closer collaboration with one of the three companies is now about to begin, following receipt by them of a paper summarising some of our research.]

This very limited participation was acutely disappointing, particularly when viewed in the light of injunctions by Argyris (1983). Argyris, well known for his writing on the unintended consequencies of rigorous research (Argyris, 1968), made a plea for research "whose nature is less congruent with the mechanistic pyramidal relationships and more congruent with organic relationships". He listed dimensions that describe differences between mechanistic and organic research, and these are given in an abbreviated form in Figure 3.1

It can hardly be claimed that the prescriptions of Argyris have been met to any great extent, but it was certainly client resistance that prevented the research being more organically orientated. As Argyris notes, "It may also be necessary to overcome the mistrust that people have begun to develop about empirical research" (Argyris, 1968). Perhaps the recent renewed interest and agreement to further collaboration from one of the host companies is explained in terms of a lessening mistrust.

Figure 3.1 Differences between mechanistically and organically orientated research (Argyris, 1983)

MECHANISTICAL ORIENTATION	ORGANIC ORIENTATION
Interventionist takes the most prominent role in defining goals	Subjects participate in defining goals
Interventionist keeps a professional stance, at a psychological distance from clients	Interventionist encourages subjects to confront and question him
Interventionist controls the amount of client participation	Client and interventionist determine amount of client participation
If participation is encouraged it tends to be only skin-deep	Client encouraged to participate in design of research methods
Feedback to subjects is designed to inform them	Feedback to subjects is designed to help them to develop more effective interpersonal relations

3.2 ACCESS TO RESPONDENTS

The initial approach to employees was made by the directors concerned. Given that participation was to be entirely voluntary, it had been emphasised that any limited sample [the senior management wished to minimise any disturbance we might cause] should preferably comprise a high response rate from a subset of project teams. Sample sizes of the order of 50 were agreed at each site. In one case a meeting was held in which we discussed the research with staff from the project teams selected by the Director as constituting a representative pilot study. In the other two cases we had no personal contact with the staff, but in all three cases it was made clear by the directorate that participation was entirely voluntary, and our written introductory note (see Appendix B), emphasised that all data would be treated anonymously.

In spite of what was a very cordial relationship between the most senior management and ourselves following several meetings and hospitality at Sheffield and at the research sites, they expressed a wish not to be associated with us in organising the research, and they made this clear to their employees. In one way this could be seen as helpful: those thinking of participating could be more readily assured that any data they provided was unconnected with a management initiative. The variety of concerns that such an initiative might have set in train were hopefully minimised, and our assurances of treating data in the strictest confidence reinforced. It was possible therefore, to have some confidence that frank responses to questionnaire items would be forthcoming. Judging by the outspoken nature of some comments on the questionnaire returns, some of our respondents quite certainly accepted our guarantee.

From the foregoing it is clear that in none of the three cases was the sample generated using random processes. We did not have a sampling frame; we were not able to calculate the response rate exactly; participation was determined subjectively. The rigour in sample selection strictly required by much of the anticipated statistical analysis cannot be demonstrated. Nevertheless, in spite of our lack of control over the sample selection, it was a reasonable expectation that fairly representative samples would result provided the great majority of the invited project teams responded, i.e. provided each of the samples numbered not far short of 50. In view of the promise of anonymity to companies as well as to individuals, the three companies will be referred to as A, B and C. The numbers of completed questionnaires received from A, B and C were 57, 19 and 39, respectively. [Photocopies ofthe questionnaire had obviously been used by some respondents in Company A, since more forms were returned than had been despatched initially.] The low response from Company B left serious doubts about the extent to which this sample was representative. The Company B sample was found to have the greatest mean age of the three samples, and it would seem that the younger scientists (aged under 30 years) decided en masse not to participate, in spite of a prompting memo sent some four weeks after the issue of the questionnaire. We are unable to account for this phenomenon. Initially, it was felt that this peculiar feature of the Company B sample would seriously undermine its value. As will be seen subsequently, this sample has in fact exhibited features similar to the other two samples, though instances where it was out of step have also been noted. In the latter cases, the small sample size has meant that sampling fluctuation could not be ruled out as the explanation.

Responses from all three sites were monitored chronologically as they were received in an attempt to detect possible trends which could signify differences between those responding immediately (within one week of receiving the questionnaire) and those responding tardily (after more than six weeks had elapsed), and hence possibly those not responding at all. The principle variable monitored was the personality measure, KAI, and its three sub-scales. No trends were discerned. However, in the case of Company A the early responses contained a high proportion of non-graduate staff. Out of the total of 115 esponses, most of the non-graduate minority were ssociated with just this one company, and for the purpose f the present analyses they have been excluded. Also xcluded were graduate staff employed in service functions ot directly involved with the work of research teams. Most f the people in the latter category were found in the ompany C sample. These exclusions reduced the total sample ize to 93 (45, 18 and 30 respectively in Companies A, B nd C). Of these science graduates, a little over ifty percent were post-doctoral. They included the entire ange of seniority from fresh graduate to departmental ıanager (two respondents) and director (one respondent).

3.3 QUESTIONNAIRE DESIGN

In discussions with senior management at the three research sites about the use of a questionnaire, it had been conceded that completion of the questionnaire should take little more than thirty minutes of a respondent's time. This proved to be a major constraint. Even with pre-coded responses it proved to be difficult to accomodate all of the data gathering instruments it *was wished to include*. It was assumed (correctly in the short term at least) that just the one opportunity to approach employees in this way would be open to us. It was necessary in the main, therefore, to use instruments which had already been tested and reported in the literature, with little modification. The questionnaire, revised after comments from several colleagues, is reproduced in its entirety in Appendix B.

Personal details

Classifying information included : sex; age; years of experience in R&D; R/D balance of work; and academic qualifications. Respondents were also asked to give their name, though it was made clear that their name was only required in order to allow a comparison to be made between self-assessment of performance and superior assessment (the latter assessment was ultimately vetoed by the directors at the three sites). We undertook not to include names on the data file, a commitment which has been honoured. Only one respondent in over one hundred declined to give their name, and we were much encouraged by this openness. Also included in the personal details was a request for data regarding work department, section, project team and job title. This part of the questionnaire proved to be abortive. A variety of alternative names and abbreviations were used and there were also several incomplete returns in this part of the questionnaire. In two of the three host companies the director had given instructions to employees as to how they should complete this part of the questionnaire. All in all it was concluded that fine detail regarding organisational structure and the deployment of staff was regarded as too confidential for disclosure. The problem had been anticipated and it had been suggested that the project team should be identified in coded form (A, B, C etc) but in spite of this forethought, some respondents revealed a scientific name, while others left the space blank! The confusion regarding the location of staff has meant that it was not possible to focus the analysis on work groups with any confidence at all. Clearly, this was to have major implications concerning the way some of the data would subsequently be used.

Personality

As noted in Chapter Two, there is a considerable body of literature concerned with relationships between creativity and personality. Our review of the literature inclined us to the view that while aspects of personality were important in a study of creativity, (a view already reinforced by discussions with research managers), there was probably little to be gained from further research using general instruments such as the Cattell 16PF. We were interested by the potential of A-I theory to offer insights into the make-up of research scientists, and intrigued by the work of Keller and Holland with A - I theory in a R & D setting, as already discussed in Section 2.2. The Myers-Briggs Type Indicator (Myers, 1962) was also considered as a possible instrument. The manual for this test suggests that two of the four bi-polar dimensions measured (specifically, sensing/intuition and judgement/perception) but not all four dimensions, are indicators of creativity. In some research to compare the KAI inventory with the Myers-Briggs test, Carne and Kirton (1982) concluded that the two Myers-Briggs dimensions mentioned above were in fact related to style of creativity, but that there was no such correlation with the other two dimensions. The manual of the Myers-Briggs Type Indicator is not clear as to whether level or style of creativity is measured, whereas the Kirton A-I Inventory specifically purports to measure style but not level.

The Kirton measure was selected for our questionnaire battery. It is a 32-item instrument. The subject is asked to imagine that he/she has been asked to present, consistently and for a long time, a certain image of himself/herself to others. The subject is then asked to rate the difficulty of presenting the image contained in each of 32 items (the first item is a blind). A scale ranging from 'very easy' to 'very difficult' and scored 1 to 5 is used by the respondent. The scale is scored so that Innovators gain higher scores than Adaptors, the neutral point being 96. Although there is very little reference in the literature to the use of the KAI sub-scales, a notable feature of the present research has been a concern with the sub-scales of KAI. From early in the research, we were inclined to feel that the 'O' and 'E' sub-scales measured sufficiently different characteristics to warrant separate consideration, certainly as far as research scientists were concerned. This point will be developed when data are presented subsequently.

Perceived organisational environment

Following the facet analysis of Payne et al (1976), the aim in this section of the Questionnaire was to obtain a set of measures where the unit of analysis was the individual, the element of analysis was (i) the team and (ii) the whole organisation, and where the nature of the measurement was descriptive. According to Payne et al, such a measure could be described appropriately as perceived organisational characteristics. At the outset some form of aggregation of the data was anticipated, so that a measure of what could have been termed organisational climate would be generated. However, this aim was abandoned because of difficulties surrounding data regarding the location of respondents and for a further reason to be mentioned shortly. Also following the literature, in particular Schneider (1975a) and Payne et al (1976), it was decided not to employ a wide variety of general measures but to focus on a restricted number of dimensions that, a priori, could be expected to be important and meaningful to research scientists. In addition, as already mentioned, it was felt to be essential to use (or develop) an instrument that had already been subject to testing in empirical research.

The work of Osbaldeston et al (1978) was of considerable interest because theirs was, at that time, the only reported work on 'climate' to have been carried out in a U.K. pharmaceutical research laboratory as far as we are aware. However, they used nine dimensions in an inventory of 49 items. As already noted, it had been decided to use fewer dimensions and no more than half that number of items because of the need to restrict the size of the questionnaire. (As already noted, to gain the support of our hosts, even for the use of a questionnaire, it had been necessary to agree to an instrument taking only about thirty minutes to complete.) Moreover, Osbaldeston etal presented no statistical analysis of their instrument.

In contrast, Aram and Morgan (1976) developed a questionnaire to operationalise just the concept of team collaboration. This dimension of the organisation environment was of particular interest because of the inter-disciplinary nature of life sciences research. The questionnaire of Aram and Morgan (1976) was derived mainly from the work of Shepard (1965) and contained eighteen items incorporating descriptions of several behaviours relevant to collaboration. Factor analysis of their data led to three dimensions of work collaboration. The first factor dealt with non-competitive, supportive problem solving. The items of this factor were concerned with the degree to which efforts of team members were integrated in seeking the best alternatives to task-related problems. This factor was termed by them, 'problem solving through support and integration'. The second factor concerned communication relationships, and described characteristics of openness and directness in team interactions. This factor was termed 'open authentic communication'. The third factor dealt with the use of expertise in a variety of ways: taking calculated risks towards innovation rather than caution; arguing a point of view regardless of formal rank; not allowing disagreements to affect future work contributions. This factor, being concerned with the utilisation of knowledge, was termed 'knowledge-based risk taking'.

In allocating scarce questionnaire space to the several measures chosen, it was decided to incorporate twelve items dealing with the three collaboration factors of Aram and Morgan (1976), and twelve items dealing with three of the climate dimensions from Osbaldeston et al (1978). The three dimensions, which could be labelled 'management style' were: personal autonomy and responsibility; work pressure; and quality of leadership. Respondents were asked to distinguish between the perceived environment of their immediate team and that of the organisation as a whole. Several respondents remarked that they felt unable to give responses concerning the organisation as a whole, either because they were unsure through inadequate knowledge or because they felt that substantial inter-team or inter-departmental differences rendered the concept of a total organisational environment meaningless. Although only a small proportion responded in this way, it was felt to cast serious doubt on the 'total organisational climate' concept. As a result it was decided to exclude the 'total organisation' measures from the present analysis. In this section therefore, it was only measures of perceived team characteristics that were generated. As will be seen subsequently, the data was ultimately used in a rather different manner to that intended at the outset.

Job needs and job satisfaction

The results obtained in connection with job needs and satisfactions by Aram and Morgan (1976) and by Osbaldeston (1978) contained similarities, but the methodology used by the former was more highly developed. Aram and Morgan had based their questionnaire on the work of Pelz and Andrews (1976), which involved measurement of (i) the 'strengths' of a person's various needs in a job, and (ii) a rating of the opportunity in the organisation to fulfil these same needs. Aram and Morgan, using factor analysis, identified four aspects of scientists' job needs, as follows.

(i) Professional needs: such as developing a reputation outside the company and professional associations.

(ii) Job condition needs: such as security of employment salary and congenial coworkers.

(iii) Status needs: such as advancement within the company and association with top executives.

(iv) Self actualisation needs: such as working on challenging problems and freedom to take initiatives.

Three questionnaire items were used for each of the four factors. For each of the items, a respondent was asked how much importance they would personally attach to each one if they were seeking a job, regardless of their present work. They were also asked to specify the extent to which their present job actually provided opportunities regarding each item. Scales of 1 to 5 were used in both cases.

In order to construct an index of job satisfaction, Aram and Morgan (1976) took the difference between a person's reported job needs and that person's estimate of the opportunites the organisation afforded for fulfilling those needs. Although the method has been used elsewhere in the literature (e.g. Pelz and Andrews, 1976; Porter, 1961) it is somewhat confusing to subtract a measure of opportunity from a measure of importance. A more appropriate system is to follow the long established methods of statistical index construction. The general expression for a simple aggregate index is:

$$\text{Index} = \sum w.x$$

where x denotes one of a portfolio of measures

and w denotes the weight to be associated with that measure as determined by an appropriate measure of importance.

In the present context, x represents a measure of <u>opportunities</u> for meeting each of the four types of job needs, and w represents the associated weight as determined by the ranked <u>importance</u> of each of the four types of needs. The method of construction gave a theoretical range of 30 to 150. It is acknowledged that the method used will tend to over accentuate differences in importance between the various job needs when reported differences are small. However, the nature of an index is such that it will not be sensitive to minor distortions of this nature. In the admittedly limited informal discussion with senior management about the questionnaire, it was remarked that "the job needs and satisfactions questions provide an interesting analysis".

Performance assessment

Reference has already been made in Chapter Two to the variety of methods to be found in the literature, and also to our mistrust, like that of McPherson (1963), of objective measures of research performance when used in an industrial setting. [With hindsight, knowing of our failure to gain any managerial or peer assessment to supplement self- assessment, we would have sought objective data via the questionnaire. Such data would have been treated with caution, but it could possibly have made a contribution.] Following the literature, it was intended that several different subjective measures of performance should be used, so that one could learn from any differences to be found among them, but as already mentioned, this proved to be impossible. The directors concerned insisted that all of the research data be obtained by questionnaire, in spite of repeated efforts on our part to explore alternatives that might have been acceptable to them.

Nevertheless, it would be wrong to under-rate the value of self-assessment. Reference has already been made to the work of Mottram (1972) concerning the validation of self-ratings of scientific creativity, and his conclusion that highly creative people are probably the best judges of creativity in others. It is noteworthy that Roe (1952) selected her sample of highly creative researchers for her research using 'experts' in the same fields of study. The author's considerable experience of working in a research laboratory leads to the belief that in a community of scientific researchers, there is a sufficient understanding of the calibre of the work of a substantial circle of colleagues to allow a scientist to make wothwhile assessments of himself/herself in relation to those colleagues. Following Osbaldeston et al (1978), who also carried out research in a life-sciences environment and relied entirely on self-assessment, respondents were asked to assess not only their own performance but also how they thought their immediate superior would assess them.

The treatment of innovative performance as a single dimension is unsatisfactory in the author's view, though it is commonplace in the literature. It is suggested that a meaningful and potentially insightful approach is to distinguish between two types of innovative ability. This suggestion is also based upon the experience of work in a research laboratory by the author. The first type of performance is defined as the generation of novel ideas, methods, insights and hypotheses in relation to problem areas. This has been labelled creative performance. The second type of innovative performance is defined as assiduous, skillful and penetrating work in the testing of ideas and hypotheses, and this has been labelled skills performance. The two labels were not regarded as ideal, and the definitions were also somewhat tentative, but it was hoped that they would be recognised by the respondents, and seen by them as meaningful. Judging by the absence of remarks in the section of the questionnaire provided for written comments, and by the different ratings given by many respondents to these two criteria, the scientists found the distinction meaningful. (It is notable that the correlation between the two measures, when determined subsequently, was found to be non-significant statistically). Access for even a limited number of interviews would have provided a valuable opportunity to explore these concepts, but as it was the research had to proceed without such validation.

Fortunately, a surprising and rather fortuitous form of validation has since become available. An article in

Chemistry in Britain by Davies (1985) published shortly after our preliminary findings had been published (Lowe and Taylor, 1985), describes two types of research scientists which Davies calls Dinosaurs and Dynamos. These two types correspond fairly closely to what one could expect of people possessing high ratings of skills performance and creative performance, respectively. Davies was formerly General Manager of Research for Imperial Chemical Industries Limited and had spent a long career in directing the work of research scientists. His article contained no theoretical foundations whatsoever, being based solely on personal observation during his career in R & D.

Each respondent was asked to rate their own performance according to each of the two definitions, using a 1 to 5 scale with '3' representing average performance in the context of their own organisation. Each respondent was also asked to provide similar ratings based on how they thought their immediate superior would assess their performance according to the two definitions. In many cases the two sets of ratings (self rating and perceived superior rating) were found to be identical. Where a difference was found it is likely that the truth would lie between the two figures. Nevertheless, parallel analyses have been carried out using (i) the aggregate score and (ii) the simple self-assessment score. Had managerial assessments been permitted, a comparison of superior's and perceived superior's assessments would have been made for each respondent. Clearly, the scoring system described above does not permit any inter-firm comparison of mean performance levels, and in much of the analysis standardised scores, taking each firm separately, have been used.

Data processing

Statistical analyses have been made using the author's own microcomputer for preliminary work. For more complex analyses, SPSSX (Statistical Package for the Social Sciences) has been used in conjunction with an IBM 4341 mainframe computer. Examples of computer print-outs from the most frequently used statistical analyses are given in Appendix C.

CHAPTER 4 BASIC DATA : A PRELIMINARY ANALYSIS

4.1 PERSONAL DATA

Age of respondents

Respondents were asked to indicate their age by reference to one of six age categories. The profiles, company by company, are shown in Table 4.1. It is readily apparent that there are differences in the age profiles between the three company samples. The Company A sample is a relatively young one, with 96% of the respondents under 40 years. The Company B sample is considerably older, with only 50% under the age of 40 years. The sample from Company C is somewhat intermediate, having a fairly uniform distribution spanning a wide age range, with 63% under the age of 40 years.

Table 4.1 Age profiles of the three company samples

Age group	<25	25-29	30-34	35-39	40-44	>=45
Company A	9	16	12	6	1	1
Company B	1	0	2	6	3	6
Company C	0	7	5	7	4	7
Total sample	10	23	19	19	8	14

In the absence of information about the populations from which these samples were drawn, it is difficult to make comments about these differences. The differences are highly significant statistically (Chi-square, $p < .001$). Summary statistics are given in Table 4.2.

Table 4.2 Age of respondents: Summary statistics (years)

	Mean	S.D.
Company A	30	6
Company B	40	8
Company C	37	8
Total sample	34	8

If these samples were unrepresentative of the age of the populations from which they were drawn, though one cannot be sure they were unrepresentative, the reason may lie in a differing approach of the senior management in encouraging staff to participate. The mean age of males was 36 years, compared to 28 years for females. The much higher proportion of females in the Company A sample (see the following paragraph) was thus consistent with the differences in Table 4.2. Age was also related to level of qualification. Those with just a first degree had a mean age of 30 years, those with a masters degree, 34 years, and those with a doctorate, 37 years. The differences were significant statistically (chi-square, $p<.001$).

Sex of respondents

The distribution of each company sample according to sex is shown in Table 4.3. Differences in the ratio of the sexes are apparent, the Company A sample having 38% female, while the samples from Companies B and C had 11% and 10% respectively. The differences between these proportions are significant statistically, (Chi-square, $p < .01$).

Table 4.3 Sex of respondents

	Male	Female	Totals
Company A	28	17	45
Company B	16	2	18
Company C	27	3	30
Total sample	71	22	93

Once again, in the absence of data on the characteristics of the populations from which these samples were drawn, it is difficult to comment on how representative these samples were. It is not easy to see why females should be more likely to respond to the questionnaire in some companies than others, unless the propensity to respond is age related (a possibility raised above) and the sex ratio is also age related. There are grounds for suggesting this explanation. In the Company A sample, 82% of the females were found to be in the under 30 age groups, and it is these age groups which are sparsely represented in the samples from Companies B and C. It can be supposed that family responsibilities tend to reduce the female proportion in age groups of 30 and over.

If age or sex prove to be important factors in the subsequent study, it can be expected that the three company samples will exhibit significant differences. However as far as A-I theory is concerned, the literature indicates that KAI is not age related, though females tend to have a very slightly lower KAI score than males (Kirton, 1977).

Work experience in R & D

The mean work experience reported was 11 years (s.d. 7 years) but there were significant differences between the three company sub-samples (chi-square, $p<.01$). The respective means were: Company A, 7.9 years; Company B, 16.3 years; Company C, 13.2 years. As might be anticipated, there was a very strong correlation between age and work experience, and it was clear that a great majority of respondents had spent all of their career in R & D work. The sexes differed significantly in work experience (chi-square, $p<.01$), but there was no evidence of an association between work experience and R/D balance (chi-square, n.s.)

R/D Balance in work experience

The distribution between research and development work showed a strong bias towards research. In this characteristic all three company sub-samples were similar (chi-square, n.s.) as Table 4.4 shows.

Table 4.4 R/D profiles of the three company sub samples

	All research	Mainly research	About equal	Mainly devel.	All devel.
Company A	18	10	9	7	1
Company B	11	6	1	0	0
Company C	19	6	3	2	0
Total sample	48	22	13	9	1

There was no evidence of a difference between the sexes in this respect (chi-square, n.s.), nor was there evidence of an association between level of qualification and R/D balance (chi-square, n.s.).

Level of qualifications

As described earlier, the very small proportion of non-graduate staff were excluded, so that this thesis is concerned with a graduate population. Three levels of qualification were identified: first degree only, masters degree, and doctorate. The profiles of the three company samples in this respect are shown in Table 4.5.

Table 4.5 Level of qualifications

	First degree	Masters	Doctorate
Company A	22	5	18 (40%)
Company B	8	0	10 (56%)
Company C	7	3	20 (67%)
Total sample	37	8	48 (52%)

The apparently substantial differences in the proportions of post-doctoral staff in the three companies just failed to be significant statistically (chi-square, p=.06). The difference between the sexes in the proportion of post-doctoral staff was also not significant statistically. However, as already noted, level of qualification was associated with age, the younger age groups having a smaller proportion of post-doctoral staff.

4.2 KAI DATA

The KAI scores and also data on the three KAI sub-scales are summarised for each company in Table 4.6.

Table 4.6 KAI data for the three companies

	Company A		Company B		Company C		Total sample	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
'O'	42.2	6.9	43.4	9.0	44.7	6.5	43.3	7.2
'E'	18.4	4.8	18.9	5.2	18.4	4.2	18.5	4.6
'R'	36.1	6.4	35.7	6.5	38.4	6.6	36.7	6.6
Total	96.7	14.9	98.0	18.1	101.5	12.7	98.5	14.9
Sample no.	45		18		30		93	

Superficially this data is unremarkable. Differences between companies in terms of the means of KAI and all three sub-scales are not significant statistically. Although the total sample mean of 98.5 is slightly on the innovator side of the neutral point, the difference is small and not quite significant statistically. This mean is, however, just significantly greater than the Kirton reference sample mean of 95.3($p<.05$), but it is slightly lower than the figure of 100.9 reported by Keller and

Holland (1978) in their study of 256 staff in three R&D organisations in the U.S.A. The variability of KAI in the present study is slightly less than that reported by Kirton with his reference population (S.D. = 17.3). Since professional employees of a research organisation would be expected to be oriented towards innovativeness, a mean slightly higher than that of the general population and a slightly lower standard deviation are not surprising.

As in work reported by Kirton (1977, 1984a) no significant correlation was observed between age and either the total KAI score or its separate sub-scales. Length of work experience and balance of R & D work were similarly unrelated to KAI and its sub-scales according to the present data. Differences were found between the KAI data of the two sexes, and once again the present results are consistent in this respect with the data published by Kirton (op cit). Table 4.7 presents a summary of the comparison. Differences between the sexes in terms of the 'O' and 'E' sub-scales were not significant statistically. However, differences in terms of the 'R' sub-scale and the total KAI score were significant ($p < .05$). The data suggests that the major KAI difference between the sexes lies in the greater tendency to rule/group conformity on the part of the females. The difference between males and females with respect to the mean KAI score was almost identical with that reported by Kirton (op cit).

Table 4.7 KAI data: differences between the sexes

	Males		Females	
	Mean	S.D.	Mean	S.D.
'O' Sub-scale	43.6	7.0	42.0	8.0
'E' Sub-scale	18.9	4.5	17.2	5.0
'R' Sub-scale	37.7	6.1	33.8	7.7
Total KAI	100.2	13.3	93.0	18.5

In line with the work of Keller and Holland (1978) but in contrast to Kirton (op cit), differences in KAI and its sub-scales were found between different educational levels. The data is summarised in Table 4.8.

Table 4.8 KAI data: differences between educational levels

	First degree		Master degree		Doctorate	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
'O' sub-scale	41.0	6.6	39.4	7.0	45.6	7.0
'E' sub-scale	16.5	4.2	21.4	5.3	19.5	4.3
'R' sub-scale	34.1	6.3	38.3	5.2	38.6	6.6
Total KAI	91.6	13.8	99.0	15.1	103.8	13.8

Discounting the Master degree sub-group owing to its small size (n=8), the differences between the means of the other two sub-groups were highly significant statistically ($p < .01$). As noted above, these results were consistent with those of Keller and Holland (op cit) who also used a sample of R & D scientists, whereas Kirton, using a general heterogeneous sample, found no correlation between KAI and educational level. It is likely that the explanation lies in the nature of the samples used, in particular the fact that R & D scientists encompass a relatively narrow band at one extreme of the educational spectrum. Subjects such as those comprising the present study might have been totally absent from the sample that Kirton took from the general population in his validation work.

Overall therefore, the KAI data was consistent with that reported in previous studies, and at first sight it appeared to be quite unremarkable. Just one feature appeared to be noteworthy. Whereas the total KAI score mean was slightly greater than the general norm, the three sub-scales exhibited differing patterns. The Originality sub-scale, 'O', had a mean in excess of the general norm, the Rule/group conformity sub-scale, 'R' had a mean close to the general norm, but the Efficiency sub-scale, 'E', had a mean lower than the general norm. According to this data therefore, the 'E' sub-scale tended to place research scientists on the Adaptor side of the continuum, whereas the total KAI score tended to place them on the Innovator side. It should be remembered that the 'E' sub-scale is negatively scored, high Weberian efficiency giving rise to a low 'E' rating.

It is not difficult to suggest how this feature can arise. The education of a scientist pays considerable attention to the need for disciplined methodology, meticulous observation, and precise description; and these are characteristics which score low on the 'E' sub-scale. Consequently, when dealing with research scientists, it appeared that the total KAI score might conceal important differences to be found in the sub-scales. Accordingly, the separate sub-scales have been the focus of attention in this study, and the central thesis is based on insights which they reveal. Little use has been made of the total KAI score, in contrast to practically all of the studies using the KAI inventory which have appeared in the literature. In pursuing analyses based on the sub-scales, it will be seen that the present work breaks new and interesting ground.

4.3 JOB SATISFACTION DATA

Job satisfaction data for the three companies are summarised in Tables 4.9 and 4.10.

Table 4.9 Job satisfaction scores

	Company A	Company B	Company C	Total sample
Mean	104.0	104.3	110.9	106.3
S.D.	14.8	18.4	15.9	16.1
Sample No.	45	18	30	93

Table 4.10 Distribution of job satisfaction scores

J/S Index	50<70	70<90	90<110	110<130	130<150
Frequency	2	12	37	37	5

The construction of the Job satisfaction index provides for absolute minima and maxima of 30 and 150 respectively, so a standard deviation approaching the value of 20 could be anticipated. The observed standard deviation figures are thus unremarkable. It would be surprising to find other than a very tiny minority in the range 30 to 60 since this would represent an abysmal job satisfaction. On the other hand the range from 120 to 150 should be fairly well populated in an organisation where there was a high level of job satisfaction. A skewed distribution such as is depicted in Table 4.10 is therefore to be expected. In comparing the three companies, two are similar, but the third, Company C, has a level of job satisfaction which is substantially greater. The difference between means just fails to be significant, but the notion that no differencs exist between the companies is hardly tenable given these data. In the absence of published norms for such an index it is difficult to say what figure represents a satisfactory level of job satisfaction, but a figure of 100 could be taken as indicative of a reasonable level. In Companies A, B, and C the proportions failing to meet this level were 40 per cent, 28 per cent and 23 per cent respectively.

There was no evidence whatsoever of any difference in job satisfaction between the sexes. Mean levels were in fact identical to the first decimal place. Neither was there evidence of any association between job satisfaction and the balance of R & D work. No such associations were expected. There was however, evidence for a very weak association between job satisfaction and age, as illustrated by Table 4.11.

Table 4.11 Job satisfaction index: breakdown by age

Age (years)	Mean	S.D.	Number
<25	98.5	13.0	10
25-29	106.9	14.8	23
30-34	104.1	19.8	19
35-39	105.5	17.2	19
40-44	111.5	9.5	8
>44	111.9	15.2	14

The Pearson correlation coefficient, r=0.19, was just significant statistically ($p< .05$).

Similarly, there was evidence of a weak association between job satisfaction and level of education, as Table 4.12 shows. In this case the Pearson correlation coefficient was r=0.29 ($p< .01$). Neither of these weak associations are surprising if one is willing to suppose that increasing age and educational level tend to bring an individual greater opportunities to meet their job needs. However, the low values of the correlation coefficients indicate that such associations are very weak.

Table 4.12 Job satisfaction: breakdown by qualification

Qualification	Mean	S.D.	Number
First degree	101.4	13.0	37
Master degree	98.6	13.2	8
Doctorate	111.3	17.2	48

The relative importance of different job needs

As described in Chapter 3, the job satisfaction index was constructed from two separate sets of measurements. Firstly the importance each subject attached to a range of job needs was determined. These were classified into four categories: professional needs; job condition needs; status needs; and self actualisation needs. Secondly, the level to which each subject's job provided opportunities regarding each of the factors was determined. The scale used for measuring the importance of the four types of job needs extended from 3 to 15 and summary statistics are presented in Table 4.13.

Table 4.13 Importance of job needs: summary statistics

Needs	Mean	S.D.	Min.	Max.
Professional	11.2	2.0	6	15
Job conditions	12.1	1.7	5	15
Status	10.3	2.2	5	15
Self actualisation	12.9	1.5	10	15

The mean levels given above exhibit differences which are statistically significant (analysis of variance, $p < .001$). Not surprisingly for researchers, self actualisation needs are ranked most importantly. What is perhaps surprising is that professional needs ranked below job conditions. As will be shown subsequently, this applied to all three companies. In fact the same ordering will be shown to apply to all three companies. The relatively high ranking accorded to job conditions may be a reflection of the current high level of unemployment nationally and hence the greater importance people tend to attach to job security, which was one of the needs listed in the job conditions category. In general therefore, the above data showed an ordering which was fairly closely in line with what was anticipated. That the samples from three quite independent companies gave the same ordering engenders confidence in the validity of the instrument, since feelings about job needs can be expected to be common to the community of research scientists rather than being strongly company-dependent.

When possible associations were investigated between importance levels of the four job needs and the various personal variables, negative results were found in general. That is to say, there was no evidence of an association between any of the four job need factors and age, sex, and length of work experience. Differences between the three companies in levels of the four need factors just failed to be significant statistically, though as already noted the ordering of importance of the factors was identical in the three companies. These results were in accord with expectation. They are illustrated, taking two examples, in Tables 4.14 and 4.15.

Table 4.14 Importance of job needs: breakdown by companies

	Company A		Company B		Company C	
Needs	Mean	S.D.	Mean	S.D.	Mean	S.D.
Professional	11.6	1.9	10.5	1.9	11.0	2.1
Job conditions	12.0	1.6	12.3	2.2	12.0	1.5
Status	10.5	2.1	10.5	2.6	9.8	2.2
Self actualisation	13.0	1.5	12.4	1.2	13.0	1.6

Table 4.15 Importance of job needs: breakdown by sex

Needs	Males Mean	Males S.D.	Females Mean	Females S.D.
Professional	11.1	2.0	11.4	1.9
Job conditions	12.0	1.8	12.2	1.4
Status	10.5	2.3	9.8	2.3
Self actualisation	12.8	1.4	13.1	1.7

There were minor associations. The importance of professional needs was very weakly associated with the level of qualifications, the Pearson correlation coefficient having a value $r=0.21$ ($p< .05$). This could be reasonably attributed to a tendency for the post-doctoral staff to be slightly more interested in professional visibility, stemming perhaps from the tradition of writing papers and addressing seminars encountered during their doctoral research. However, such a weak correlation, only just significant, hardly warrants discussion. The data is illustrated in Table 4.16. The importance of professional needs was also weakly associated with R & D work balance. Those who had spent all of their career in research as opposed to development rated professional needs slightly less in importance than development orientated staff. However, this association was also very weak ($r=0.23$) and being only just significant ($p < .05$), no importance is attached to it.

Table 4.16 Importance of job needs: by qualifications

Needs	First degree Mean	First degree S.D.	Master degree Mean	Master degree S.D.	Doctorate Mean	Doctorate S.D.
Professional	10.8	1.9	10.3	2.0	11.6	1.9
Job conditions	12.3	1.4	12.0	1.6	12.0	1.9
Status	10.1	2.2	8.9	2.2	10.7	2.2
Self actualisation	12.7	1.4	12.3	1.5	13.1	1.5

The data suggests a tendency for the Masters degree category to rate all needs lower than the other categories. However, the differences were not significant owing to the very small size (n=8) of this category.

In summary, it can be seen that with very few exceptions, the rated importance of different types of job needs was independent of the classificatory variables. Even where associations were indicated, they were weak, usually only just significant statistically, and hence worthy of little comment. In the next Section it will be seen that the same did not apply to opportunities for meeting those needs.

Opportunities for satisfying job needs

As described in Chapter Three, the level to which each subject's job provided opportunities for satisfying the four types of needs was measured on a scale which extended from 3 to 15. Summary statistics are given in Table 4.17.

Table 4.17 Opportunities re job needs: summary statistics

Needs	Mean	S.D.	Min.	Max.
Professional	9.8	2.0	5	14
Job conditions	11.5	1.7	6	15
Status	8.7	2.3	3	14
Self actualisation	11.0	2.3	4	15

Differences between these mean levels are highly significant statistically (analysis of variance, $p < .01$). The ordering is not quite the same as the ordering of these needs by importance (see Table 4.13), and it is notable that whereas self actualisation needs were ranked rather uniformly high in importance, there is much variation in the extent to which such needs were satisfied.

When the three companies were compared, similar levels of satisfaction were found with respect to job conditions and status needs. With the other two needs, differences between the companies were just significant statistically ($p < .05$). With all four types of job needs, greatest opportunity for meeting needs was recorded by Company C. It is to be expected therefore, that Company C would show the greatest mean job satisfaction index (see Table 4.9). Details are given in Table 4.18.

Table 4.18 Opportunities re job needs: by companies

Needs	Company A Mean	Company A S.D.	Company B Mean	Company B S.D.	Company C Mean	Company C S.D.
Professional	9.5	2.1	9.5	2.1	10.4	1.9
Job conditions	11.4	1.7	11.2	2.4	11.7	1.3
Status	8.6	2.2	8.6	2.4	8.8	2.3
Self actualisation	10.7	2.2	10.9	2.2	11.6	2.3

When responses from the two sexes were compared, differences in all four needs were not significant statistically. However, it is intriguing to note that the two needs where opportunities recorded by females were lower than those of males, were professional and status. Perhaps this is a shred of evidence suggesting lack of sexual equality! Data are given in Table 4.19.

Table 4.19 Opportunities re job needs: by sex

Needs	Males Mean	Males S.D.	Females Mean	Females S.D.
Professional	9.9	2.1	9.4	2.0
Job conditions	11.4	1.8	11.7	1.6
Status	8.8	2.3	8.4	2.2
Self actualisation	11.0	2.3	11.1	1.9

Opportunities for meeting self actualisation and job condition needs were found to be independent also of age, R & D work experience, R & D work balance, and level of qualifications. With professional and status needs, however, opportunities were associated with age and level of qualifications, both positively. These patterns, which are not surprising, are illustrated in Tables 4.20 (means only) and 4.21. The associations are not strong, however. In the case of professional needs, where opportunities could be expected to some extent to increase with age and with level of qualifications, the Pearson correlation coefficients were 0.39 and 0.31, respectively. In the case of status needs, where similar expectations could apply, the respective correlation coefficients were 0.23 and 0.41. Taken all together, the data on job needs and satisfactions have prima facie validity.

Table 4.20 Opportunities re job needs: by age

Needs	Age in years <25	25-29	30-34	35-39	40-44	>44
Professional	10.9	11.0	11.3	10.5	11.6	12.1
Job conditions	11.0	11.8	11.7	11.1	11.4	11.4
Status	7.0	8.6	8.7	8.8	10.0	9.1
Self actualisation	10.5	11.1	10.5	11.0	11.5	11.6

Table 4.21 Opportunities re job needs: by qualifications

	First degree		Master degree		Doctorate	
Needs	Mean	S.D.	Mean	S.D.	Mean	S.D.
Professional	9.2	1.7	8.8	1.3	10.5	2.2
Job conditions	11.1	1.6	11.0	2.4	11.8	1.7
Status	7.7	1.9	7.6	1.2	9.6	2.3
Self actualisation	10.7	2.1	9.9	1.6	11.5	2.4

4.4 ORGANISATION ENVIRONMENT DATA

As described earlier in Chapters 1 and 3, it was hoped at the outset of the present research to obtain data which would provide insights into the functioning of project teams. With this in mind, the research questionnaire sought to obtain data on the environment existing within project teams. Following the work of Aram and Morgan (1976) and using their methodology and terminology, three dimensions of the perceived team environment were measured. These were (i) warm supportive integation (WSI); (ii) open authentic communication (OAC); and (iii) knowledge based risk taking (KBRT). Each of these measures was concerned with facets of the collaboration within teams, and it was intended that the aggregate of these measures could be used as an index of collaboration. Three other measures of the environment concerned with management style which were based on the work of Osbaldeston et al (1978), were also used. They were as follows: personal autonomy and responsibility (PAR); work pressure (WP); and quality of leadership (L). Although any form of aggregation to permit an analysis of team characteristics proved to be impossible, as previously described, the data has been used in the sense that it provides a reflection of the individual making the assessment. With that purpose in mind, the data on perceived team characteristics is summarised in the present Section, and further analysed subsequently. All of these dimensions were measured on a scale extending from 4 to 20, with the exception of the collaboration index, where the scale extended from 12 to 60.

Collaboration dimensions

Summary statistics are shown in table 4.22

Table 4.22 Collaboration dimensions: summary statistics

	Mean	S.D.	Min.	Max.
Warm supportive integation	15.7	2.4	9	20
Open authentic communication	15.5	2.4	7	20
Knowledge based risk taking	14.1	2.3	9	18
Collaboration index	45.3	5.7	31	58

Table 4.23 Correlation matrix for collaboration measures

	WSI	OAC	KBRT
Warm supportive integation	1.0	-	-
Open authentic communication	.66	1.0	-
Knowledge based risk taking	.32	.45	1.0
Collaboration index	.83	.87	.72

These figures indicate that the questionnaire instrument was capable of achieving considerable discrimination on the collaboration dimensions, but otherwise the data is unremarkable. The correlation matrix given in Table 4.23, shows a set of highly significant intercorrelations.

Two of the collaboration dimensions, WSI and OAC, showed no significant variation between the three companies, but in the case of knowldge based risk taking the differences were significant statistically (analysis of variance, $p < .05$). The total collaboration index placed companies A and B at very similar levels with company C just failing to be significantly greater. These patterns are shown in Table 4.24.

Table 4.24 Collaboration dimensions: company comparisons

	Company A		Company B		Company C	
	Mean	S.D	Mean	S.D	Mean	S.D
WSI	15.8	2.5	15.1	2.6	16.0	2.3
OAC	15.3	2.0	15.3	3.3	15.8	2.4
KBRT	13.6	2.4	14.1	1.7	14.9	2.2
Coll. index	44.7	5.2	44.4	6.8	46.7	5.7

No significant association was detected between any of the collaboration dimensions and the personal classificatory variables, with one exception. The exception was sex, with females recording a greater perceived collaboration than males in the case of WSI and OAC. One can only speculate on the possibility that females have a natural advantage in this respect, and by experiencing greater collaboration their assessment of team collaboration is thus affected. Alternatively, their perception of team collaboration may differ from that of males, perhaps through differing expectations. Significance levels (t-tests) of differences betwween the sexes in the case of WSI, OAC and the Collaboration Index were $p < .01$, $p < .05$ and $p < .01$, respectively. The data are shown in Table 4.25.

Table 4.25 Collaboration dimensions: comparison by sex

	Males		Females	
	Mean	S.D.	Mean	S.D.
WSI	15.4	2.4	16.9	2.3
OAC	15.2	2.4	16.4	2.2
KBRT	13.9	2.1	14.7	2.7
Coll. index	44.4	5.7	48.0	5.0

Management style dimensions

Table 4.26 gives summary statistics for these three measures.

Table 4.26 Management style measures: summary statistics

	Mean	S.D.	Min.	Max.
Personal autonomy & resp.	15.4	2.7	4	20
Work pressure	14.6	2.0	11	20
Quality of leadership	15.5	2.6	4	20

As with the collaboration dimensions, the questionnaire instrument is seen to be capable of achieving considerable discrimination. All six of the environment measures have standard deviations in the range 2.0 to 2.7, which is very satisfactory for an instrument where the range between maxima and minima is 16. When inter-company comparisons were made, only one of the management style measures showed significant differences between companies. This was personal autonomy and responsibility, as illustrated in Table 4.27 (analysis of variance, $p < .01$). Company C scored highest on this dimension, as with all of the collaboration measures.

Table 4.27 Management style measures: company comparisons

	Company A		Company B		Company C	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Pers. auton./respon.	15.5	2.0	13.7	3.4	16.1	2.9
Work pressure	14.6	1.9	14.7	2.2	14.6	2.0
Quality of leadership	15.6	2.3	14.7	3.5	15.9	2.5

Also in line with the collaboration measures, was the fact that with only one exception, the personal classificatory variables showed no association with the management style measures. The exception, as before, was sex, but a significant difference was only found in the case of personal autonomy and responsibility (t-test, $p < .01$).

Table 4.28 Management style measures: comparisons by sex

	Males		Females	
	Mean	S.D.	Mean	S.D.
Pers. auton./respon.	14.9	2.9	16.7	1.6
Work pressure	14.5	1.9	15.0	2.1
Quality of leadership	15.3	2.6	16.4	2.5

As with the collaboration measures, the higher score was recorded by the female sub-group. One can only speculate that females perceive greater personal autonomy and responsibility than males through lower expectations and/or needs. The data are shown in Table 4.28.

4.5 PERFORMANCE MEASURES.

As already noted in Chapter 3, concern was felt when it became clear that performance measurements would of necessity have to be restricted to self assessments. Although this restriction was regretted, nevertheless it was felt that such self assessment could give valid measures, as discussed in Chapter 3. Accordingly, in this Section attention has been given to examining performance data with the intention of seeking prima facie validity.

Since it proved to be impossible to identify many respondents with either their department or project team, measures of creative and skills performance of departments and project teams are excluded from the main analysis of this thesis. Nevertheless, they are included in this Section in order to learn as much as possible about the validity of the self assessment measures. It should be noted that the self assessments of creative and skills performance have been standardised, as described earlier in Chapter 3, to a mean of 6, (by definition, average performance = 6), taking each company separately. In contrast, all the measures of project team and department performance have been processed exactly as recorded by the respondents, since a similar basis of standardisation had no logical attraction in these cases. Measures of project team and department performance are therefore integers, in contrast to the standardised measures of self performance. Table 4.29 presents summary statistics for all six performance measures.

Table 4.29 Performance measures: summary statistics

	Mean	S.D.	Min.	Max.
Creative perf. (self)	6.01	1.36	2.1	9.1
Skills perf. (self)	6.02	1.35	2.7	8.7
Creative perf. (proj. team)	3.52	0.72	2	5
Skills perf. (proj. team)	3.66	0.63	2	5
Creative perf. (department)	3.38	0.71	2	5
Skills perf. (department)	3.66	0.62	2	5

It should be noted that even in the case of self performance, where means have been standardised, there has been no standardisation of variability. Thus the standard deviations of all six measures directly reflect the variability in each measure. It can be appreciated then, that the values of the standard deviations are very satisfactory. They are close to what could be anticipated for random normal variates whose extreme ranges were as specified by the scales prescribed in the questionnaire (a range of 2 to 10 in the case of self performance; a range of 1 to 5 in the remaining cases).

Inter-correlations between the six performance measures were of interest, and are shown in Table 4.30. A moderate amount, though certainly not a l'rge amount, of correlation would not be surprising between pairs of measures (creative and skills performances) for a particular entity. However, it was difficult to form an expectation, and on balance a low correlation would lend support to the idea that a respondent was making assessments in an independent and careful manner. As Table 4.32 shows, there were only four moderate, highly significant correlations, and nine correlations were non-significant. In particular, it was encouraging to observe that the two measures which would feature importantly in subsequent analysis in this thesis had a set of non-significant correlations, save for one minor exception.

Table 4.30 Performance measures: inter-correlations

	1.	2.	3.	4.	5.	6.
1. Creative perf. (self)	1					
2. Skills perf. (self)	.18	1				
3. Creative perf. (pr. team)	-.06	.08	1			
4. Skills perf. (pr. team)	-.11	.11	.32**	1		
5. Creative perf. (dept.)	.18	.13	.36**	.32**	1	
6. Skills perf. (dept.)	.26*	.19	-.01	.25*	.45**	1

* $p < .05$ ** $p < .001$ (two-tail tests)

When the performance measures were examined for association with the personal classificatory variables, once again very few statistically significant associations were found. None of the project team and departmental performance measures were associated with any of the personal classificatory variables. This was an encouraging feature of the data, since it would have been difficult to hypothesise why there should be such correlations. They would have suggested that sex, age, etc. were introducing bias into the assessment of project team and departmental performance.

However, there were associations on a limited scale between the self performance measures and personal variables, though it will be realised that this is a quite different matter. Regarding creative performance, there was just one personal variable that was significantly associated, namely the level of qualifications. Table 4.31 presents the data for both creative and skills performance.

Table 4.31 Self performance measures: by qualification

	First degree		Master degree		Doctorate	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Creative perf.	5.58	1.22	5.75	1.00	6.39	1.41
Skills perf.	5.99	1.36	6.26	1.08	6.01	1.40

Analysis of variance revealed highly significant differences in the case of creative performance ($p < .01$), and the Pearson correlation coefficient was 0.29 (also $p < .01$). Although a doctorate could hardly be said to be a sure indicator of creative ability, it would be surprising to find no correlation, and so a correlation of $r=0.29$ can be regarded as a reasonable result. At first sight the pattern of results for skills performance appears interesting with the highest mean score recorded by the Master degree staff. One could hypothesise that those scientists with Masters degrees had obtained them in a particular practical specialty (eg in instrumental chemical analysis), which could thus confer on them enhanced skills performance. However, the differences between these means are far from being statistically significant owing to the very small sub-group ($n=8$) of Master degree staff.

In view of the significantly higher ratings recorded by females in connection with several of the perceived team environmental measures, it was interesting to note that females rated themselves very slightly lower than males on both creative and skills performance. The differences, shown in Table 4.32, were very small however, and far from significant statistically.

Table 4.32 Self performance measures: by sex

	Males		Females	
	Mean	S.D.	Mean	S.D.
Creative performance	6.08	1.40	5.80	1.20
Skills performance	6.05	1.30	5.94	1.49

Nevertheless, skills performance was significantly associated with age and also with work experience in R & D. The data is given in Tables 4.33 and 4.34.

Table 4.33 Self assessment measures: by age (years)

	<25	25-29	30-34	35-39	40-44	>44
Creative perf.	4.96	5.83	6.53	6.02	6.77	5.91
Skills perf.	4.89	5.85	6.29	6.22	6.41	6.26

Table 4.34 Self assessment measures: by work in R & D (yr)

	<1	1-5	6-10	11-15	16-20	>20
Creative perf.	4.60	5.63	6.01	6.33	6.72	5.86
Skills perf.	4.20	5.54	5.83	6.59	6.65	6.23

The figures have several interesting features. Although there was a significant correlation between skills performance and age (Pearson correlation coefficient, $r=0.24$, $p< .05$), the gradient of performance with respect to age was only apparent below the age of thirty years. Above thirty years there was no significant change in skills performance. A similar pattern was observed when skills performancd was related to length of R & D work experience, though taking the entire data the Pearson correlation coefficient was $r=0.29$ ($p< .01$). These patterns were hardly anticipated, since, to detect such fine structure in the relationship between two variables one could expect to need larger sample sizes in each sub-group than were involved in the present research. Nevertheless, they can be interpreted as very reasonable patterns on the grounds that most scientists are likely to have reached the limit of their skills after ten years of R & D experience.

Although Pearson correlation coefficients between creative performance and both age and length of R & D work experience were not statistically significant ($r=0.17$ in both cases), it could be argued that the data gave evidence of greater correlation than the Pearson coefficients imply. It must be noted that the Pearson correlation coefficient is strictly applicable only in situations where a linear relationship exists. The data in Tables 4.33 and 4.34 suggest otherwise in the case of both creative and skills performance. The non-linear correlation implied in the data would not be properly reflected in the Pearson correlation coefficient.

In the case of creative performance, the evidence of a downturn after the age of forty four and after twenty years of R & D experience looks impressive in view of the much discussed 'too old at forty' syndrome. Unfortunately,(or perhaps fortunately, depending on one's viewpoint !), the present data does <u>not</u> offer strong support for such a hypothesis. The sample sizes in the separate age sub-groups are such that differences in mean levels between the age groups involved are not statistically significant. On balance, therefore, the evidence suggests a moderate association between skills performance and age, but it would be unwise to conclude that a similar association exists with creative performance. Nevertheless, the results were of interest because of the similarity with the results given by Pelz and Andrews (1976) in their monumental work. They found a steady rise in performance with age until it peaked in the forties. (Pelz and Andrews also found a second, later, subsidiary peak, but the statistical significance of this is open to question.) Taken altogether, then, the performance data analysed in this Section appeared to afford prima facie validity, and gave enhanced confidence in using these self assessed measures in subsequent analysis.

CHAPTER 5 ASSOCIATIONS WITH KAI AND ITS SUB-SCALES

5.1 CREATIVE AND SKILLS PERFORMANCE MEASURES AND KAI

It was of particular interest to find to what extent KAI and its sub-scales were associated with the two dimensions of performance. Reference has already been made to the work of Keller and Holland (1978a), who reported highly significant correlations between scientists' KAI scores and sveral measures of their research performance. As in the present research, Keller and Holland were interested in the possibility of using KAI in a predictive way, and they went on to incorporate KAI in a selection battery (Keller and Holland, 1979). However, Keller and Holland did not identify the two dimensions of research performance which the present work suggests is *a meaningful and valuable* distinction. Neither did they present detailed analytic studies of the KAI sub-scales, although the sub-scales were quoted by them, if in a somewhat confused way. Further reference will be made to this point subsequently. Table 5.1 gives the initial set of zero order Pearson correlation coefficients obtained in the present study, from the data already summarised in Chapter Four.

Table 5.1 Performance measures: correlations with KAI

	KAI	O	E	R
Creative perf. (self)	.46***	.59***	.10	.31**
Skills perf. (self)	-.13	-.05	-.33***	-.01
Creative perf. (team)	-.09	-.10	-.16	.03
Skills perf. (team)	-.12	-.08	-.11	-.11
Creative perf. (dept)	.05	.10	-.10	.09
Skills prf. (dept)	.07	.15	-.16	.09

* p< .05   ** p< .01   *** p< .001   (two tail tests)

This was most interesting data because of the fairly sharp distinction between the first two rows of correlation coefficients and the remainder. Although it was anticipated that scientists' performance might well be related to certain aspects of their KAI score (following the work of Keller and Holland, op cit), there were no grounds for expecting scientists' ratings of performance by their project team and department to be related to their own KAI score. The data in Table 5.1 bears out this expectation. None of the correlation coefficients concerned with project team and departmental performance were significant statistically. In contrast, several highly significant correlation coefficients were found with self performance measures, including one figure which was extra-ordinarily high in view of the complex nature of creative performance. (A correlation of r=0.59 implies that 35% of the variance in creative performance is accounted for by the 'O' score.

As already explained, it has not been possible to identify many respondents with project teams and departments, and so no further reference will be made to performance by project teams and departments. All further reference to creative and skills performance will relate to individual performance.

The data in Table 5.1 were also of interest because of the comparison afforded with the published work of Keller and Holland (1978a). Table 5.2 gives an extract from their work

Table 5.2 KAI correlates: Keller and Holland (1978a) n=256

	KAI Total	KAI Sub-scales Originality	Effic.& Conform.
Innovativeness (peer nomination)	.40***	.37***	-.28***
Innovativeness (mangt. ratings)	.40***	.39***	-.20***
Publications	.22***	.13*	-.16**
Performance (mangt. rating)	.25***	.26***	-.15**

It can be seen that, as in the present research, Keller and Holland recorded some relatively large correlations, but what is particularly remarkable is the opposite sign of correlations recorded against the two sub-scales. Keller and Holland do not discuss the implications of this feature in their paper. Unfortunately, neither do they make it clear what they meant by the title 'efficiency and conformity'. It might be taken to mean simply the sum of the 'E' and 'R' sub-scales, but other data given in their paper suggest that this was not the case. Data given in their paper also reveal the fact that their 'Originality' scores gave a mean above the neutral point (45.2 compared with 39.0) whereas their 'Efficiency and Conformity' scores gave a mean below the neutral point (32.9 compared with 36.0). The data from the present research can be seen, therefore, to have many similar features to that of Keller and Holland. Where the present research breaks new ground is in pursuing the nature of the dissimilarity between the sub-scales, based on the idea already mentioned in Chapter Four that with scientists the separate sub-scales could give insights which would be concealed by the aggregate score.

The initial lead towards investigating the sub-scales of KAI, referred to above, focussed interest on the 'O' and 'E' scales. Before dismissing the 'R' scale from further study, however, partial correlation coefficients were determined to control for the interaction between the sub-scales. Table 5.3 gives the results, the parentheses indicating which variables were controlled.

Table 5.3 Performance measures: partial correlations

	O (E,R)	E (O,R)	R (O,E)
Creative performance	.54***	-.16	.02
Skills performance	.02	-.35***	.11

*** $p < .001$ (two tailed tests)

These figures need to be compared with the first two rows of figures in Table 5.1. It can then be seen that the strong and complementary correlations of the 'O' and 'E' sub-scales remain after partialling, whereas the correlation of the 'R' scale vanishes when the effects of the 'O' and 'E' scales are partialled out. In view of this result, little further analysis was made using the 'R' scale, and the main thrust of the analysis was focussed on the 'O' and 'E' scales.

Inter - company comparisons

The analysis in the previous Section served to reinforce the idea that the 'O' and 'E' sub-scales needed to be considered separately, at least in the case of research scientists. Even though these two sub-scales contribute to the same measure of cognitive style, KAI, and are themselves correlated ($r=0.37$), the evidence already presented indicated that the two sub-scales had quite different performance correlates. However, it was clear that the evidence would be very much strenghened if similarly contrasting correlates were found in all three company sub-samples. Table 5.4 presents the breakdown by company.

Table 5.4 Performance correlates: inter-firm comparison

	Company A (n=45) 'O'	'E'	Company B (n=18) 'O'	'E'	Company C (n=30) 'O'	'E'	Total (n=93) 'O'	'E'
Creative perf	.62$	.06	.72$	.44	.44*	-.10	.59$	.10
Skills perf	.08	-.31*	-.49*	-.52*	.15	-.20	.05	-.33$

* p< .05 $ p< .001 (two tailed tests)

Although all of the detail was not the same in the three sub-samples, the overall pattern could be recognised in each company. That is to say, the 'O' factor exhibited a remarkably strong positive correlation with creative performance, but little or no evidence of a correlation with skills performance. In contrast, the 'E' factor showed negative correlations with skills performance, but no evidence of a significant correlation with creative performance. Of the three companies, Company B appeared to be more out of step. This could be satisfactorily attributed to the very small sample size.

Partial correlation coefficients were determined next in order to control for the inter correlations between the 'O' and 'E' scales. The results are shown in Table 5.5, the parentheses indicating which variables are controlled.

Table 5.5 Performance partial correlates: inter-firm compn.

	Company A		Company B		Company C		Total	
	O(E)	E(O)	O(E)	E(O)	O(E)	E(O)	O(E)	E(O)
Creative perf	.64$	-.21	.66+	-.20	.45	-.15	.59$	-.16
Skills perf	.09	-.36*	-.19	-.26	.17	-.21	.09	-.33$

* p< .05 + p< .01 $ p< .001 (two tailed tests)

The results are very interesting. It can be seen that the effect of partialling out 'O' and 'E' as appropriate was to reinforce the similarity of correlative patterns found in the three companies. Company B became much more in line with the other two companies. Overall, Table 5.5 provides strong support for the thesis that 'O' and 'E' contribute substantially different information about research scientists.

5.2 JOB NEEDS AND OPPORTUNITIES IN RELATION TO KAI

Job satisfaction index

The job satisfaction index was tested for associations with the total KAI score and with the 'O' and 'E' sub-scales. Pearson correlation coefficients calculated for each company separately and for the total sample (n=93) are given Table 5.6.

Table 5.6 Job satisfaction index: KAI correlations

	KAI	'O'	'E'
Company A (n=45)	-.11	.12	-.19
Company B (n=18)	.04	.06	-.11
Company C (n=30)	-.10	.20	-.09
Total sample	-.04	.15	-.14

None of the correlation coefficients were statistically significant, and this absence of evidence for an association between job satisfaction and KAI is in accord with the work of Keller and Holland (1978a). In their total sample, the correlation found between job satisfaction and KAI was r=.01, figures for their three company sub-samples ranging from -.04 to .21. Keller and Holland (op cit) noted that the lack of correlation "would suggest that the scale is relatively free of a halo effect from a favourable attitude towards the job." Without wishing to emphasise the point unduly, it was also of interest to note that Keller and Holland obtained correlations (non significant) which were of opposite sign when using the 'originality' subscale and the 'efficiency and conformity' subscale.

In line with the previous Section, partial correlatives were also determined in order to control for the effects of inter-correlations between 'O' and 'E'. Controlling for 'E', the correlation between job satisfaction and 'O' was r=0.22, while controlling for 'O', the correlation between job satisfaction and 'E' was r=-0.21. Although just statistically significant, these correlations were very weak, but they were of some interest because of their opposite sign. The difference between them was highly significant ($p < .01$).

Importance of different job needs

When the four types of job needs were examined separately for associations with KAI, the data given in Table 5.7 were obtained. [Perhaps it should be emphasised in a Section where many correlation coefficients were determined, that caution needs to be exercised in reading too much into coefficients which are only just significant ($p < .05$). Where no correlation exists in a population, 5% of sample coefficients can be expected to exceed the p=.05 level.]

Table 5.7 Importance of job needs: KAI correlations

Needs	KAI	'O'	'E'	'R'
Professional	.06	.16	-.14	.06
Job conditions	-.30**	-.07	-.28**	-.40***
Status	.02	.17	-.09	-.07
Self actualisation	.39**	.51***	.05	.29**

* $p < .05$ ** $p < .01$ *** $p < .001$ (two tailed tests)

A contrast was apparent between the four types of job needs. In the case of professional and status needs, there was no evidence of an association between need importance and KAI and its sub-scales. The strong evidence for a negative correlation between job conditions needs and KAI, 'E', and 'R' was interesting. A person scoring <u>low</u> on 'E' and 'R' is one who is 'prudent, disciplined and conforming', and it is not surprising that such a person would be more concerned with job conditions needs. Perhaps even more interesting was the strong correlation between self actualisation needs and the 'O' scale. Self actualisation needs included 'freedom to carry out my own ideas'. Thus those scientists scoring high on 'O', and who by preference proliferate ideas, might well feel that freedom to follow up their ideas is a valuable facet of their job.

Partialling out the effects of all but one of the KAI sub-scales in turn, changed the pattern of correlations slightly as Table 5.8 shows. (Parentheses indicate the variables controlled.)

Table 5.8 Importance of job needs: KAI partial correlations

Needs	O (E,R)	E (O,R)	R (O,E)
Professional	.20*	-.22*	.02
Job conditions	.24*	-.19	-.41***
Status	.27*	-.12	-.17
Self actualisation	.46***	-.18	.05

* $p < .05$ ** $p < .01$ *** $p < .001$ (two tailed tests)

Comparing Tables 5.8 and 5.7, a major change was the loss of correlation between self actualisation needs and 'R' (but not 'O'), and between job condition needs and 'E', though in the latter case the correlation became only just non significant. Significant, though very weak, correlations appeared between the 'O' scale and several job needs. As noted earlier, it is difficult to resist the temptation to comment upon correlations which are significant statistically, yet caution needs to be exercised when many coefficients are under scrutiny. In reviewing Table 5.8, it is difficult not to comment on the apparent contrast between the 'O' and 'E' sub-scales. Since it is a major argument in the present thesis that these two sub-scales contribute importantly different information about research scientists, it is tempting to cite the above contrast as further, if rather weak, evidence.

Opportunities for satisfying job needs

Table 5.9 presents the set of zero order correlation coefficients between opportunities for satisfying job needs and KAI and its sub-scales.

Table 5.9 Opportunities re job needs: KAI correlations

Opportunities	KAI	'O'	'E'	'R'
Professional	.04	.16	-.14	.01
Job conditions	-.04	.10	-.07	-.14
Status	.07	.16	.03	-.04
Self actualisation	.03	.25*	-.11	-.12

* p< .05 (two tailed test)

This analysis could reasonably be taken as presenting no evidence for any association between opportunities for meeting job needs and KAI and its sub-scales. However, partialling out all but one of the sub-scales in turn, yielded several weak, just significant, correlations as Table 5.10 shows. It would seem that a high 'O' score was associated not only with a high importance rating of self actualisation needs, but also with opportunities for meeting those needs. Once again, taking the overall pattern of figures, it is difficult to escape the conclusion that the KAI sub-scales need to be considered separately in relation to research scientists.

Table 5.10 Opportunities re job needs: KAI partial corrs.

Opportunities	O (E,R)	E (O,R)	R (O,E)
Professional	.22*	-.20*	-.05
Job conditions	.23*	-.06	-.23*
Status	.21*	.01	-.15
Self actualisation	.40***	-.16	-.28**

* p< .05 ** p< .01 *** p< .001 (two tailed tests)

5.3 PERCEIVED ENVIRONMENT MEASURES IN RELATION TO KAI

At the outset it must be emphasised, as intimated earlier, that the data generated in this Section was not used in the way envisaged when the questionnaire was designed. It had been intended that teams of researchers would be identified and that individual perceptions would be compared, and possibly aggregated. It had been anticipated that intra-team and inter-team comparisons of perceived environment thus made, would be related to a range of team parameters, particularly the KAI characteristics of teams. Inability to identify many respondents with their teams precluded this approach. Nevertheless, the data was far from useless. Perceived environment measures also reflect on the individual making the assessment, as pointed out by Jabri (1986). In considering measures of team collaboration which form the first of the two parts of this Section, it was assumed that the extent of collaboration perceived within his/her team by an individual was influenced strongly by the extent of collaboration experienced by the individual concerned. The measures of perceived team collaboration have thus been utilised as measures of individually experienced collaboration within a team.

Perceived collaboration measures

As already noted in some detail in Chapter Two, A - I theory pays considerable attention to the question of collaboration between individuals. Much of the evidence in the literature in support of the predictions stemming from A - I theory is anecdotal, and the data of the present Section was seen as providing an opportunity to test some of the ideas of A - I theory. Specifically, A - I theory suggests that large differences in KAI scores between individuals (and groups) lead to increased difficulties in collaboration and even communication (Kirton, 1984b). Adaptors may be viewed pejoratively by Innovators, and vice versa, thus suggesting that extreme types are more likely to reject than collaborate. Kirton (1984b) has stated that it is typical to find a wide variation in KAI scores within working groups. At the outset of the present work therefore, it was anticipated that individuals with KAI scores near to the neutral point would have better prospects for collaboration than those with extreme scores. By obtaining a measure of collaboration, albeit an indirect one, one of the prominent facets of A - I theory could be put to the test. It did in fact seem remarkable that the literature contained little or no reference to such a test of the theory. Table 5.11 presents the initial check, where total KAI scores were tested for correlation with each of the three collaboration measures and the aggregate Index.

Table 5.11 Collaboration measures: KAI corr. by company

	Company A	Company B	Company C	Total
W S I	-.18	-.23	.42*	-.03
O A C	-.03	-.23	.31	.01
K B R T	.10	-.12	.20	.12
Coll. Index	-.05	-.23	.38*	.04

* $p < .05$ (two tailed tests)

Note W S I : Warm sympathetic integration

O A C : Open authentic communication

K B R T : Knowledge based risk taking

All but two of the sixteen correlation coefficients were non significant, and those two were only just so. Eight of the coefficients were positive, eight were negative. On these grounds there is practically no evidence of an association between KAI and the collaboration measures. However, Company C does appear to stand out as exhibiting different characteristics from the other two companies. While it is difficult to overlook the difference between Companies B and C, it would be unwise to read much into such differences because so many of the coefficients are small and non significant. Overall, the evidence presented in Table 5.11 suggests an absence of correlation between total KAI score and collaboration. This conclusion is consistent with the hypothesis stemming from A - I theory which was identified above. If middle ranking KAI scores make for the best prospects of collaboration, then a non-linear relationship between collaboration and KAI would be anticipated. The properties of the Pearson correlation coefficient would result in a coefficient near to r=0.0.

Turning to the separate sub-scales of KAI, a different and interesting picture emerged. Table 5.12 gives details.

Table 5.12 Collaboration measures: sub-scale correlations

	KAI	'O'	'E'	'R'
W S I	-.03	.13	-.18	-.07
O A C	.01	.17	-.28**	.04
K B R T	.12	.25*	-.24*	.05
Coll. Index	.04	.22*	-.29**	.05

* p< .05 ** p< .01 (two tailed tests)

As with the total KAI score, the 'R' sub-scale showed no evidence of correlation, but the 'O' and 'E' sub-scales tended to show evidence of correlations of opposite sign. The evidence was not strong regarding a correlation involving the 'O' sub-scale, but the negative correlation with the 'E' sub-scale was more pronounced. The picture became more sharply defined when the sub-scales were partialled out in turn, as Table 5.13 shows.

Table 5.13 Collaboration measures: partial KAI correlations

	O (E,R)	E (O,R)	R (O,E)
W S I	.24*	-.22*	-.12
O A C	.26*	-.37***	.02
K B R T	.27**	-.38***	.14
Coll. Index	.32***	-.40***	.01

* p< .05 ** p< .01 *** p< .001 (two tailed tests)

These coefficients showed remarkably distinctive patterns, in contrast to the zero order coefficients in Table 5.12. The figures in Table 5.13 provided further evidence supporting the hypothesis that the three sub-scales justify separate treatment. The 'O' amd 'E' sub-scales clearly exhibited correlations of opposite sign, while the 'R' sub-scale once again failed to show any association. In view of the differences between companies suggested in Table 5.11, a further inter-firm comparison was made using first order partial correlations, as shown in Table 5.14.

Table 5.14 Collaboration measures: partial corr. by company

	Company A		Company B		Company C		Total	
	O(E)	E(O)	O(E)	E(O)	O(E)	E(O)	O(E)	E(O)
W S I	.05	-.15	.34	-.49*	.54+	-.14	.21*	-.25*
O A C	.22	-.24	.37	-.54*	.50+	-.40*	.31+	-.38$
K B R T	.34*	-.25	.02	-.16	.47+	-.55+	.37$	-.37$
Coll. Index	.27	-.28	.31	-.49*	.61$	-.47+	.37$	-.41$

* p< .05 + p< .01 $ p< .001 (two tailed tests)

It was clear that there were still differences between companies, particularly regarding 'O' sub-scale correlations, but the degree of uniformity in terms of the overall patterns of correlations was now considerable. Although the strengh of evidence varied from company to company, there was a clear indication that the 'O' sub-scale, controlled for 'E', was positively associated with collaboration. In contrast, the 'E' sub-scale, controlled for 'O', showed a similar strengh of correlation with collaboration, but of opposite sign. These patterns reinforced the patterns found in connection with performance/ KAI relationships, and led to the characterisation of researchers to be developed in Chapter Six.

Management style measures

Table 5.15 presents the initial analysis, where total KAI scores were correlated with each of the three management style measures.

Table 5.15 Management style measures: KAI corr. by company

	Company A	Company B	Company C	Total
P A R	-.25	-.27	-.23	-.21*
W P	.16	-.30	.10	.02
Q L	-.22	-.36	-.28	-.26*

* $p < .05$ (two tailed tests)

Note P A R : Personal autonomy and responsibility

W P : Work pressure

Q L : Quality of leadership

All but two of the twelve correlation coefficients were non significant, and those two were only just so. However, there is, cumulatively, evidence for a very weak negative association between KAI and two of the measures (PAR & QL), particularly in view of the similarity between the companies, but such weak associations justify little comment. Replicating the approach used in connection with the collaboration measures, the sub-scale correlations were determined next. Again, as Table 5.16 shows, there was no evidence of an association between perceived work pressure and either KAI or its sub-scales. Personal autonomy and responsibility, and quality of leadership showed weak, just significant, associations with the 'E' and 'R' sub-scales.

Table 5.16 Management style measures: sub-scale correlation

	KAI	'O'	'E'	'R'
P A R	-.21*	-.06	-.26*	-.22*
W P	.02	.04	-.08	.07
Q L	-.26*	-.12	-.29**	-.25*

These somewhat weakly defined patterns were even less marked when the sub-scales were partialled, as shown in Table 5.17.

Table 5.17 Management style measures: part. sub-scale corr.

	O (E,R)	E (O,R)	R (O,E)
P A R	.12	-.21*	-.18
W P	.03	-.11	.08
Q L	.08	-.23*	-.18

Although two of the partial correlation coefficients were just significant statistically, it would be unwise to conclude that there was substantial evidence of an association between these three management style variables and any of the KAI sub-scales.

Replicating the approach used with the collaboration measures, a further inter-firm comparison was made using the first order partial correlation coefficients. This is given in Table 5.18, which shows some surprisingly close similarities between the three companies. However, none of the correlation coefficients within the separate companies were significant statistically.

Table 5.18 Management style measures: part. corr. by comp.

	Company A		Company B		Company C		Total	
	O(E)	E(O)	O(E)	E(O)	O(E)	E(O)	O(E)	E(O)
P A R	-.01	-.24	.20	-.40	-.01	-.24	.04	-.25*
W P	.13	-.01	.10	-.34	.13	-.01	.07	-.10
Q L	-.07	-.06	.17	-.47	-.07	-.06	-.01	-.27*

* p< .05 (two tailed tests)

With such a high proportion of non significant correlation coefficients, there was, overall, little or no evidence of an association between any of the management style variables and the 'O', 'E' and 'R' sub-scales. However, it should be noted that in the case of Personal autonomy and responsibility (PAR) and Quality of leadership (QL), there was an indication of a very weak negative association with the 'E' sub-scale, and this was reflected in the total KAI score.

On the basis that such weak associations are worthy of some comment, it could be asked how they might arise. In other words, why might PAR and QL be negatively associated with the 'E' sub-scale?, ie why might percived PAR and QL be positively associated with methodical Weberianism? The answer may lie in the possibility that the disciplined characteristic of low 'E' scientists may allow them to more readily accept the discipline imposed by lower levels of personal autonomy and responsibility, and also more readily accept perceived shortcomings in leadership. Such an explanation could just as easily be applied to the rule and group conforming characteristics of low 'R' scientists, and it can be seen that the negative correlations of the 'R' sub-scale are not far short of those of the 'E' sub-scale (-0.18 compared with -0.21 and -0.23, Table 5.17). Further speculative comment is felt to be unjustified on such weak associations.

Some comment was felt to be desirable on a related issue, however. Throughout the evidence of correlation coefficients presented in this Chapter, there has been a frequently recurring pattern of positive associations with the 'O' sub-scale and negative associations with the 'E' sub-scale. One can readily attempt to interpret such associations as evidence of the insights that A - I theory has to offer on the perceptions and attitudes of research scientists, and thus on their behaviour, including creative and skills performance in a research setting. Indeed such an approach forms an important thread of this thesis. Nevertheless, it is necessary to question whether such associations could arise by an entirely different process. Is it possible that the differences in cognitive style associated with different 'O' and 'E' sub-scale scores could lead to a different attitude to completing a questionnaire? Is it possible, for example, that'low-'E'' scientists could have a 'more generous' stance towards completing questionnaire items? This notion expresses very crudely the idea that cognitive style, and in particular the cognitive style(s) tapped by the sub-scales of KAI, may be able to bring about a bias in the way a questionnaire is completed. It brings into question the whole idea of gaining an understanding of people's attitudes by means of a questionnaire. It needs to be remembered that the 'independent variables' in the present focus (KAI and its sub-scales) were also measured by a questionnaire instrument. It is beyond the scope of this thesis to probe the general problem of the validity of questionnaires in social science research. The question raised is whether there was a persistent bias which was related to a person's position on the 'O' or 'E' sub-scale, such that the questionnaire data set would be bound to generate correlation coefficients of a particular sign when there was a complete absence of any association between the property that 'O' or 'E' purports to measure and the variable under investigation. Such a bias, and the resultant correlations, not necessarily significant statistically, would persist in the case of variables where A - I theory would have no hypothesis to account for them.

A test of this 'bias leading to spurious correlation' hypothesis was thus possible. It was necessary to identify variables where A - I theory would predict no association whatsoever with any of the sub-scales (apart from the possibility of the bias in question) and to examine those cases for any evidence of persistent weak correlations. The absence of evidence of any correlation in such cases would go a long way towards dispelling the idea of a pervasive bias. Table 5.19 presents the data on five variables: the four performance measures relating to a respondent's project team and department; and perceived work pressure. Only an extremely tenuous link could be hypothesised between a person's team or department performance and their A - I cognitive style (other than the possibility of the bias in question. Similarly, A - I theory would appear to make no prediction of a correlation between perceived work pressure and 'O', 'E' and 'R' characteristics.

Table 5.19 Testing for a persistent bias (partial corr.)

	O (E,R)	E (O,R)	R (O,E)
Creative perf. (team)	-.10	-.16	.13
Skills perf. (team)	-.01	-.07	-.05
Creative perf. (dept.)	.09	-.16	.08
Skills perf. (dept.)	.17	-.24*	.07
Perceived work pressure	.03	-.12	.08
Mean correlation $	.04	-.15	.06

* p< .05 (two tailed test) $ Using Fisher's z transform

Out of fifteen correlation coefficients, only one was significant statistically, and in total seven were positive and eight were negative. However, the distribution of signs was clearly uneven. Tests were carried out therefore, taking each sub-scale separately, to check the hypotheses that he mean correlation coefficients were not significantly different from zero (using the Fisher z transformation). In the cases 'O (E,R)' and 'R (O,E)' the hypotheses were tenable, but with 'E (O,R)' the hypothesis was rejected ($p < .01$). It was concluded therefore that there was evidence of a bias in the case of 'E (O,R)', though a very weak one leading to a correlation of -0.15. Such a correlation accounts for only approximately 2% of the variance. In spite of this skeptical view of the data, it must be added that the above argument does not <u>prove</u> that a weak bias persists throughout the whole body of data but it would be prudent to bear in mind the possibility of bias when interpreting data.

CHAPTER 6 A TAXONOMY OF RESEARCHERS USING KAI

The substantial body of evidence presented in Chapter Five served to demonstrate the difference between the three sub-scales of the KAI regarding associations with many of the variables of interest in the present study. A particularly sharp contrast was noted in the case of associations between the sub-scales and creative and skills performance (see Table 5.3). It was felt to be most remarkable that three factors of a measure(KAI), which has been stressed by its originator to be unidimensional, should exhibit such pronounced differences.

During the past decade, factor analytic studies have been carried out on the KAI using large samples drawn from different populations in four countries; U.K., U.S.A., New Zealand and Italy, and using different factoring techniques (Kirton, 1976; Kirton, 1977; Keller and Holland, 1978a; Mulligan and Martin, 1980; Goldsmith, 1985; Prato Previde, 1985, unpublished). In each case three factors were reported with internal reliabilities estimated at around 0.80. The stability of the factor structure across the above studies is also impressive. Taking the Kirton (1977) classification as the basis, the average percentage of terms 'correctly' classified was 83 per cent. In other words, an average of approximately 26 items out of the 32 were similarly classified. With regard to the consistency of individual items appearing under the original factor allocation of Kirton, 16 (50%) were classified consistently by all the separate studies, and an additional 12 were classified consistently by all but one study. In other words, 28 items out of 32 were consistently allocated to Kirton's placements in at least four out of the five studies. Taken altogether, this is strong evidence for the existence of three stable factor traits within the KAI inventory, labelled 'O', 'E' and 'R' by Kirton.

Correlations between these three sub-scales are not very strong. Table 6.1 shows a comparison of the data reported by Kirton (1977) from his main reference sample (n = 532), and the correlations found in the present study.

Table 6.1 KAI sub-scales: inter-correlations

	'O' sub-scale		'E' sub-scale	
	Kirton	Taylor	Kirton	Taylor
'O' sub-scale	*	*		
'E' sub-scale	.36	.37	*	*
'R' sub-scale	.47	.56	.42	.39

Overall the agreement was good, extremely good in relation to correlations involving the 'E' sub-scale. These coefficients did serve to show, however, that the inter-correlations were only of moderate strength. For example, a correlation of r=.36 amounts to only 13% of explained variance. Taking this data in conjunction with the factor analytic studies noted earlier, it was difficult to avoid the conclusion that the KAI contained three substantially different measures. Indeed, it seemed easier to justify the use of the KAI in terms of three separate measures than in terms of one aggregate measure. Such an approach had , of course, already been suggested by the analyses presented in Chapters Four and Five.

6.1 REGRESSION MODELS USING KAI SUB-SCALES AS PREDICTORS

[In all of the regression analyses to be presented in this Section, the SPSSX package was employed, using the backward stepping method.]

Creative performance as a dependent variable

Regression analysis using all three sub-scales as independent variables gave the following model.

	Coeff.	S.E.	t	Sig. t	Intercept
'O'	.1177	.0196	6.00	<.001	1.55
'E'	-.0410	.0275	-1.49	.14	(t=2.00)
'R'	.0036	.0213	0.17	.87	

Multiple R	: .6001	Analysis of variance	
R squared	: .3602	F = 16.7	($p < .001$)
Adjusted R square	: .3386		
St. error of est.	: 1.103		

Clearly, the 'R' sub-scale was of no value as an explanatory variable, and its removal gave an improved regression model, as follows.

	Coeff.	S.E.	t	Sig. t	Intercept
'O'	.1193	.0170	7.02	<.001	1.59
'E'	-.0399	.0266	-1.50	.14	(t=2.19)

Multiple R	: .6000	Analysis of variance	
R squared	: .3600	F = 25.3	($p < .001$)
Adjusted R square	: .3458		
St. error of est.	: 1.097		

The 'E' sub-scale remained of marginal value, and was thus removed to give a simple regression using only the 'O' sub-scale, as follows.

	Coeff.	S.E.	t	Sig. t	Intercept
'O'	.1099	.0159	6.91	<.001	1.26
					(t=1.81)

Multiple R : .5865

R squared : .3439

Adjusted R square : .3367

St. error of est. : 1.104

Analysis of variance

F = 47.7 (p< .001)

It was apparent that there was little to choose between these last two models. On balance, the marginally lower standard error of estimate and more significant intercept might weigh very slightly in favour of the two variable model. The one very clear conclusion from this analysis was that the 'R' sub-scale was of no value in the regression model.

Skills performance as a dependent variable

Regression analysis using all three sub-scales as independent variables gave the following model.

	Coeff.	S.E.	t	Sig. t	Intercept
'O'	.0044	.0227	0.19	.85	6.95
'E'	-.1119	.0319	-3.51	<.001	(t=7.76)
'R'	.0258	.0247	1.04	.30	

Multiple R	: .3521	Analysis of variance	
R squared	: .1240	F = 4.20 (p= .008)	
Adjusted R square	: .0944		
St. error of est.	: 1.280		

In this case, the 'O' sub-scale was clearly of no value as an explanatory variable (in sharp contrast with the previous model), and its removal gave the following model.

	Coeff.	S.E.	t	Sig. t	Intercept
'E'	-.1107	.0311	-3.56	<.001	7.04
'R'	.0281	.0215	1.31	.20	(t=8.93)

Multiple R	: .3516	Analysis of variance
R squared	: .1236	F = 6.35 (p= .003)
Adjusted R square	: .1041	
St. error of est.	: 1.273	

It was not really justifiable to retain the 'R' sub-scale as an independent variable, and so a simple regression model using only the 'E' sub-scale was derived, as follows.

	Coeff.	S.E.	t	Sig. t	¦	Intercept
'E'	-.0950	.0288	-3.30	.001	¦	7.78
						(t=14.2)

Multiple R : .3270

R squared : .1069

Adjusted R square : .0971

St. error of est. : 1.278

Analysis of variance

F = 10.9 (p= .001)

With so low a value of R squared, this model was clearly of limited use , even though the t and F statistics were both very satisfactory.

Collaboration index as a dependent variable

Collaboration was of particular interest as a dependent variable. There were two reasons. Firstly, collaboration (and communication) have received considerable attention in the literature as important factors in research performance (see Chapter 2). Secondly, collaboration was of interest because of the opportunity afforded to test one of the central ideas of A - I theory, namely that a person's position on the KAI spectrum is a determinant of his/her collaboration with others (see Chapter 2). With the collaboration index as the dependent variable, regression analysis using all KAI three sub-scales as independent variables gave the following results.

	Coeff.	S.E.	t	Sig. t	Intercept
'O'	.2974	.0923	3.22	.002	41.98
'E'	-.5372	.1293	-4.15	<.001	(t=11.5)
'R'	.0096	.1003	0.10	.92	

Multiple R : .4572

R squared : .2090

Adjusted R square : .1823

St. error of est. : 5.190

Analysis of variance

F = 7.84 (p<.001)

Very clearly, the 'R' sub-scale was of no value as an explanatory variable, and its removal gave a much improved regression model, as follows.

	Coeff.	S.E.	t	Sig. t	Intercept
'O'	.3017	.0800	3.77	<.001	42.09
'E'	-.5343	.1251	-4.27	<.001	(t=12.3)

Multiple R : .4571

R squared : .2089

Adjusted R square : .1913

St. error of est. : 5.161

Analysis of variance

F = 11.88 (p<.001)

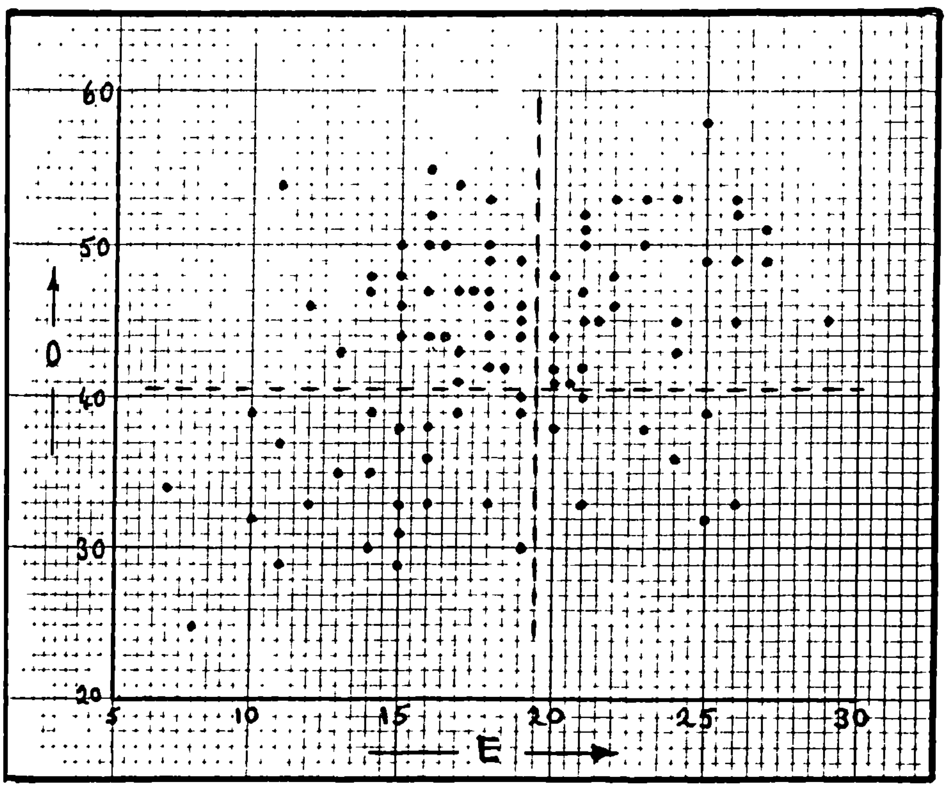
It was apparent that both of these two remaining sub-scales justified their presence in the regression model.

In a sense, the regression analyses presented above were little more than an alternative form of expression to the partial correlation analyses described in Chapter 5. The persistent pattern of positive correlations with the 'O' sub-scale and negative correlations with the 'E' sub-scale was reflected in the pattern of positive regression coefficients with the 'O' sub-scale and negative regression coefficients with the 'E' sub-scale. The weaker correlations associated with the 'R' sub-scale resulted in the virtual elimination of this sub-scale from the regression models.

6.2 A KAI TAXONOMY OF RESEARCH SCIENTISTS

As a result of the foregoing analysis, and the analysis in Chapter Five, it had become apparent that the 'O' and 'E' sub-scales presented the opportunity of a two dimensional taxonomy of research scientists. The initial idea involved a four-way classification in which research scientists would be identified as either 'high' or 'low' on each of the two sub-scales. Since bivariate data can be conveniently expressed as a scatter diagram in two dimensions, this form of expression was applied to the 'O' and 'E' measures of the entire sample of 93 research scientists. The diagram shown in Figure 6.1 resulted.

Figure 6.1 Scatter diagram in the 'O'/'E' plane.



Not surprisingly, with a correlation of only $r = 0.37$, the data exhibited very considerable scatter. [Were the correlation very strong, say $r = 0.9$, such a scatter diagram would have shown points which were densely distributed around a regression line]. Several criteria were considered regarding the question of determining when 'O' and 'E' scores were 'high' and 'low'. One possibiity was to use the mean 'O' and mean 'E' values to define the boundary lines. However, using such a basis, the classification criteria would be subject to variation according to the sample statistics in question. Another alternative considered was the use of boundary lines based on the neutral points of the 'O' and 'E' sub-scales ('O'=39 'E'=21). This approach would not have suffered from the disadvantage of the previous basis, but was not felt to be satisfactory because these values *are in a sense* 'theoretical' mid-points on the scale, but actual mean values in practice do not coincide with them. A better alternative was felt to be the use of boundary lines which were determined by the mean 'O' and mean 'E' in the general population. Such levels could reasonably be described as general norms. Based on published data at that time, 'high' 'O' was defined as 41 and above, 'high' 'E' was defined as 20 and above. Both of the sub-scales being integers, the boundary lines were set at 'O' = 40.5 and 'E' = 19.5, as shown in Figure 6.1.

The above basis of characterisation resulted in four groups of research scientists with the KAI parameters as given in Table 6.2.

Table 6.2 KAI parameters of the four types of scientists

HIGH 'O'

	TYPE II (n=33)			TYPE I (n=29)	
	Mean	S.D.		Mean	S.D.
'O'	47.2	3.7	'O'	47.9	4.4
'E'	16.4	2.0	'E'	23.0	2.6
'R'	38.9	5.8	'R'	39.1	5.6
KAI	102.5	8.2	KAI	110.0	10.1

LOW 'E' ———— HIGH 'E'

	TYPE III (n=23)			TYPE IV (n=8)	
	Mean	S.D.		Mean	S.D.
'O'	34.2	4.1	'O'	36.1	3.1
'E'	14.1	3.4	'E'	23.1	2.2
'R'	31.7	6.9	'R'	34.4	5.7
KAI	80.0	11.6	KAI	93.6	4.6

LOW 'O'

Those twenty nine scientists who were high on 'O' and 'E' (31% of the sample), were labelled Type I. With only three exceptions, they were Innovators, having a mean KAI score of 110.0. In A - I terminology they could be regarded as Inefficient Innovators, or perhaps more prosaically as all-out ideas people.

The thirty three scientists who were above average on 'O' but below average on 'E', (35% of the sample), were labelled Type II. This group, containing twenty five Innovators and eight Adaptors and having a mean KAI score of 102.5, could be regarded as Efficient Innovators, or alternatively as all-round researchers. That is to say, they were above average on the originality dimension yet found it easy to attend to detail and do thorough painstaking work, features which are not characteristic of the KAI Innovator.

The twenty three scientists who were below average on both 'O' and 'E', (25% of the sample), were labelled Type III. With only one exception, they were Adaptors, having a mean KAI score of 80.0. In A - I terminology they could be regarded as Efficient Adaptors. It might be supposed from A - I theory that they would be more comfortable in work on the development side of the R & D spectrum, though the same theory suggests that they could have a valuable role in research teams to complement the Innovators.

The fourth group, labelled Type IV, were particularly interesting, being below average on 'O' but above average on 'E', with a mean KAI score of 93.6. Only eight in number, (9% of thesample), the group contained five Adaptors, and they could be regarded as Ineffficient Adaptors. It was not easy to see where the strengths of this group would lie in a research unit since they neither proliferate ideas nor do they easily attend to detail. It seemed that these scientists might be misplaced in R & D.

The basis of classification used in Table 6.2 was bound to lead to four groups having a high level of intra-group homogeneity with respect to the 'O' and 'E' sub-scales. [The mean S.D. for 'O' in the four groups was 3.8, compared with S.D.=7.2 in the total sample; the mean S.D. for 'E' in the four groups was 2.5, compared with S.D.=4.6 in the total sample.] In contrast, but not surprisingly, the four groups remained heterogeneous with respect to the 'R' sub-scale [the mean S.D. for 'R' in the four groups was 6.0 compared with S.D.=6.6 in the total sample.]

Before proceeding with the characterisation of the four Types identified on the basis described above, one further approach was considered: the use of cluster analysis. Although at the outset this approach was felt to be very exploratory in nature, the results were of considerable interest.

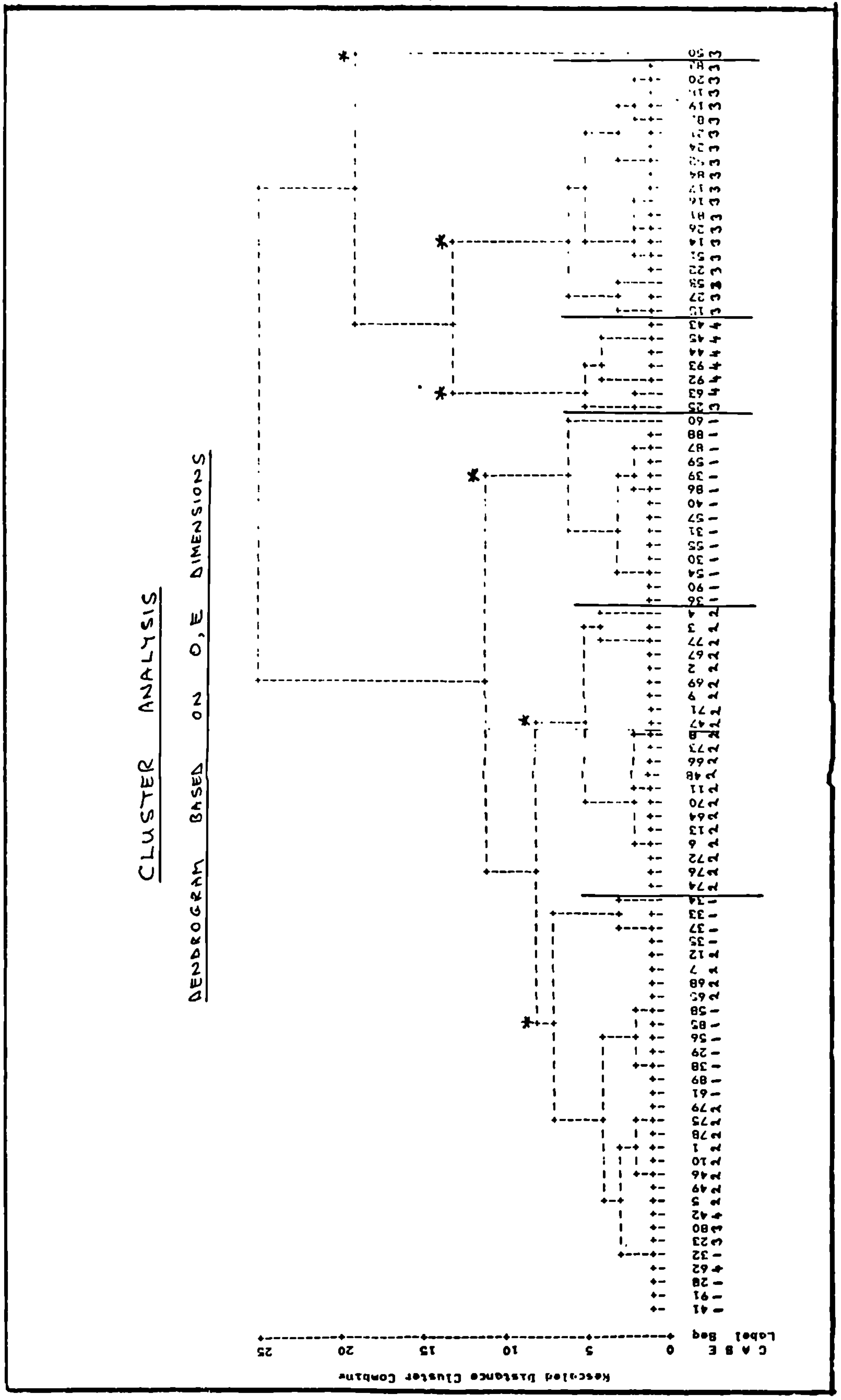
Taxonomy using cluster analysis

Cluster analysis seeks to take a sample of N objects or individuals, each of which is measured on each of Q variables, and to devise a classification scheme for grouping the N objects into C classes. The number of classes and the characteristics of these classes remain to be determined in the course of the analysis. It was not the purpose of this thesis to explore the array of alternative approaches within the general area of cluster analysis, but to take a single commonly used approach available through SPSSX. Two analyses were carried out; firstly, a clustering using just the 'O' and 'E' sub-scales, and secondly, a clustering using the 'O', 'E' and 'R' sub-scales [although by now the 'R' sub-scale had become of much less interest.]

Clustering on the basis of the 'O' and 'E' sub-scales generated a very interesting analysis. The dendrogram generated by SPSSX is shown in Figure 6.2. Marked by hand on the dendrogram alongside each serial number of the 93 individuals is the KAI Type as identified by the procedure described earlier and depicted in Figure 6.1. It can be seen that the dendrogram identifies six clusters, which are indicated by asterisks. However, because one cluster contained only a single member [extreme right hand side], the number was reduced by amalgamation to five clusters. These five clusters were labelled as follows [reading from the right hand side of the dendrogram].

(i) A Type III group: all members were Type III
(ii) A Type IV group: all members but one were Type IV
(iii) A Type I group: all members were Type I
(iv) A Type II group: all members were Type II
(v) A Central group: composed of all four Types, but predominantly Types I and II

Figure 6.2 Cluster analysis



The spatial relationships of these groups in the 'O'/'E' plane are shown by the scatter diagram in Figure 6.3.

Figure 6.3 Cluster analysis based on 'O' and 'E'
Scatter diagram showing the five clusters

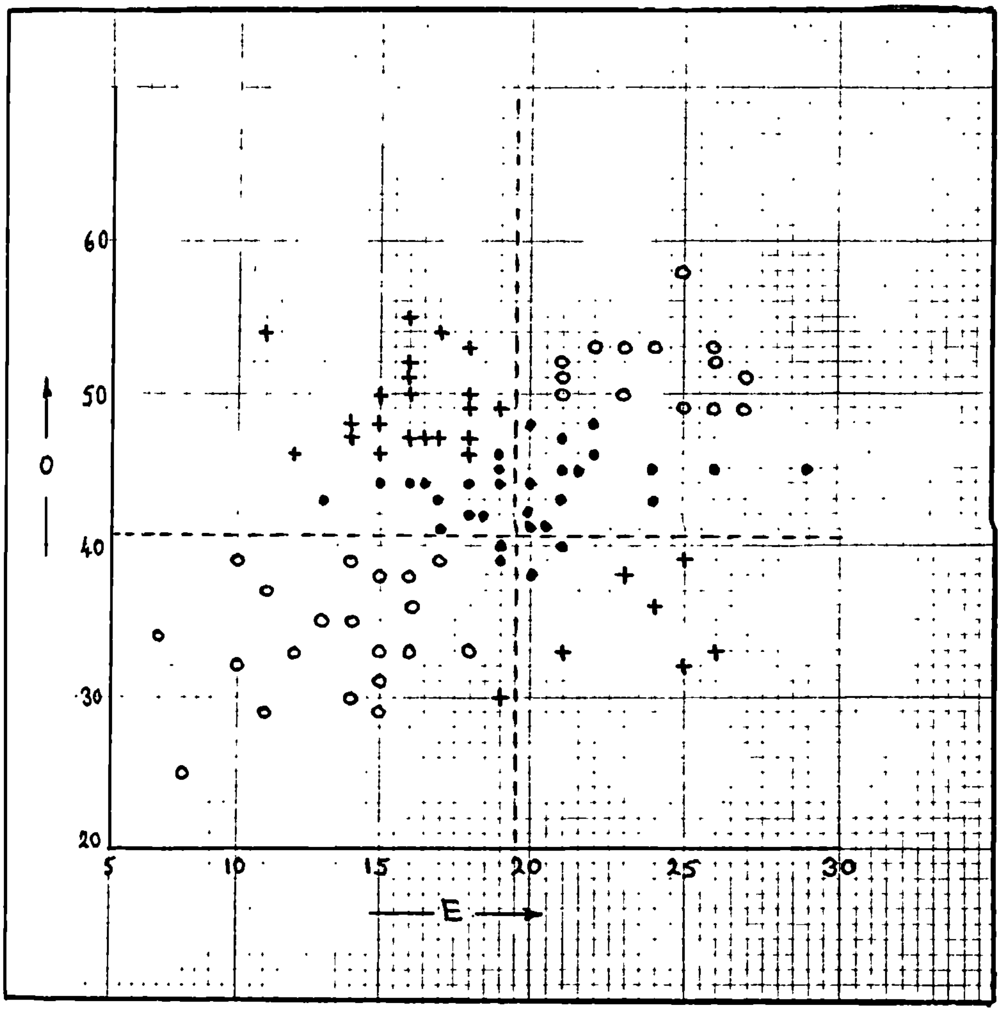


Table 6.3 gives the KAI characteristics of the five clusters identified.

Table 6.3 KAI characteristics of clusters using 'O' & 'E'

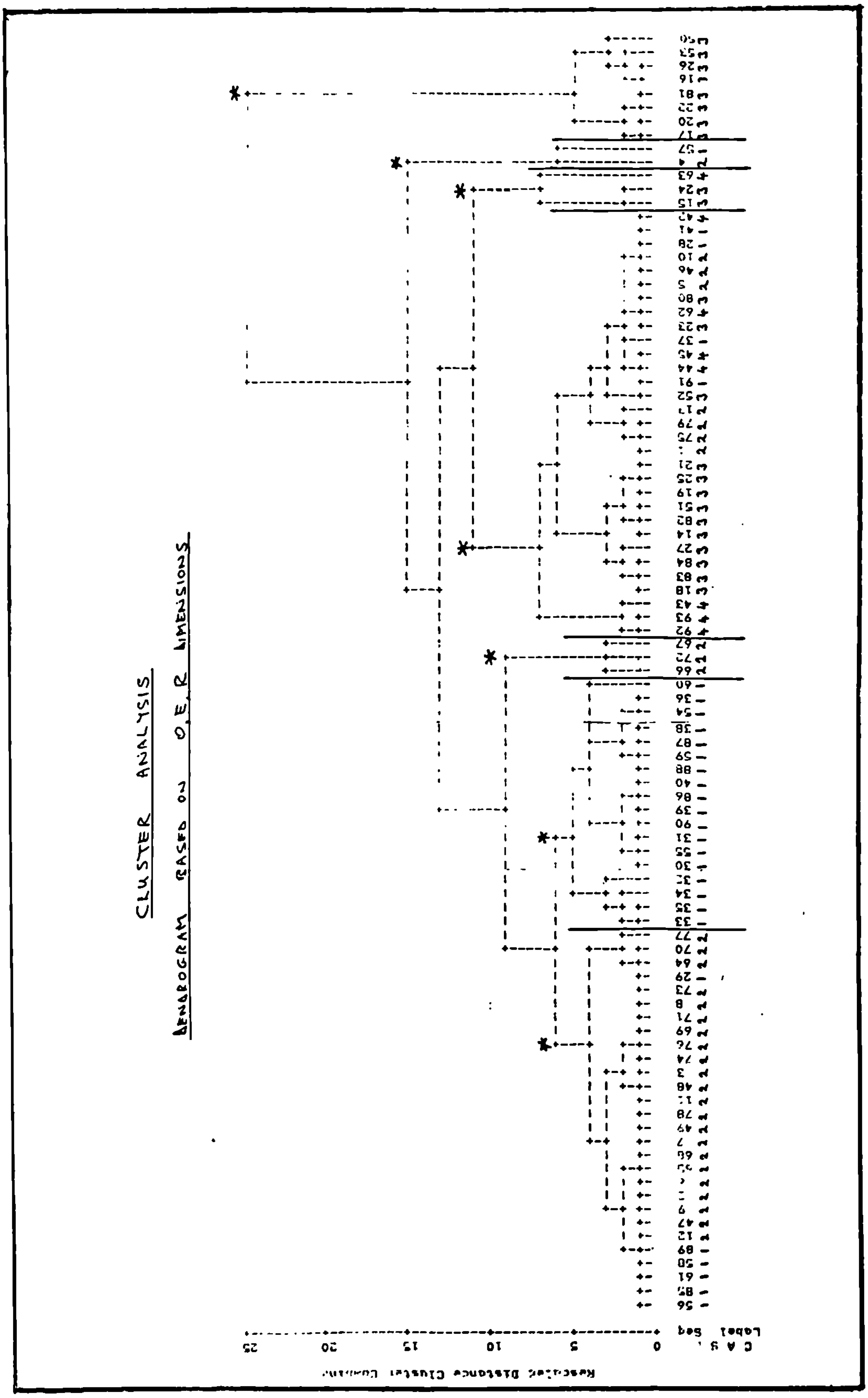
		'O'	'E'	'R'	KAI
Central cluster	Mean	43.4	19.8	36.1	99.4
(n = 31)	S.D.	2.5	3.2	4.3	7.7
Type I cluster	Mean	51.6	24.1	41.6	117.3
(n = 14)	S.D.	2.4	2.2	5.3	6.1
Type II cluster	Mean	49.3	16.0	40.7	106.0
(n = 21)	S.D.	2.8	2.0	5.8	7.2
Type III cluster	Mean	33.9	13.4	31.0	78.3
(n = 20)	S.D.	3.9	3.0	7.1	11.2
Type IV cluster	Mean	34.4	23.3	34.7	92.4
(n = 7)	S.D.	3.3	2.5	6.0	5.3

It was felt that this basis of classification was of considerable interest. By identifying a central cluster, the four peripheral clusters became in general more homogeneous with respect to the 'O' and 'E' sub-scales.

Furthermore, those individuals lying close to the intersection of the boundary lines (see Figures 6.1 and 6.3) and having similar 'O' and 'E' sub-scale values were brought into the same class. In the Four-Types model, such individuals might be split among four different groups. One obvious disadvantage of the Five-Cluster model was the reduced sample size of the groupings but a more serious disadvantage was felt to lie in the definition of the central cluster. This group, as Figure 6.3 shows, could be said to be central with respect to the 'O' sub-scale, but not with respect to the 'E' sub-scale. The individual with the greatest 'E' score in the entire sample (n=93) lay in the central cluster. The definition of this central cluster will obviously be susceptible to peculiarities in the spatial distribution of a particular sample. That is to say, any estimation of the 'O'/'E' parameters of a central group by cluster analysis will be subject to sampling error. It was felt that a much larger sample size was needed before the central group could be defined with confidence by means of cluster analysis. With some reluctance, therefore, the Four-Types model defined earlier and summarised in Table 6.2, was the only one that was used in further analysis.

The opportunity was taken , however, to carry out cluster analysis using all three KAI sub-scales. The resulting dendrogram generated by SPSSX is shown in Figure 6.4.

Figure 6.4 Cluster analysis



It can be seen that the dendrogram identifies seven clusters, which are identified by asterisks. The KAI Type, as identified in Figure 6.1 is marked on the dendrogram alonside the serial number of each of the 93 individuals in the sample. Table 6.4 gives the KAI characteristics of the seven clusters, appropriate labels having been added.

Table 6.4 KAI characteristics of clusters using 'O'/'E'/'R'

		'O'	'E'	'R'	KAI
Central cluster	Mean	38.0	18.2	33.3	89.5
(n = 31)	S.D.	4.6	4.0	2.9	5.6
Type I cluster	Mean	49.8	24.3	42.2	116.3
(n = 18)	S.D.	3.8	2.4	3.7	5.6
Type II cluster	Mean	47.3	17.8	39.2	104.3
(n =28)	S.D.	3.0	2.1	3.1	3.8
Type III cluster	Mean	32.0	11.5	23.9	67.4
(n = 8)	S.D.	4.0	3.1	2.5	7.8
Type II (High 'R')	Mean	50.0	16.7	50.7	117.3
(n = 3)	S.D.	3.6	2.5	2.9	6.4
Type II (Low 'R')	Mean	53.0	16.0	28.5	97.5
(n = 2)	S.D.	1.4	7.1	2.1	7.8
Type III (High 'R')	Mean	37.0	15.0	44.7	96.7
(n = 3)	S.D.	3.5	5.6	2.5	3.8

Tables 6.3 and 6.4 provide an interesting comparison of

the two different cluster analyses. The penalty paid when introducing the third dimension, the 'R' sub-scale, became readily apparent, viz., the homogeneity of the clusters with respect to both the 'O' and 'E' sub-scales was impaired. The extent can be quantified by considering the mean S.D. of clusters. Taking the 'O' sub-scale; in Table 6.3 the mean S.D. was 3.0; in Table 6.4 the mean S.D. was 3.4. Taking the 'E' sub-scale; in Table 6.3 the mean S.D. was 2.6; in Table 6.4 the mean S.D. was 3.8. Clearly any advantage stemming from reduced S.D. on the 'R' sub-scale, is eclipsed by the greater S.D. on the more important 'O' and 'E' sub-scales.

The presence of several very small clusters was also a disadvantage. Perhaps even more serious, however, was the absence of a cluster that could be described as Type IV, in view of the interest in this category from a theoretical viewpoint.

In view of the foregoing points, subsequent work in the present research regarding a KAI taxonomy will be concerned solely with the four-way classification described earlier and summarised in Table 6.2.

CHAPTER 7 CHARACTERISING THE FOUR KAI TYPES

The analysis in Chapter Five provided justification for utilising the sub-scales of KAI as separate measures, at least in the case of research scientists. Extension of the analysis in Chapter Six provided the basis of a taxonomy of research scientists using the 'O' and 'E' sub-scales to provide a four-way classification. The four types, labelled Types I, II, III and IV, were defined in terms of the KAI parameters given in Table 6.2. In the present Chapter, these four Types will be characterised in terms of personal data, research performance, job needs and satisfactions, and perceived environment measures.

7.1 PERSONAL DATA AND THE FOUR TYPES

Characterisation by company

Numbers of each of the four types in each of the three company sub-samples are given in Table 7.1. Percentages of each Type in each company are shown in parentheses. Although Company C had a considerably higher proportion of Type II researchers (53%) than the other two companies, and other differences were also apparent, the differences in proportions shown in Table 7. were far from significant statistically (chi-square, p=.27). It would be unwise therefore, to conclude that there were differences in general between the three companies in the proportions of the four Types.

Table 7.1 Numbers of the four Types by company

	Company A	Company B	Company C	Total
Type I	14 (31.1%)	8 (44.4%)	7 (23.3%)	29 (31.2%)
Type II	13 (28.9%)	4 (22.2%)	16 (53.3%)	33 (35.5%)
Type III	14 (31.1%)	4 (22. 2%)	5 (16.7%)	23 (24.7%)
Type IV	4 (8.9%)	2 (11.1%)	2 (6.7%)	8 (8.6%)

Characterisation by sex

Table 7.2 gives the numbers of each of the four Types of researcher for each of the sexes.

Table 7.2 Numbers of the four Types by sex

	Male	Female	Total
Type I	24 (33.8%)	5 (22.7%)	29 (31.2%)
Type II	24 (33.8%)	9 (40.9%)	33 (35.5%)
Type III	17 (23.9%)	6 (27.3%)	23 (24.7%)
Type IV	6 (8.5%)	2 (9.1%)	8 (8.6%)

Percentages of each Type in each category are given in parentheses. The proportions of the four Types are seen to be similar for each sex, and there is no evidence here of any difference between the sexes in this respect (chi-square, p=.80).

Characterisation by age

Summary statistics for the age of individuals in each of the four Types are given in Table 7.3. The mean ages are seen to be remarkably similar, and analysis of variance confirms that there is no evidence of a significant difference in age between the four Types (F = 0.7, p=.54).

Table 7.3 The four Types compared by age (years)

	Type I	Type II	Type III	Type IV
Mean	35.6	32.9	33.1	33.3
S.D.	7.7	7.7	7.5	10.6

Nevertheless, it is perhaps worthy of note that the Type I researchers were on average slightly older than the other three sub-groups. In Chapter Four it was noted that in the total sample there was a significant correlation between age and level of qualifications, and it will be shown subsequently that the Type I group contained the highest proportion of doctorates. One other feature of note is that there was much less difference regarding age between the four Types than there was between the three companies. It will be recalled that some concern was expressed earlier about the substantial difference in age distributions between the three companies. Differences between the four Types regarding mean levels of work experience in R & D were also found to be non-significant ($F = 0.2$, $p=.90$).

Characterisation by R/D work balance

Numbers of each of the four Types in each R/D work balance category are given in Table 7.4.

Table 7.4 The four Types compared by R/D balance

	Type I	Type II	Type III	Type IV
All research	18	17	11	2
Mainly research	7	9	3	3
About equal	3	3	5	2
Mainly development	1	4	3	1
All development	0	0	1	0

Testing for differences in the R/D work balance between the four Types using a chi-square test of association indicated no evidence of significant differences (chi-square, $p=.53$).

The test was not altogether satisfactory, however, because 70% of the 'expected frequencies' had numerical values of less than 5. An alternative approach was to use analysis of variance, though the underlying assumption of measurement on an interval scale cannot be substantiated. Proceeding in this way, a similar conclusion resulted, viz., that differences between the four Types in the mean levels of the R/D balance variable were not statistically significant (F ratio, p=.17). Nevertheless, mean levels were of some interest, as Table 7.5 shows.

Table 7.5 R/D work balance: mean levels of the four Types

	Type I	Type II	Type III	Type IV	Total
Mean	1.55	1.82	2.13	2.25	1.85
S.D.	0.83	1.04	1.29	1.03	1.06

It is tempting to comment on the progression of mean level from Type I to Type IV which shows that, in this research sample, the work of Type I scientists was orientated strongly towards the research end of the R/D spectrum, with diminishing research orientation on passing from Types II to IV. Although analysis of variance gave a non-significant result, the 'no difference' hypothesis is not tenable with much confidence in the face of the above data. It seemed desirable to question, if such differences as Table 7.5 exhibits were to be substantiated, what the direction of causality might be. A scientist's cognitive style as depicted by their Type might tend to determine the R/D orientation of their career. Alternatively, it is plausible that a scientist's career experience might have an influence on their cognitive style. However, in view of the non-significant analysis of variance, the pattern in Table 7.5 cannot be generalised with any confidence, and no further comment seems justified.

Characterisation by level of qualifications

Level of qualifications was the only one of the personal variables which showed a significant variation between the four Types. Table 7.6 gives the cross tabulation.

Table 7.6 The four Types compared by level of qualification

	Type I	Type II	Type III	Type IV	Total
First degree	4	15	14	4	37
Master degree	2	1	3	2	8
Doctorate	23	17	6	2	48

A test of association indicated that differences in qualifications between the four Types were highly significant statistically (chi-square, $p<.01$), though the validity of the test was placed in some doubt by the 50% of 'expected frequencies' which had a numerical value of less than 5. An alternative approach, analysis of variance, gave a similar result (F ratio, $p<.001$). Using the Scheffe procedure, at the .01 level, to detect which sub-groups were significantly different, only Types I and III were identified in this way. It seemed clear from this evidence that Type I scientists as a group contained a significantly higher proportion of doctorates than Type III scientists, and possibly other Types too. Once again, the question arises as to the direction of causality. Is it possible that the process of acquiring a doctorate, that is to say experience of the milieu of academic research, influences a person's cognitive style as depicted by the KAI Type? Or does a scientist's KAI Type have an influence in determining whether he/she chooses or is chosen to work for a doctorate? On the basis that a person's KAI is relatively stable over time (Kirton, 1984b), it seems plausible to suggest the second explanation. An alternative suggestion which has some attraction, is that these two influences are not mutually exclusive, and that there is a mutually reinforcing influence in both directions. It is eyond the scope of the present research to explore this issue further, but it remains an area of interest for future research.

7.2 RESEARCH PERFORMANCE AND THE FOUR TYPES

Creative performance

As in previous analyses involving performance measures (Chapters 4 and 5), the creative performance measure was used in standardised form so that the mean value for each company taken separately had a value of 6.0. [As defined in the questionnaire, an 'average performance' was equal to a value of 3 on the assessment scale, and hence the overall measure formed by the aggregate of two such measures should have a mean of 6]. Having grouped the respondents into the four Types, summary statistics were calculated for each Type. Numbers lying above and below the overall mean were also noted for each Type. Table 7.7 presents the data.

Table 7.7 Creative performance and the four Types

HIGH 'O'

LOW 'E'	TYPE II (n=33) Mean : 6.46 S.D. : 1.28 Number > average : 22 Number < average : 11	TYPE I (n=29) Mean : 6.53 S.D. : 1.15 Number > average : 20 Number < average : 9	HIGH 'E'
	TYPE III (n=23 Mean : 5.16 S.D. : 1.20 Number > average : 5 Number < average : 18	TYPE IV (n=8) Mean : 4.73 S.D. : 0.73 Number > average : 0 Number < average : 8	

LOW 'O'

Testing for differences between the means of the four Types using analysis of variance indicated very highly significant differences ($F = 10.6$, $p < .001$). In order to further identify which pairs of means were significantly different, the Scheffe procedure was employed, using the $p=.01$ level as the criterion. As might be anticipated from the data in Table 7.7, Type I and Type II were each significantly different from both Type III and Type IV. In contrast, Types I and II were not significantly different, neither were Types III and IV.

It can be readily appreciated that these findings are in effect an alternative expression of the partial correlation analysis given in Chapter 5. The difference found between Types I and IV and between Types II and III corroborates the strong correlation between creative performance and the 'O' sub-scale ($r=.59$) given in Table 5.5. The absence of a difference between Types I and II and between Types III and IV corroborates the non-significant correlation between creative performance and the 'E' sub-scale ($r=-.16$), given in the same Table. Differences between the four Types according to the numbers lying above and below the overall mean were also very highly significant statistically (chi-square, $p < .001$).

In order to further characterise the four Types, 95% confidence intervals for the mean levels of creative performance were determined as follows.

Type I	:	6.10	to	6.97
Type II	:	6.00	to	6.91
Type III	:	4.64	to	5.68
Type IV	:	4.12	to	5.33

An inter-firm comparison of the mean levels of creative performance of the four Types is given in Table 7.8.

Table 7.8 Creative perf. : four Types by company (means)

HIGH 'O'

	TYPE II		TYPE I	
Company A	6.56	(n=13)	6.67	(n=14)
B	6.70	(n=4)	6.70	(n=8)
C	6.31	(n=16)	6.07	(n=7)

LOW 'E' ——— HIGH 'E'

	TYPE III		TYPE IV	
Company A	5.24	(n=14)	4.60	(n=4)
B	4.70	(n=4)	4.70	(n=2)
C	5.30	(n=5)	5.00	(n=2)

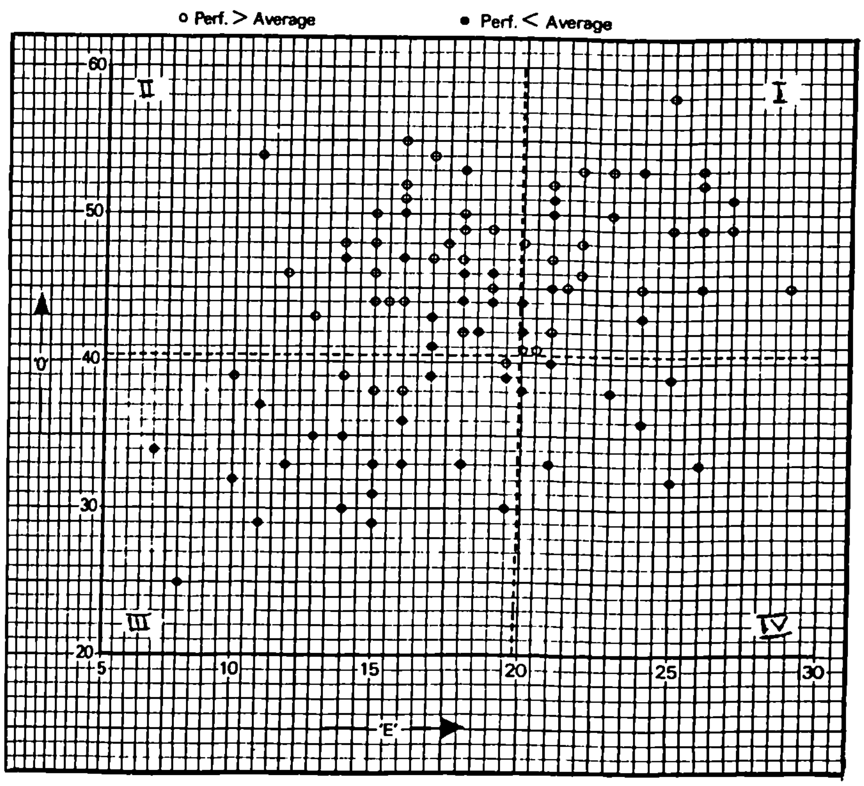
LOW 'O'

The inter-firm comparison is remarkable for the degree of consistency of patterns found in the three companies, particularly in view of the very small sample sizes in some cases. Inevitably, several of the differences between means which were significant in the aggregate sample, fail to be statistically significant in the separate company samples.

Nevertheless, the overall impression gained from Table 7.8 is one of a convincing similarity between the three companies regarding the pattern of creative performance among the four Types.

A graphic illustration which adds more detail to the pattern of distribution of creative performance in the 'O'-'E' plane is given in Figure 7.1.

Figure 7.1 Creative performance and the four Types



Perhaps the most striking feature of Figure 7.1 is the concentration of below average performers beneath the horizontal boundary line. Indeed, not one above average performer was to be found with an 'O' sub-scale score of less than 38. Kirton (1984b) has suggested that a person scoring high on the 'O' sub-scale corresponds to the 'creative loner' of Rogers (1959), a person who compulsorily toys with ideas. In contrast then, one could regard a person scoring low on the 'O' sub-scale as one who does not naturally proliferate ideas. To associate such a person with below average creative performance is an obvious hypothesis which is well supported by the present data. In a sense, the association is stronger than one might expect, that is to say the demarcation is more clear cut than might be anticipated, because the question of the quality of ideas is not considered. In fact, the association is less strong for 'O' sub-scale scores above 'O' = 38, where Figure 7.1 shows a considerable heterogeneity. It would be unwise to read more from this data, where sample sizes are not particularly large, but it is tempting to suggest that a boundary line at 'O' = 38 might separate those who, lying below the boundary, are seriously disadvantaged with respect to creative performance by their cognitive style.

It is perhaps easy to allow the absence of a contrast on either side of the vertical boundary line to pass without comment. Nevertheless, it is remarkable that two sub-scales (correlated r=.37) of what is claimed to be a uni-dimensional measure of cognitive style should exhibit such markedly different characteristics. The point can be made in an alternative way by comparing Types II and IV. These two groups are fairly similar in terms of total KAI score (means of 102.5 and 93.6, respectively) but are very different in terms of creative performance, as Figure 7.1 and Table 7.7 demonstrate.

Skills performance

The skills performance measure was used in a standardised form in the same way as the creative performance measure discussed above. That is to say, the mean level of skills performance was standardised to a value of 6.0 in each company taken separately. Having grouped the respondents into the four Types, summary statistics were calculated for each Type. Numbers of researchers lying above and below the overall mean were also noted for each Type, as in the previous Section. Table 7.9 presents the data.

Table 7.9 Skills performance and the four Types

	LOW 'E'	HIGH 'E'
HIGH 'O'	TYPE II (n=33) Mean : 6.57 S.D. : 1.25 Number > average : 27 Number < average : 6	TYPE I (n=29) Mean : 5.31 S.D. : 1.20 Number > average : 9 Number < average : 20
LOW 'O'	TYPE III (n=23) Mean : 6.10 S.D. : 1.36 Number > average : 13 Number < average : 10	TYPE IV (n=8) Mean : 6.18 S.D. : 1.25 Number > average : 5 Number < average : 3

Testing for differences between the means of the four Types using analysis of variance indicated highly significant differences (F = 5.2, p=.002). Differences between the four Types according to numbers lying above and below the overall mean level were also very highly significant statistically (chi-square, p<.001). Nevertheless, a visual scrutiny of the data in Table 7.9 suggested that any difference between the Types identified in these tests stemmed mainly from the difference between Type I scientists and the remainder, particularly Type II. Using the Scheffe procedure, Types I and II were identified as having significantly different means (at the .01 level).

There was, therefore, a less well defined pattern regarding skills performance amongst the four Types than with creative performance. The negative correlation between skills performance and the 'E' sub-scale was clearly evident in those cases where the 'O' sub-scale score was above average, but no such pattern was manifest with low 'O' sub-scale scores. It may be that this somewhat confused, though intriguing, picture was a function of the small sample size of the Type IV group. However, other speculative explanations could be considered. For example, the Type IV scientists have been shown to be very low on creative performance, and so perhaps an inflated self-assessment of skills performance might result by way of a compensatory mechanism.

Characterising the four Types by means of 95% confidence intervals for the mean level of skills performance gave the following figures. They reveal the less clear-cut characterisation already referred to.

Type I	:	4.85	to	5.77
Type II	:	6.12	to	7.01
Type III	:	5.51	to	6.68
Type IV	:	5.13	to	7.22

Inevitably, with a very small sample size (n=8) the confidence interval regarding Type IV researchers is very wide.

An inter-firm comparison of the mean levels of skills performance of the four Types is given in Table 7.10.

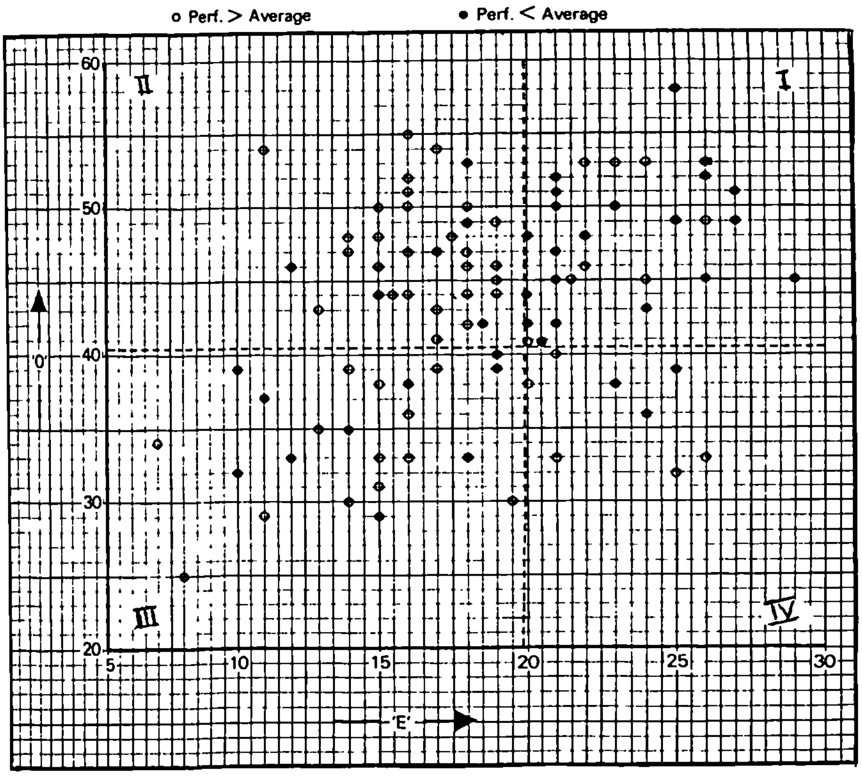
Table 7.10 Skills perf. : four Types by company (means)

	HIGH 'O'	
TYPE II		TYPE I
Company A : 6.68 (n=13)		Company A : 5.41 (n=14)
B : 6.10 (n=4)		B : 5.10 (n=8)
C : 6.45 (n=16)		C : 5.34 (n=7)
LOW 'E'		HIGH 'E'
TYPE III		TYPE IV
Company A : 6.06 (n=14)		Company A : 5.45 (n=4)
B : 6.85 (n=4)		B : 7.60 (n=2)
C : 5.60 (n=5)		C : 6.20 (n=2)
	LOW 'O'	

Although the inter-company similarities were not so very remarkable as those already given for creative performance (Table 7.8), nevertheless the similarities were encouraging, particularly in relation to Types I and II. With the very small sample sizes of Company sub-samples within Types (sample sizes ranged from n=2 to n=16) close similarity of sample means could hardly be expected.

A graphic illustration of the distribution of skills performance in the 'O'-'E' plane is given in Figure 7.2.

Figure 7.2 Skills performance and the four Types



The pattern is less clear than that found in Figure 7.1, regarding creative performance. Below the horizontal demarcation line there is no visual evidence of a pattern. Above this demarcation line, however, there is a contrast between the Type I and Type II researchers which is perhaps more striking than appears at first sight. For example, of the Type II researchers with an 'E' sub-scale score of less than 17, only one in sixteen appears as below average in skills performance.

At the stage of the present research when the methodology was formulated, it had been hypothesised that the Weberian efficiency and diligence purportedly measured by the 'E' sub-scale should give an indication of a research ability which was ultimately labelled skills performance. The label was not felt to be ideal but was the best that could be devised at the time. The research ability that it sought to identify was a skill in the assiduous development of ideas, concepts and hypotheses, a skill in bringing about incremental progress, consolidating the potential of conceptual innovations. It was a construct based on the ten years of full-time research experience in manufacturing industry by the author.

It can be seen that the data in Tables 7.9 and 7.10 and in Figure 7.2 give some, albeit partial, support for this hypothesis. What had not been foreseen at the outset, but which began to emerge when the data in Figures 7.1 and 7.2 were taken together, was the interesting combination of researcher abilities detected in the Type II researchers. This will be discussed further in a subsequent Section.

Creativity / skills orientation

It has been argued in Chapter 3 that scientists are well able to assess the performance of other scientists with whom they have close working or disciplinary ties, and that in a research laboratory there is to a large extent a shared understanding of standards that allows a scientist to make a self assessment in relation to the unit as a whole. Indeed, it has been argued that subjective assessments as a class are superior to objective measures which may fail badly to capture the essential contributions an individual makes to the progress of work in a laboratory.

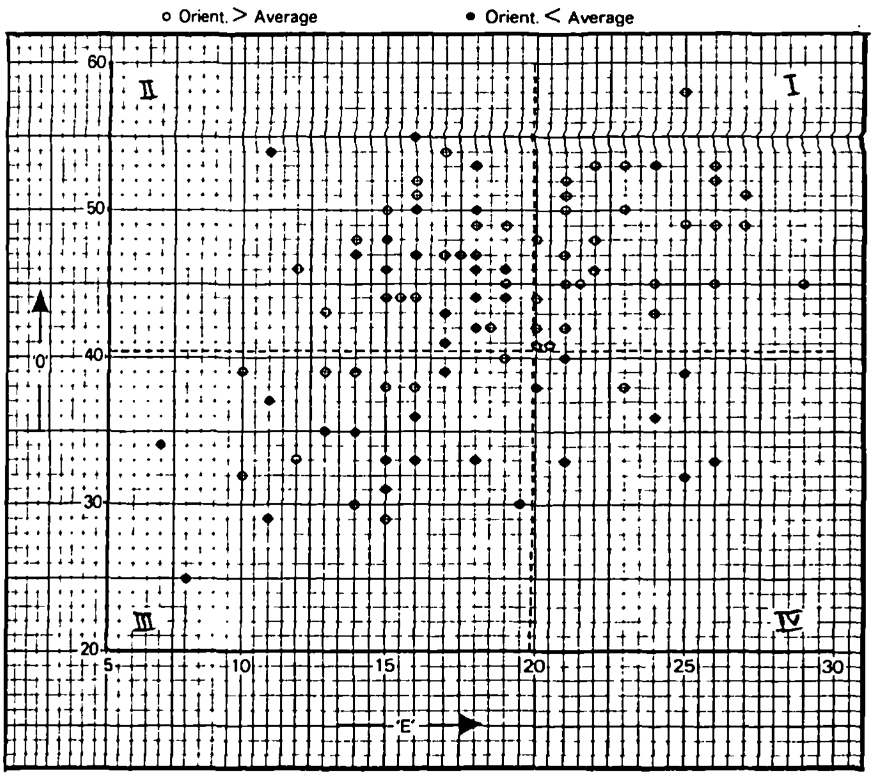
Nevertheless, in using a subjective scale of measure such as has been used in the present work to measure creative and skills performance, one cannot be sure that all individuals will follow the guidelines given for using a measure in an identical way. For example, it cannot be demonstrated that one person's '4' on the scale of measure means the same as every other person's '4'. Accordingly, it was felt desirable to supplement the analysis in the two previous sub-sections with an approach that made fewer demands on the data. Instead of treating the two measures, creative and skills performance, as separate independent entities, the difference between them was used as a single measure of the creative / skills orientation. This was equivalent to the device of substituting a research methodology based on a 'two independent sample t test' by one based on a 'paired sample t test'. Where such an approach is feasible, it is acknowledged that the statistical power of the test can be increased in that way. In the present case, the attraction was that with a difference measure, the same person supplied both subjective quantities and so the objection raised above about differing interpretations of the scale lost some of its force. Inevitably, there was a penalty to be paid for this gain, in that the individual measures were lost. It should also be noted that the correlation between creative and skills performance (r= .18) was non-significant, and so there were good grounds for treating the two measures as independent. Table 7.11 gives the 'orientation' measures for the four Types.

<u>Table 7.11 Creative / skills orientation and the four Types</u>

	LOW 'E'	HIGH 'E'
HIGH 'O'	TYPE II (n=33) Mean : -0.11 S.D. : 1.56	TYPE I (n=29) Mean : +1.22 S.D. : 1.11
LOW 'O'	TYPE III (n=23) Mean : -0.94 S.D. : 1.74	TYPE IV (n=8) Mean : -1.45 S.D. : 1.56

Testing for differences between the means of the four Types using analysis of variance indicated very highly significant differences (p< .001). The Scheffe procedure was employed to test for differences between pairs of means, and showed Type I scientists to be significantly different from Type II, Type III and Type IV. Types II and III and Types III and IV just failed to be significantly different. These results could be seen to corroborate the findings from the previous two sub-sections. A graphic illustration is given in Figure 7.3.

Figure 7.3 Creative / skills orientation and the four Types



The process of amalgamating the two individual performance measures in one 'orientation' measure enhanced differences between the four Types. As anticipated, Type I scientists were seen to be strongly orientated in the direction of creative performance, while Types III and IV were strongly orientated in the direction of skills performance. Type II scientists were very evenly balanced with respect to the two measures of research pereformance. What was obscured by the use of the orientation measure was the high level of performance of the Type II scientists on both measures. There will be further reference to this feature subsequently.

An opportunity was taken to reduce even further the demands made on the self assessment data. Although it is common to find reference in the behavioural literature to the use of parametric statistical methodology, such as analysis of variance, t tests and regression analysis, with variables which are measured on an ordinal scale, such analysis is not strictly valid. Thus with the present research it was felt to be desirable to take an opportunity to use a mode of analysis whose demands on the calibre of measurement involved could be more readily justified. By disregarding the magnitude of the difference between creative performance and skills performance, and simply recording the sign of the difference between the two measures, no assumption of interval scale measure was invoked at any stage. Using this approach, each researcher was placed into one of two categories, a '+' category indicating that creative performance exceeded skills performance, and a '-' category vice versa. Table 7.12 gives the resultant data.

Table 7.12 Creative / skills orientation and the four Types

Orientation	Type I	Type II	Type III	Type IV
'+' (Creative)	28	17	9	1
'-' (Skills)	1	16	14	7

The differences between the four Types in terms of creative / skills orientation were clearly evident. A non-parametric statistical test, chi-square, demonstrated that the differences were very highly significant statistically ($p < .001$).

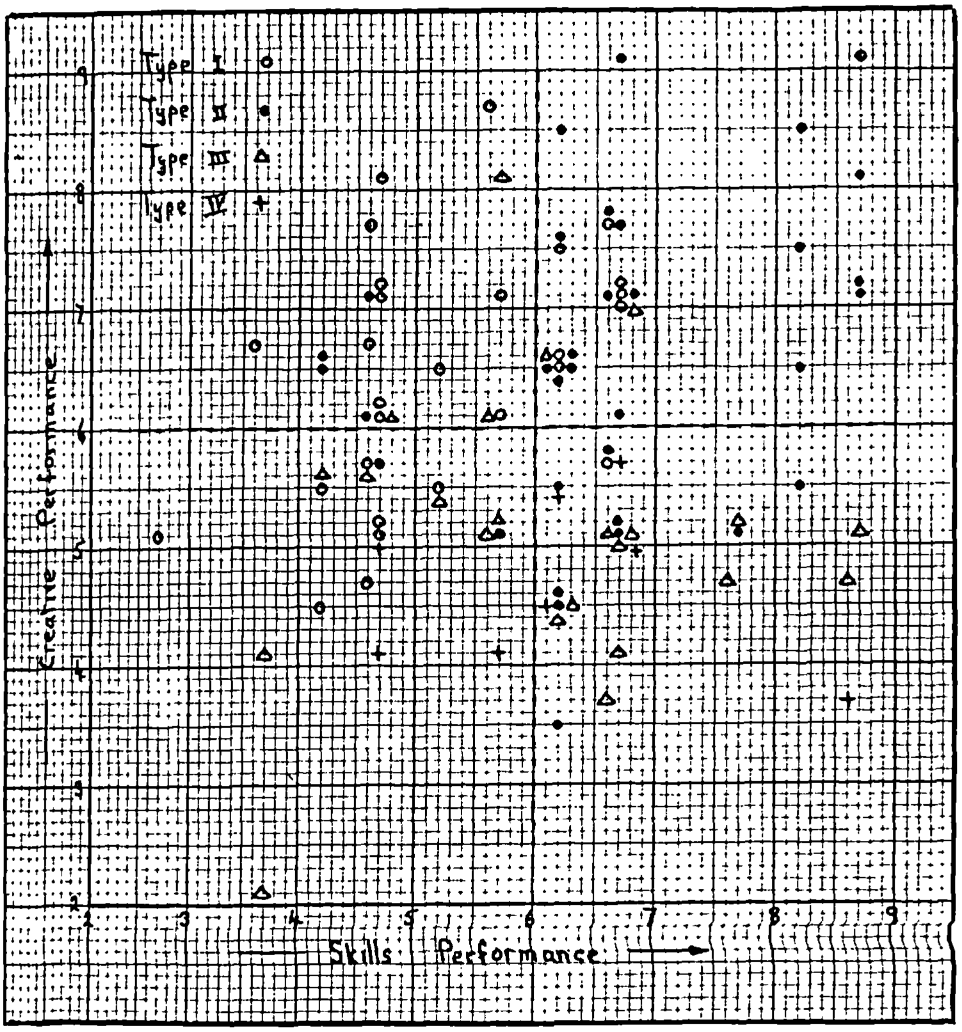
Notwithstanding the limited nature of the assessment of performance in the present research the cumulative evidence of the foregoing analyses suggested very strongly that A - I theory could provide a useful characterisation of research scientists. In particular, the analyses provided a powerful argument for using the separate sub-scales of KAI rather than their aggr egate.

Creative & skills performance as a basis of classification

The analysis earlier in this Chapter using the 'O' and 'E' KAI sub-scales as a basis of classification has demonstrated relationships between creative and skills performance and the four categories generated by the dichotomy of the two KAI variables. An alternative basis of classification using the creative and skills performance measures was also investigated. That is to say, the 93 respondents were located in the plane formed by axes representing creative and skills performance, instead of axes representing the 'O' and 'E' sub-scales. Since it had already been noted that the correlation between creative and skills performance was only 0.18 (non-significant), an even greater scatter of points in the plane could be expected. The scatter diagram is given in Figure 7.4. Each of the points in the plane is identified by its KAI Type, according to the classification developed earlier.

Boundary lines corresponding to the mean creative performance and the mean skills performance were used to divide the plane into four quadrants. The 93 points were found to be distributed as follows: 28, 19, 20, 26, reading anti-clockwise starting from the top right hand quadrant. Patterns in the spatial distribution of the four Types in the performance plane were not readily discerned from Figure 7.4. Hence, further scatter diagrams using the same

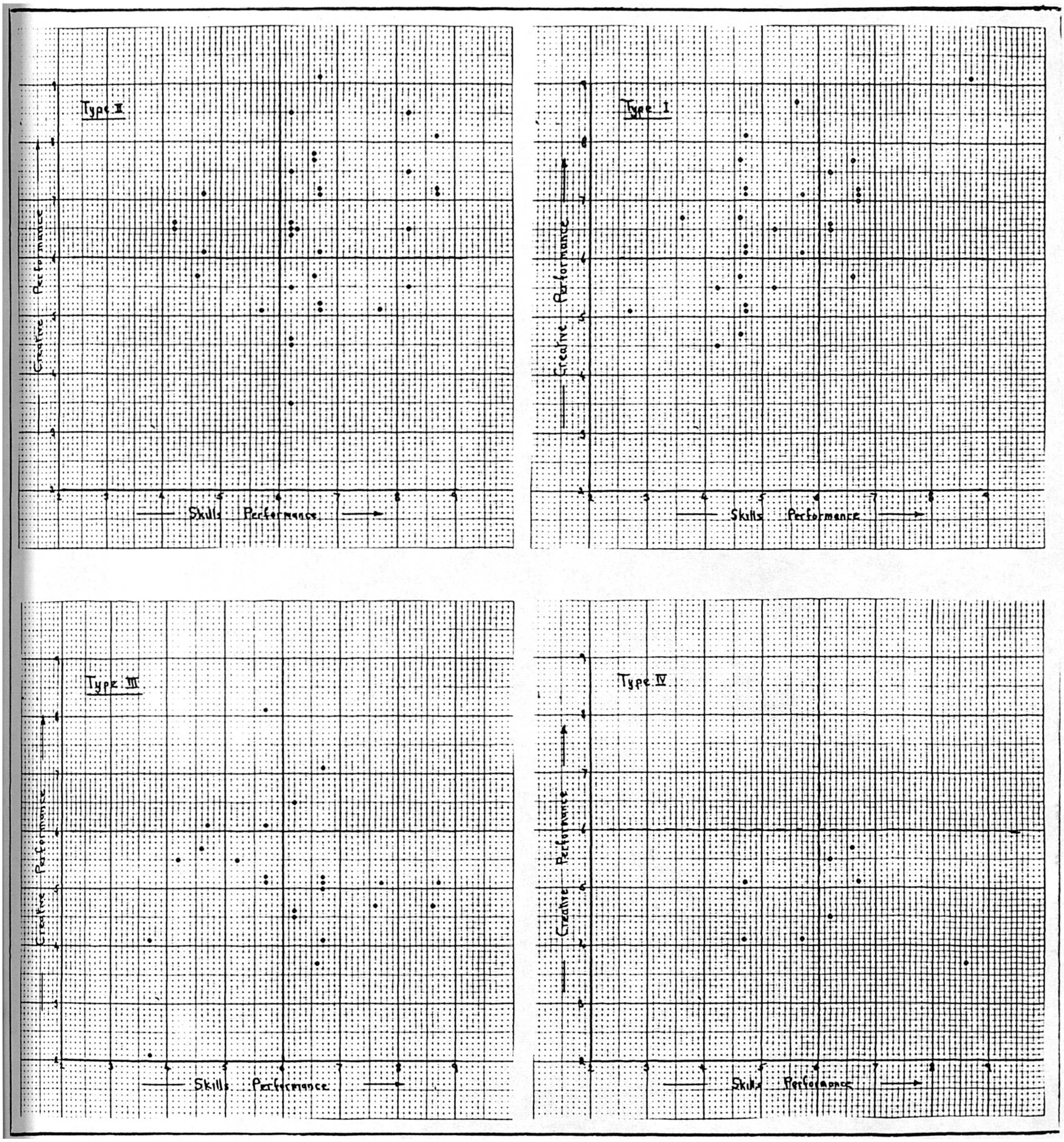
Figure 7.4 Scatter diagram based on creative & skills perf.



xes but taking each of the four Types separately were rawn. These are given in Figure 7.5.

he patterns became readily apparent. Type I scientists ere clustered fairly tightly towards the top left hand uadrant, ie they were high on creative performance, low on kills performance, as already identified in the earlier nalysis. Only one Type I scientist was found to be in the iametrically opposed quadrant. Type II scientists were

Figure 7.5 Scatter diagrams taking each Type separately



not quite so tightly clustered, but nevertheless they populated the top right hand quadrant in the main. That is to say, Type II scientists were in the high creative / high skills quadrant as would be expected from previous analysis. Only two Type II scientists were found in the diametrically opposed quadrant. Type III scientists were least well clustered, though as expected from previous analysis, they populated mainly the bottom right hand quadrant, i.e. low creative / high skills performance. Just three Type III scientists were found in the diametrically opposed quadrant. Type IV scientists were fairly tightly clustered but were rather evenly split between the two lower quadrants. Perhaps with a larger sample size a dominant quadrant might have been identified. It is noteworthy that no Type IV scientist was to be found in either of the upper quadrants.

This alternative mode of analysis was felt to be valuable even though the patterns proved to be closely in line with what was expected from the previous analysis using the 'O' and 'E' sub-scales as coordinates. What had not been readily apparent from the previous analysis was the tightness of the clustering. [However, values of standard deviations of the two performance measures in each of the four Types had given an indication of the degree of homogeneity within Types.] Clearly, Figure 7.5 reveals substantial overlapping between the four Types, particularly between Types III and IV and also between Types I and II. Nevertheless, considering the complexity of influences which have a bearing on research performance, the clustering is remarkable, and valuable support for the developing thesis of four cognitive Types of researcher.

7.3 JOB NEEDS AND OPPORTUNITIES AND THE FOUR TYPES

At the outset of this research it had been hoped to learn about motivations of research staff, and in particular how such motivations might be related to personality differences as identified by the Kirton A - I inventory. Aram and Morgan (1976) had been forced by their data to conclude that need satisfaction was not related to individual performance, except in the case of job conditions need satisfaction. [The four types of job needs used in the present study were modelled on the work of Aram and Morgan.] Their work was rather inconclusive. In finding difficulty in understanding their data, they noted that relations among the three variables they studied (communication, need satisfaction and individual performance) appeared to contain more complexity than was accomodated in their study. They suggested that there were influences by factors extraneous to their models. Aram and Morgan did not incorporate any measure of cognitive style in their work, and it was hoped that the present study would lead to a clearer understanding by its use of A - I theory. In the following Section, the data on job needs and opportunities for satisfying those needs is structured according to the four KAI Types already identified.

Job satisfaction index

Characterising the four Types by reference to the job satisfaction index gave the data in Table 7.13. In addition to the usual summary statistics, numbers of each Type which lay above and below the overall mean level are also given.

Table 7.13 Job satisfaction index and the four Types

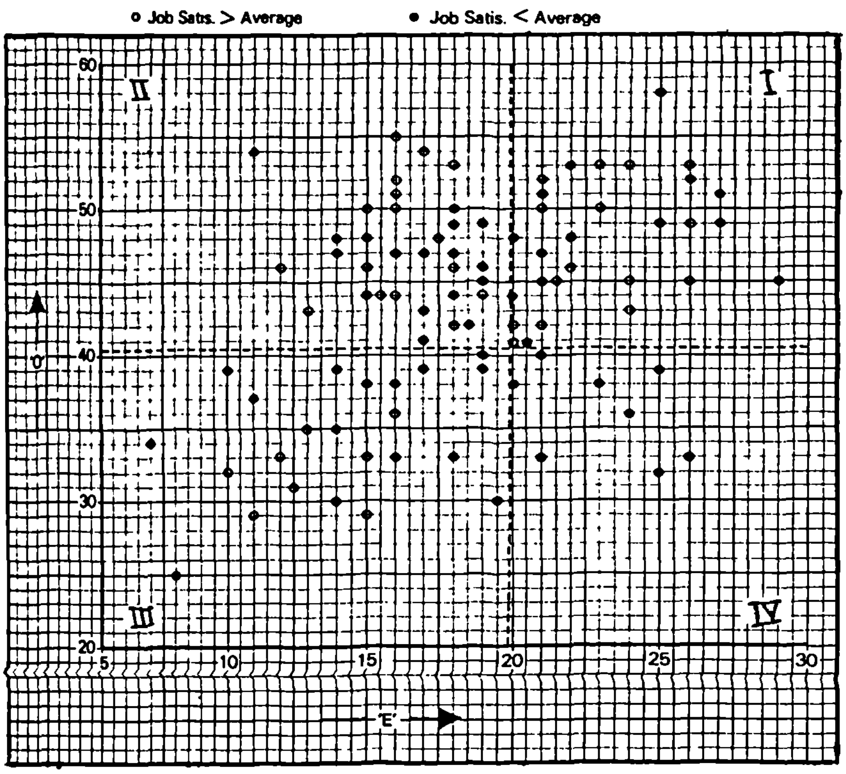
HIGH 'O'

TYPE II (n=33)	TYPE I (n=29)
Mean : 110.2	Mean : 107.8
S.D. : 14.8	S.D. : 19.6
Number > average : 17	Number > average : 18
Number < average : 16	Number < average : 11
LOW 'E'	HIGH 'E'
TYPE III (n=23)	TYPE IV (n=8)
Mean : 102.6	Mean : 95.0
S.D. : 13.0	S.D. : 7.0
Number > average : 10	Number > average : 0
Number < average : 13	Number < average : 8

LOW 'O'

Testing for differences between the mean levels of job satisfaction of the four Types, using analysis of variance, just failed to give a significant result ($F=2.61$, $p=.056$). However, when the numbers above and below average in each Type were subjected to a chi-square test (to compare the four Types on this basis) a statistically significant result was obtained (chi-square $= 10.0$, $p< .05$). It was clear that the significant difference lay in connection with Type IV scientists. This data is presented graphically in Figure 7.6.

Figure 7.6 Job satisfaction index and the four Types



Although a Scheffe test was bound to yield non-significant differences between all pairs of Types (since analysis of variance was just non-significant), a t-test comparing Types I and IV gave a significant difference ($p < .01$). Summing up the data in Table 7.13, it was concluded that there was no substantial evidence for differences in job satisfaction between Types I, II and III, but that Type IV scientists were lower in this respect. One other point which will be referred to subsequently was the remarkably high standard deviation of the Type I researchers.

An inter-firm comparison yielded interesting results, serving to strengthen the above conclusion. The data is given in Table 7.14. The figures in parentheses give the rank ordering of the four Types for each company separately.

Table 7.14 Job satisfaction: inter-firm comparison (means)

	LOW 'E'	HIGH 'E'
HIGH 'O'	TYPE II	TYPE I
Company A	110.2 (1)	106.0 (2)
B	104.8 (2)	103.9 (3)
C	111.6 (2)	116.0 (1)
LOW 'O'	TYPE III	TYPE IV
Company A	99.9 (3)	91.0 (4)
B	106.8 (1)	100.5 (4)
C	106.8 (3)	97.5 (4)

Clearly, there were differences between the three companies, but there was one common feature. In each company, Type IV scientists had the lowest mean level of job satisfaction. Moreover, as the low standard deviation in Table 7.13 shows, they were consistently low on job satisfaction as a group.

Summing up the evidence on job satisfaction, it seemed clear that the detailed probing of the present research had cast doubt on the conclusion of Keller and Holland (1978a) that job satisfaction was unrelated to KAI. Certainly, the present research had confirmed a non-significant zero order correlation coefficient (r= -.04, Table 5.6), but the identification, through a KAI taxonomy, of a Type with significantly lower job satisfaction was felt to be an important finding because of potential implications for the deployment of highly qualified scientific staff in research and development.

Importance of different job needs

Summary statistics for each of the four KAI Types are given for each of the four classes of job needs: professional, job conditions, status and self actualisation, in Tables 7.15 to 7.18.

Table 7.15 Importance of professional needs: the four Types

TYPE II (n=33) Mean : 11.4 S.D. : 2.1	TYPE I (n=29) Mean : 11.3 S.D. : 1.9
TYPE III (n=23) Mean : 10.9 S.D. : 1.6	TYPE IV (n=8) Mean : 10.5 S.D. : 2.4

Analysis of variance : F = 0.63, p= .60 (non-significant)

Table 7.16 Importance of job condition needs: four Types

TYPE II (n=33) Mean : 12.1 S.D. : 1.5	TYPE I (n=29) Mean : 11.9 S.D. : 1.5
TYPE III (n=23) Mean : 12.9 S.D. : 1.4	TYPE IV (n=8) Mean : 10.5 S.D. : 2.7

Analysis of variance : F = 4.7, p= .004 (highly signif.)

Table 7.17 Importance of status needs: the four Types

TYPE II (n=33) Mean : 10.6 S.D. : 2.5	TYPE I (n=29) Mean : 10.3 S.D. : 2.0
TYPE III (n=23) Mean : 9.8 S.D. : 2.2	TYPE IV (n=8) Mean : 10.5 S.D. : 2.3

Analysis of variance : F = 0.52, p= .67 (non-significant)

Table 7.18 Importance of self actualisation needs: by Types

TYPE II (n=33) Mean : 13.4 S.D. : 1.4	TYPE I (n=29) Mean : 13.2 S.D. : 1.2
TYPE III (n=23) Mean : 12.0 S.D. : 1.4	TYPE IV (n=8) Mean : 12.0 S.D. : 1.4

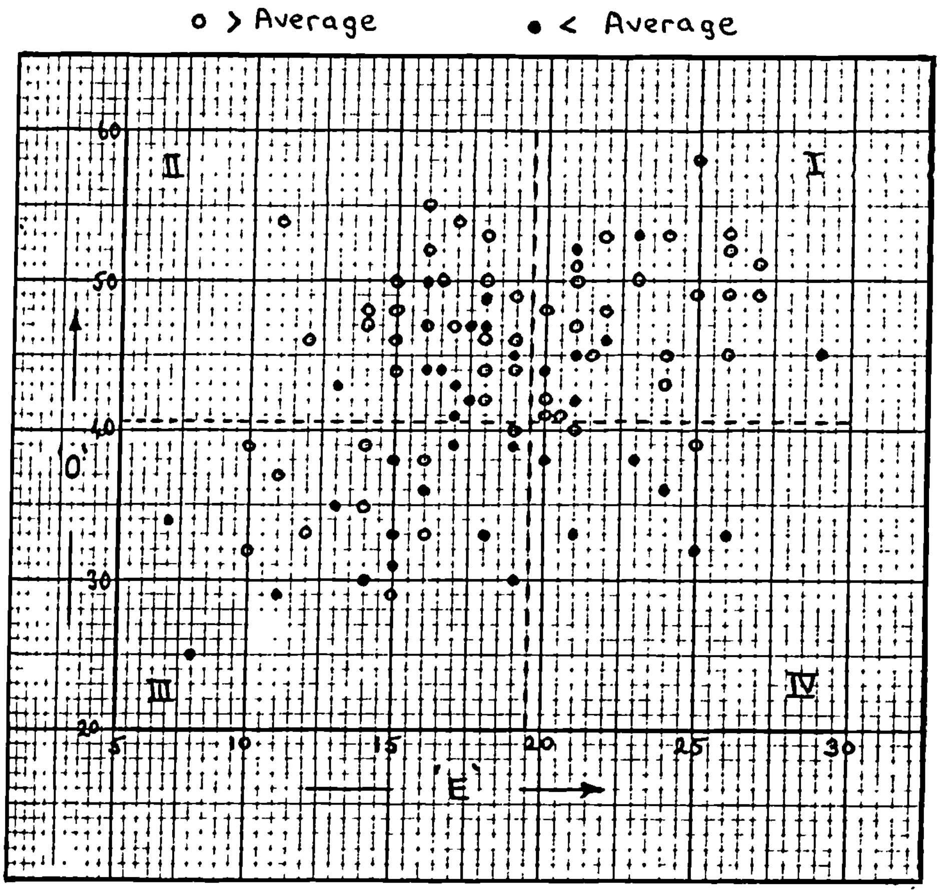
Analysis of variance : $F = 6.38$, $p < .001$ (v. highly sig.)

The above four Tables revealed several interesting features. With regard to professional needs and status needs, the data provided no evidence of any difference between the four Types. In terms of mean levels of importance, all four Types rated status needs [for example; to advance in *administrative status and authority; to* associate with top managers in the company] as their lowest priority, though with Type IV scientists there was little discrimination between any of the job needs. One could cite this data as evidence in support of the dual ladder system of promotion, in the sense that advanced company status is less highly regarded than other aspects of the job which are closely connected with the scientific content.

All but Type III scientists rated self actualisation needs as the highest priority, for example; to work on difficult and challenging problems; to learn new knowledge and skills; to have freedom to carry out one's own ideas. Moreover, all four Types were relatively homogeneous as groups with respect to self actualisation needs (S.D. varied from 1.2 to 1.4). A high priority regarding self actualisation needs could be anticipated for research scientists because the amount of routine work and the level of prescription is of necessity low in work which seeks to break new ground. To do well in such work would seem to require a person who is driven by high self actualisation needs. What is worthy of comment is the top priority accorded by Type III scientists to job conditions needs, for example; good salary; security of employment; congenial co-workers. The differences were statistically significant as demonstrated by the Scheffe procedure ($p < .01$) on self-actualisation needs, where Type III scientists were significantly lower than both Types I and II. A good measure of agreement was also found between the three company sub-samples. Type III scientists rated job conditions needs highest in Companies A and C, and second equal in Company B. It could be argued that the Adaptor's preference for a methodical and structured mode of working leads to a strong preference for a working environment which pays attention to job conditions. Hence the Type III scientist, strongly Adaptor orientated, is likely to place job conditions needs as a high priority. In contrast, the Innovator, and more particularly the person with a high score on the 'O' sub-scale, who compulsively toys with ideas and produces many which are extra-paradigmic, is likely to place most emphasis on freedom to indulge those predispositions, viz. self actualisation needs.

It was noted in Chapter Five (Table 5.7) that a strong, highly significant correlation existed between the 'O' Sub-scale and the importance of self actualisation needs r= .51). Figure 7.7 presents a graphic representation of the importance of self actualisation needs as distributed among the four Types.

Figure 7.7 Importance of self actualisation needs: 4 Types



Taking the third of the sample with highest 'O' sub-scale scores ('O' > 47), twenty five out of twenty nine 86%) were above average in terms of the importance self actualisation needs. Taking the third of the sample with the lowest 'O' sub-scale scores ('O' < 40), nineteen out of twenty nine (66%) were below average in terms of the importance of self actualisation needs. With hindsight, this finding may seem a fairly straightforward extension of A - I theory, but it has received no attention in the literature as far as the author is aware. Clearly the finding has implications for the deployment of scientific staff. Although it may be important to have teams which comprise both Adaptors and Innovators, as Kirton (1976) has emphasised, it is questionable whether those who are <u>very</u> low on the 'O' sub-scale, and thus do not rate self actualisation needs very highly, would be well placed in research (as opposed to development).

<u>Opportunities for satisfying job needs</u>

Summary statistics for each of the four KAI Types are given for each of the four classes of job needs; professional, job conditions, status and self actualisation in Tables 7.19 to 7.22.

Table 7.19 Opportunities re professional needs: four Types

TYPE II (n=33) Mean : 10.2 S.D. : 1.7	TYPE I (n=29) Mean : 10.0 S.D. : 2.4
TYPE III (n=23) Mean : 9.4 S.D. : 1.8	TYPE IV (n=8) Mean : 8.8 S.D. : 2.4

Analysis of variance : F = 1.49, p= .22 (non-significant)

Table 7.20 Opportunities re job condition needs: four Types

TYPE II (n=33) Mean : 11.5 S.D. : 1.5	TYPE I (n=29) Mean : 11.7 S.D. : 1.9
TYPE III (n=23) Mean : 11.5 S.D. : 1.7	TYPE IV (n=8) Mean : 10.3 S.D. : 2.1

Analysis of variance : F = 1.53, p= .21 (non-significant)

Table 7.21 Opportunities re status needs: the four Types

TYPE II (n=33) Mean : 8.8 S.D. : 2.5	TYPE I (n=29) Mean : 9.4 S.D. : 2.1
TYPE III (n=23) Mean : 7.9 S.D. : 2.0	TYPE IV (n=8) Mean : 7.8 S.D. : 1.8

Analysis of variance: F= 2.4, p= .07 (just non-significant)

Table 7.22 Opportunities re self actualisation needs: Types

TYPE II (n=33) Mean : 11.9 S.D. : 1.9	TYPE I (n=29) Mean : 11.1 S.D. : 2.5
TYPE III (n=23) Mean : 10.1 S.D. : 2.2	TYPE IV (n=8) Mean : 9.8 S.D. : 0.7

Analysis of variance : F = 4.3, p=.007 (highly significant)

With regard to opportunities for meeting professional and job conditions needs, the evidence of Tables 7.19 and 7.20 indicated that no differences existed between the four Types. However, the data regarding Type IV scientists is suggestive of lower levels, but with such a small sample size (n=8) statistical significance was not found and further comment is hardly justified. In the case of opportunities for meeting status needs, the evidence of Table 7.21, although not very strong, suggested that Type I scientists experienced most oppoertunity. In view of the fact that the Type I group contained the highest proportion of doctorates, this would not be a surprising conclusion.

It was with opportunities for meeting self actualisation needs that the data was most intriguing. Analysis of variance clearly indicated differences between Types, and the Scheffe procedure (p= .01) identified Types II and III as significantly different. Were it not for the considerable variation within the Type I group (S.D. = 2.5) Types I and II might also have yielded a statistically significant difference. It is interesting to speculate on these differences. It may be that graduates without a doctorate have less opportunity for personal initiative and hence for self actualisation. Since Types III and IV contain a lower proportion of doctorates than Types I and II, this would be a plausible explanation were it not that Type II scientists were highest in self actualisation yet Type I scientists had the highest proportion of doctorates. Furthermore, the Pearson correlation coefficient between level of qualifications and opportunities for self actualisation was very weak (r= .18), and not quite significant statistically. This hypothesis is not tenable, therefore. In fact all correlation coefficients between opportunities for self actualisation and 'personal' variables were non-significant.

The very considerable variation in self actualisation among Type I scientists (S.D.= 2.5), and to a lesser extent among Type III, also calls for comment, but it is difficult to offer an explanation. One clue may lie in the strong correlation found between opportunities for self actualisation and personal autonomy and responsibility r=.48) and also between self actualisation and the collaboration index (r=.45). Reference will subsequently be made to the high level of collaboration reported by Type II scientists, and the explanation of this observation which is afforded by A - I theory.

Since self actualisation needs ranked most importantly for three of the four Types (and second in importance for the remaining Type) it was felt to be important to try to understand reasons for variations in opportunities to meet those needs. It was at this point in the research that lack of personal contact with the respondents was felt most acutely. In the absence of interview data, the questionnaire data has been very closely analysed, but it was felt that inevitably some issues would remain unresolved by questionnaire data alone.

7.4 PERCEIVED ENVIRONMENT AND THE FOUR TYPES

It has already been noted that those aspects of the present research concerned with perceived organisation environment did not develop along the lines intended at the outset. Following in part earlier work, in particular the research by Osbaldeston et al. (1978) carried out in one company in the pharmaceutical industry, it had been intended to examine the perceived organisation environment within project teams and departments. As already explained, major difficulties in identifying respondents with project teams and departments restricted the way in which the perceived environment data could be used.

Nevertheless, it would have been wrong to dismiss the perceived environment data as of no account therefore. One issue in organisational climate research which was noted in Chapter Two, is the matter of consensus within groups. As Jabri (1986) quotes, many climate studies have been based on the assumption that consensus among team members was present, and that there existed only a small amount of variation around mean responses. In such studies simple aggregate measures have been used without due consideration of the issue of agreement within a group. Jabri (19 6) goes on to note that while high consensus is desirable from the point of aggregation, low consensus may be viewed as a pre-condition for categorising the respondents in terms of how and why they perceive various climate dimensions. Although the present data does not allow any measure of consensus within teams and departments to be obtained, it is in terms of categorising the respondents themselves that the data has been used.

In the limited range of perceived environment measures used in the present research, attention was focussed particularly on collaboration / communication measures because of the connection with KAI data that such variables could be expected to have on the basis of A - I theory. As noted in Chapter Two, A - I theory makes several predictions about collaboration between Adaptors and Innovators. Thus, although any aggregate measure of team environment was denied, the data offered the possibility of interesting analysis from the point of a validatory check on A - I theory.

Collaboration measures

Characterising the four Types by reference to the three collaboration measures; warm sympathetic integration (WSI), open authentic communication (OAC), and knowledge based risk taking (KBRT), gave the data in Tables 7.23, 7.24 and 7.25. Similar data regarding the aggregate measure, collaboration index, is given in Table 7.26.

Table 7.23 Warm sympathetic integration: the four Types

TYPE II (n=33) Mean : 16.4 S.D. : 1.9	TYPE I (n=29) Mean : 15.4 S.D. : 2.8
TYPE III (n=23) Mean : 15.6 S.D. : 2.6	TYPE IV (n=8) Mean : 14.3 S.D. : 2.3

Analysis of variance : F = 2.12, p= .10 (non-significant)

Table 7.24 Open authentic communication: the four Types

TYPE II (n=33) Mean : 16.5 S.D. : 1.8	TYPE I (n=29) Mean : 15.1 S.D. : 2.7
TYPE III (n=23) Mean : 15.3 S.D. : 2.2	TYPE IV (n=8) Mean : 13.0 S.D. : 1.5

Analysis of variance : F = 5.93, p= .001 (v. highly sig.)

Table 7.25 Knowledge based risk taking: the four Types

TYPE II (n=33)	TYPE I (n=29)
Mean : 15.6 S.D. : 1.6	Mean : 13.3 S.D. : 2.2
TYPE III (n=23)	TYPE IV (n=8)
Mean : 13.3 S.D. : 2.1	Mean : 12.6 S.D. : 2.1

Analysis of variance : F = 10.46, p< .001 (v. highly sig.)

Table 7.26 Collaboration index : the four Types

TYPE II (n=33)	TYPE I (n=29)
Mean : 48.5 S.D. : 4.2	Mean : 43.8 S.D. : 6.1
TYPE III (n=23)	TYPE IV (n=8)
Mean : 44.3 S.D. : 5.6	Mean : 39.9 S.D. : 3.0

Analysis of variance : F = 8.30, p< .001 (v. highly sig.)

The similarity of patterns shown by the three separate collaboration measures was felt to be remarkable, as was the strength of the patterns. Although differences between the four Types were non-significant statistically in the case of Warm sympathetic integration (WSI), the pattern of differences matched those found with the remaining measures. Applying the Scheffe procedure (p=.01) to identify differing pairs of Types, Type II scientists were different in terms of the mean level from Types I, III and IV, except in the case of WSI.

It was very easy to understand, from the above Tables, why no correlation was found between the collaboration measures and the total KAI score(Table 5.11), when A - I theory would lead one to expect an association. Not only did the scientists at the opposite poles of the KAI continuum (Type I and Type III) perceive a similar level of collaboration, but also Types II and IV, lying near the middle of the continuum, perceived very different levels of collaboration. A plot of collaboration index against total KAI score, shown in Figure 7.8, gives a very good example of a random scatter diagram. One wonders, skeptically, about the absence in the literature after ten years of KAI research, of data to test the prominent A - I hypotheses concerning collaboration. Might data such as that in Figure 7.8 have inhibited publication! In contrast, when the analysis developed in this thesis is applied, the diagram shown in Figure 7.9 results.

Figure 7.8 Collaboration index and KAI score

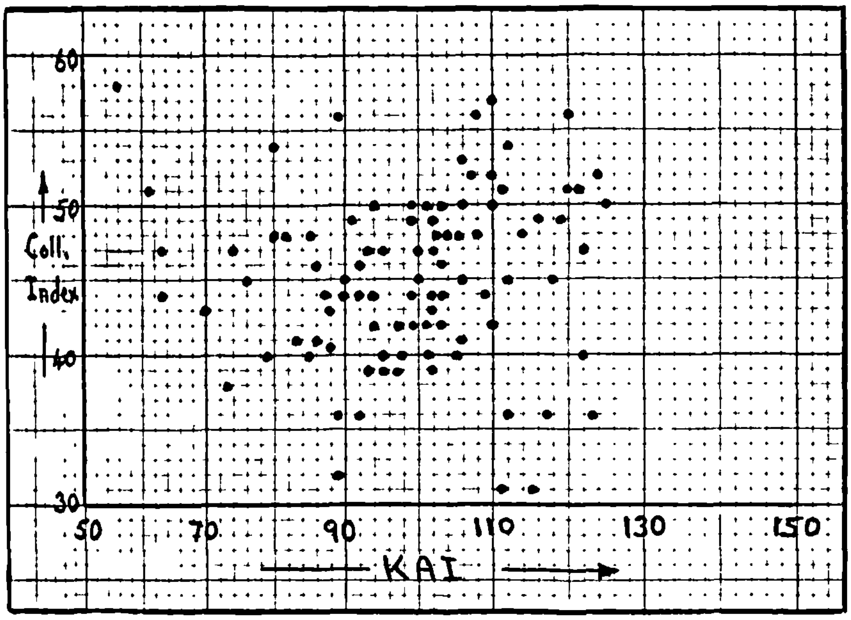
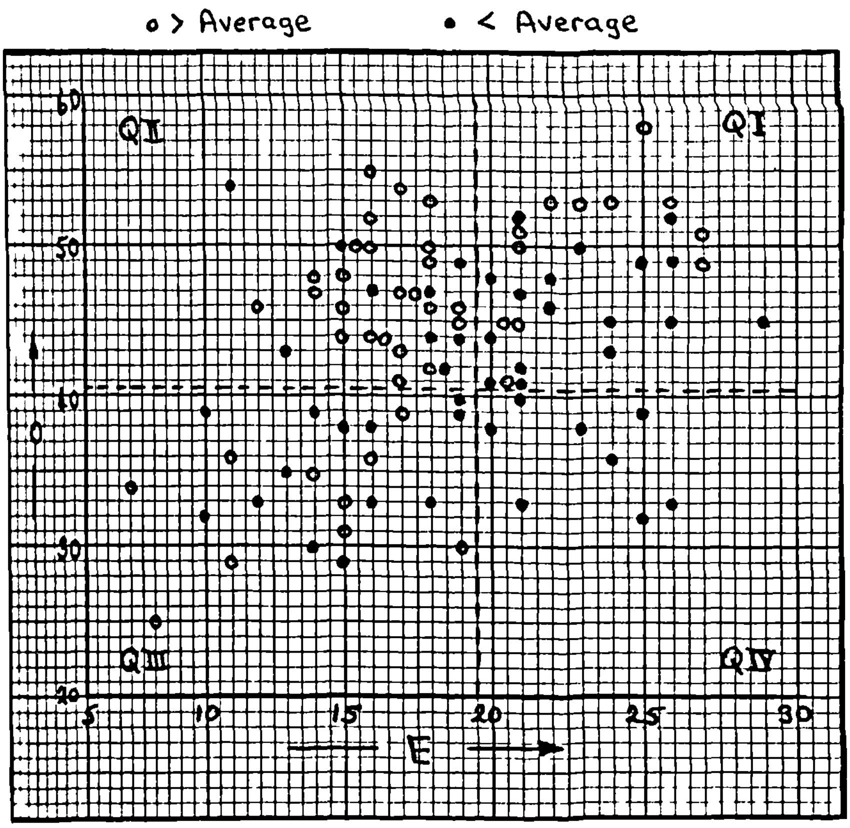


Figure 7.9 Collaboration index and the four Types



The concentration of low perceived collaboration in the right and lower right of the diagram in Figure 7.9 is very notable, as is the complementary concentration of high perceived collaboration in the top left of the diagram.

It should be stressed, however, that the collaboration measures were concerned with perceived collaboration <u>within the team</u>. Thus the way in which the data has been used is not as it was originally intended. As noted earlier, it was felt that a major determinant of a person's perceived team collaboration would be the extent of collaboration which he/she experienced personally. Hence the data has been used as an indirect measure of the collaboration experienced on a personal basis.

Differences between the three separate collaboration measures were also of interest. The WSI factor was concerned with supportive problem solving, the items in the questionnaire being related to the extent to which the efforts of team members were integrated in seeking the best alternatives to task-related problems. The OAC factor was more directly concerned with communication. The questionnaire items related to the extent to which team members kept each other informed and acted as consultants to each other. The KBRT factor was concerned with the use of expertise, seeking to measure the amount of freedom in expressing ideas, the extent to which technical competence over-rides official rank. It is not clear why there should be a marked difference between the three separate measures in terms of the strength of differentiation among the four Types, particularly between WSI and KBRT. Why should KBRT achieve a much stronger differentiation among the four Types? It is notable that Aram and Morgan (1976), who developed the three collaboration measures, referred only to KBRT when discussing their data, and one could presume that this collaboration factor alone gave statistically significant associations. It is also noteworthy that the organisational descriptions contained in the questionnaire items relating to the KBRT factor resemble the descriptions given by Burns and Stalker (1964) of what they termed an organismic organisation. Burns and Stalker had coined that expression to describe R & D organisations which they had found to be effective. A high KBRT score should be characteristic of an organismic organisation. (This is not an observation made by Aram and Morgan.)

As in previous analyses, it was felt to be desirable to make inter-firm comparisons, and these are given in Tables 7.27 to 7.30.

Table 7.27 WSI : inter-firm comparisons (means)

TYPE II			TYPE I		
Company A	16.7	(n=13)	Company A	15.1	(n=14)
B	15.0	(n=4)	B	14.9	(n=8)
C	16.6	(n=16)	C	16.6	(n=7)
TYPE III			**TYPE IV**		
Company A	15.6	(n=14)	Company A	15.7	(n=4)
B	16.5	(n=4)	B	13.0	(n=2)
C	14.8	(n=5)	C	12.5	(n=2)

Similarities between companies were not very great, and so Table 7.27 did not afford a demonstration of the trans-company applicability of the analysis. Differences between the four Types were non-significant in all three companies, though only just so (p= .06) in the case of Company A.

Table 7.28 OAC : inter-firm comparisons (means)

TYPE II			TYPE I		
Company A	16.4	(n=13)	Company A	15.1	(n=14)
B	16.3	(n=4)	B	14.8	(n=8)
C	16.6	(n=16)	C	15.4	(n=7)
TYPE III			**TYPE IV**		
Company A	15.1	(n=14)	Company A	13.3	(n=4)
B	16.5	(n=4)	B	13.5	(n=2)
C	15.2	(n=5)	C	12.0	(n=2)

The similarities between companies were much more convincing in this case. Analysis of variance indicated statistically significant differences between Types in the case of Company A (p= .02) and Company C (p= .05). In view of the very small sample sizes involved in some sub-groups, the predominant pattern of: Type II - high score; Types I and III - medium score; Type IV - low score; was most remarkable.

Table 7.29 KBRT : inter-firm comparison (means)

TYPE II			TYPE I		
Company A	15.2	(n=13)	Company A	13.1	(n=14)
B	14.3	(n=4)	B	13.6	(n=8)
C	16.3	(n=16)	C	13.4	(n=7)
TYPE III			**TYPE IV**		
Company A	12.9	(n=14)	Company A	12.3	(n=4)
B	14.5	(n=4)	B	14.5	(n=2)
C	13.6	(n=5)	C	11.5	(n=2)

Table 7.30 Collaboration index: inter-firm comp. (means)

TYPE II			TYPE I		
Company A	48.2	(n=13)	Company A	43.4	(n=14)
B	45.5	(n=4)	B	43.3	(n=8)
C	49.5	(n=16)	C	45.4	(n=7)
TYPE III			**TYPE IV**		
Company A	43.6	(n=14)	Company A	41.3	(n=4)
B	47.5	(n=4)	B	41.0	(n=2)
C	43.6	(n=5)	C	36.0	(n=2)

Apart from Company B, where sample sizes were extremely small, the same predominant pattern was found with KBRT and Collaboration index as with OAC. In the case of KBRT, analysis of variance indicated significant differences between Types in Company A ($p = .03$) and Company C ($p < .001$). In the case of Collaboration index, analysis of variance again indicated significant differences between Types in Company A ($p = .02$) and Company C ($p = .002$). With Company B, where the predominant pattern was not found, it was Types II and III which were out of step with those Types in Companies A and C. The large sampling error associated with the very small sub-samples involved provides a plausible explanation of the discrepancy. The possibility that the different age structure of Company B might account for the difference was also considered, but no firm hypothesis is offered. In conclusion, the discrepancy was regarded as a minor one in the context of so much data which formed a coherent pattern.

The overall effect of the analysis summarised in Tables 7.23 to 7.30 was to give strong support to the concept of four cognitive Types of research scientist. More particularly, the analysis further underlined the value in treating the KAI inventory as a source of three scales of measure, at least in the context of scientific research. At the same time, however, the analysis has provided strong, yet novel, support for one of the central theses of A - I theory, that KAI offers insights regarding inter-personal collaboration.

It should be stressed that the present data and analysis does rather more than provide support for the concepts of collaboration in A - I theory which have hitherto been based on somewhat anecdotal evidence (Kirton, 1984b). Kirton has already identified the possibility that while extreme Innovators and extreme Adaptors could be expected to experience problems of collaboration, those people with somewhat mid-range scores might be able to take on the role of an intermediary. He had coined the word 'Bridgers' to descibe the role, though as far as the author is aware no hard data has been adduced. The present research suggests that a mid-range KAI score can be advantageous, and the evidence of Tables 7.25 and 7.26 in particular provide support for the idea that Type II scientists might be regarded as Bridgers. What has been utterly unforeseen, however, in all the literature on A - I theory as far as the author is aware, is the recognition that people with a mid-range KAI score might be far from homogeneous in creative style, the very cognitive element that KAI seeks to measure. This paradoxical conclusion stems from the substantial difference to be found between the 'O' and 'E' sub-scale measures.

In a research scientist, a priori reasoning based on the nature of research identifies both a high 'O' trait compulsively toys with ideas) and low 'E' trait meticulous) as advantageous. Similar a priori reasoning suggests that both a low 'O' trait and a high 'E' trait are unhelpful. Two very different combinations of 'O' and 'E' sub-scale scores can thus lead to KAI scores which are mid-range. These two combinations are manifest in the groups which have been dubbed Type II and Type IV in the present research. As far as the author is aware, this distinction has not hitherto been identified. It is an important strand of the present thesis that this distinction is a valuable one in the context of research management.

In conclusion, a word of counterpoint is perhaps desirable. It could be argued that the KAI inventory does indeed tap meaningful aspects of cognitive style and that several Types can be identified. However, such differences in cognitive style might be associated with differences in expectation and perception of organisational characteristics such as collaboration. Accordingly, it could be argued that differences will be perceived where none exist. Such a view, while tenable, is likely to be neither verifiable nor refutable using the sort of questionnaire data available in the present research. Furthermore, such a view and the one developed in this Chapter are not mutually exclusive.

Management style measures

As with the collaboration measures, it had been hoped to collate perceptions of management style within project teams. Since this proved to be impossible, as already explained, it remained to examine perceptions of management style within groups comprising the four Types of researcher already identified in the previous taxonomy. The management style measures were: personal autonomy and responsibility (PAR); work pressure (WP); and quality of leadership (QL). A summary of the analysis for PAR is given in Table 7.31.

Table 7.31 PAR : the four Types

TYPE II (n=33) Mean : 16.0 S.D. : 2.9	TYPE I (n=29) Mean : 14.6 S.D. : 3.2
TYPE III (n=23) Mean : 15.7 S.D. : 1.9	TYPE IV (n=8) Mean : 14.6 S.D. : 1.9

Analysis of variance indicated that differences between means were not significant statistically (p= .20), so it would be unwise to read much into any apparent pattern. In as much as one is justified in using the word 'pattern' in the face of non-significant differences, the pattern was different to that found in connection with collaboration measures. There appeared to be a tendency for those low on the 'E' sub-scale (high Weberian efficiency) to perceive greater personal autonomy and responsibility. Perhaps the tendency to more readily accept bureaucratic constraints, which could be inferred from a low 'E' score, could explain the greater perceived personal autonomy and responsibility. An inter-firm comparison, given in Table 7.32, is suggestive of similar patterns in Companies A and C. Company B once again stands out, not only in terms of a different pattern, but also in the general level of the mean responses. However, in all three companies, analysis of variance indicated that differences between means were non-significant statistically.

Table 7.32 PAR : inter-firm comparisons (means)

TYPE II			TYPE I		
Company A	16.1	(n=13)	Company A	15.1	(n=14)
B	13.3	(n= 4)	B	13.3	(n=8)
C	16.5	(n=16)	C	15.3	(n=7)
TYPE III			**TYPE IV**		
Company A	15.6	(n=14)	Company A	15.0	(n=4)
B	15.5	(n=4)	B	13.0	(n=2)
C	16.2	(n=5)	C	15.5	(n=2)

No strong indications about likely differences in PAR between Types had been available from A - I theory. However it had been supposed that Type I scientists (all-out ideas people) might feel more constrained by management controls, having less freedom to follow up ideas than they would wish to have. Accordingly, they might perceive lower personal autonomy and responsibility. Type I scientists were indeed as low as any group on PAR. The large standard deviation in the case of Type I researchers (Table 7.31) signifies much variation which is not readily explained.

A similar analysis in connection with perceived work pressure is given in Tables 7.33 and 7.34.

Table 7.33 Perceived work pressure and the four Types

TYPE II (n=33) Mean : 15.1 S.D. : 1.9	TYPE I (n=29) Mean : 14.5 S.D. : 2.0
TYPE III (n=23) Mean : 14.0 S.D. : 2.0	TYPE IV (n=8) Mean : 14.8 S.D. : 1.7

Analysis of variance to test for differences between means gave non-significant results taking each company separately and taking the aggregate sample. The probabilities were far from significant, and it was concluded that there was no evidence of any difference between Types with respect to perceived work pressure. Indeed, non had been expected.

Table 7.34 WP : inter-firm comparisons (means)

TYPE II			TYPE I		
Company A :	14.9	(n=13)	Company A :	15.0	(n=14)
B :	15.7	(n=4)	B :	14.0	(n=8)
C :	15.1	(n=16)	C :	14.0	(n=7)
TYPE III			**TYPE IV**		
Company A :	14.0	(n=14)	Company A :	14.5	(n=4)
B :	15.3	(n=4)	B :	14.5	(n=2)
C :	13.2	(n=5)	C :	15.5	(n=2)

A similar analysis in connection with perceived quality of leadership is given in Tables 7.35 and 7.36.

Table 7.35 Quality of leadership and the four Types

TYPE II (n=33)		TYPE I (n=29)	
Mean :	15.9	Mean :	14.9
S.D. :	2.6	S.D. :	3.1
TYPE III (n=23)		**TYPE IV (n=8)**	
Mean :	15.9	Mean :	15.0
S.D. :	1.7	S.D. :	3.2

Table 7.36 Quality of leadership: interfirm comp. (means)

TYPE II			TYPE I		
Company A	16.3	(n=13)	Company A	15.1	(n=14)
B	15.5	(n=4)	B	13.5	(n=8)
C	15.7	(n=16)	C	15.9	(n=7)
TYPE III			**TYPE IV**		
Company A	15.7	(n=14)	Company A	14.5	(n=4)
B	16.7	(n=4)	B	14.0	(n=2)
C	15.8	(n=5)	C	17.0	(n=2)

As in the case of perceived work pressure, analysis of variance to test for differences between means gave non-significant results, taking each company separately and taking the aggregate sample. The probabilities were far from significant in all cases. It would be unwise, therefore, to comment on any observed differences. No pronounced differences had been expected on the basis of A - I theory. However, the possibility that Type I staff might perceive lower personal autonomy and responsibility, and that this might be reflected in their view of leadership, had been borne in mind.

7.5 CONCLUDING REVIEW

The associations with KAI and its sub-scales, described in Chapter Five, led to the taxonomy of research scientists developed in Chapter Six. With this taxonomy of four Types as the basis, Chapter Seven has characterised the four Types of researchers in terms of a range of personal and work related measures. Particular attention has been paid to the use of inter-firm comparisons to test the extent to which it was possible to generalise the characterisations.

Each company contained roughly similar proportions of the four Types, any differences being non-significant statistically. From the present data it was estimated that the population of research scientists consists of about one third of each of Type I and Type II, one quarter of Type III, and the remainder, about nine percent, of Type IV. There was no evidence of differences between the sexes in this respect, and each Type had a similar age profile. The Type I group contained a higher proportion of doctorates, however, and there was an indication that Type I scientists had a career based predominantly at the research end of the R - D spectrum, Type IV being based more towards the other end. Although the association found was not quite significant statistically, it was interesting to speculate on the direction of causality, given that such an association were to be substantiated.

Particular attention was paid to performance measures of the four Types, marked differences being observed. Type I scientists were strong on creative performance but low on skills performance; Type III were complementary to Type I, being low on creative performance but strong on skills; while Type II were strong on both performance criteria. Type IV were not clearly distinct from Type III, though very slightly lower on creative performance. Since the nature of performance assessment in the present research was more restricted than had been hoped for (only self-assessment was ultimately available), the performance data was analysed in several ways to progressively reduce assumptions made about the calibre of measurement involved. In all the analyses, a strong distinction between Types I, II, and III remained. Type I can confidently be regarded as orientated towards creative performance, Type III as orientated towards skills performance, with Type II as a hybrid group seeming to possess both abilities in high measure.

In terms of job satisfaction, Types I, II, and III were not clearly differentiated, though Type II scientists as a group had the highest or second highest level of job satisfaction in all three companies. What was most notable, was the low level of job satisfaction of Type IV scientists who recorded the lowest level, as a group, in all three companies. Without doubt, this finding has important implications for research managers. The point attracted attention when research findings were presented to senior managers in the host organisations. In terms of different job needs, all four Types showed similarities concerning the low rating accorded to status needs, and one could regard this as support for the concept of a dual ladder reward system for research staff. Regarding the importance of self actualisation needs, there were differences, Types I and II recording significantly higher ratings than the other two Types. Type III staff were notable for their high rating of job condition needs. Concerning opportunities for meeting job needs, the main differences lay in connection with self actualisation needs. Type II researchers recorded the highest level, followed by Type I, with Types III and IV considerably lower. Type IV scientists recorded the lowest levels of opportunities for meeting all four types of job needs. It is unfortunate that this research cannot make more progress in understanding these differences, and the lack of personal contact with the respondents was most acutely felt at this point.

Perceived environment data related to collaboration within project teams revealed remarkable differences between Types. On the basis that this data indirectly measured the collaboration perceived by individuals, the differences provided a test of one of the postulates of A - I theory.

Type II scientists recorded the highest mean level, followed by Types I and III at similar levels, followed by Type IV at the lowest level. With only minor irregularities this pattern was found across the three companies. The association between KAI Type and collaboration was particularly notable in view of the absence of a correlation between an individual's KAI score and their collaboration index; a further example of the insight to be gained by using the separate KAI sub-scales. The high level of collaboration reported by Type II scientists suggests that these staff might be regarded as the Bridgers that Kirton (1984b) had suggested could be found among those with a mid-range KAI score. The present taxonomy is notable in particular for its ability to distinguish between Type II and Type IV staff, both roughly mid-range as far as KAI is concerned, but very different in terms of collaboration, and in many other criteria examined in the present research.

Reference was made in Chapter One to a recent paper by Davies (1985) in which he described two types of scientist, 'Dinosaurs and Dynamos'. Davies depicted the Dinosaurs as robust and reliable, scientists of the sort that make things work, attend to issues such as quality and efficiency, and do well in pushing ahead incrementally. His description matches well the Type III scientists characterised earlier in this Chapter. Dynanos were depicted by Davies as the ideas people, impatient of professionalism, respecters neither of disciplinary boundaries nor of many other things that have been necessary to create the equipment they use. They correspond to the Type I scientists of this thesis. A central idea of Davies's paper was that both are necessary. An organisation needs the steady dedicated people who rationalise and consolidate the idiosyncratic and disorderly approach of the ideas people. Davies referred, on the basis of his long e periemce in managing R & D, to the tensions between Dinosaurs and Dynamos, a reflection of the problems of collaboration postulated in A - I theory.

If Type I scientists are the Dynamos and Type III scientists are the Dinosaurs of Davies's schema, where do Types II and IV fit into his conception? Davies did refer to a hybrid group 'who are equally capable of the disorderly discipline crashing of the Dynamos and the orderly hedge cultivation of the Dinosaur'. He did not coin a name for them, but his description fits the characteristics of Type II scientists in this thesis. It would seem that it is just the ten percent or so of research scientists that this thesis labels Type IV that find no mention in Davies's schema. One can presume that Davies, in his long experience of R & D, would have encountered such people. One might also presume that, having encountered and identified them, steps were taken to relocate them outside R & D. One of the valuable outcomes of the present research may be a means to identify Type IV scientists before they find their way into R & D units. As the data on job satisfaction earlier in this Chapter suggests, they need to be identified for their own good as well as for the good of their organisation. They might well be cognitively well equipped to perform a useful role in other areas of an organisation's activities, in a technical sales capacity, for example.

Implicit in the four-way classification developed in this chapter, was the notion that the four Types could properly be described as 'cognitive types', in the sense of a charcterisation based purely on cognitive style. Indeed, such a view followed from the literature on the use of the KAI, as reviewed in Chapter Two. It will be shown later in this thesis that there is serious doubt about the status of the 'O' sub-scale, particularly, that it is more a measure of cognitive ability than cognitive style. This does not undermine the basis of the classification developed in the present chapter, nor its usefulness. However, as will be discussd subsequently, it does raise the question of revising the KAI inventory to clarify its conceptual status.

CHAPTER 8 FURTHER EMPIRICAL DATA

8.1 SOME CONCERNS ABOUT THE DANISH SAMPLE

The late arrival of a fourth sample (n=26) of questionnaire data from a Danish pharmaceutical company has already been referred to. By the time this additional empirical material was available, analytical work on the British data (n=93) and the thesis stemming from that analysis were at an advanced stage. Because of the small size of the new sample, particularly in relation to expectations on our part and on the part of the management concerned, there were doubts as to how well it represented the R & D unit as a whole. As will be seen shortly, this latest sample was another sample with a dearth of young scientists.

Although we did not at any time personally meet the senior management of this Company (apart from a brief discussion between the writer and one senior manager at a R & D Conference in Manchester in July 1984) it is probably true t say that of the four companies, it was in the Danish one that management was most enthusiastic in collaborating with us. The very small sample was surprising as well as disappointing to both the management and ourselves. The person liaising with us expressed the view that staff were frightened" about participating in the study. Although we addressed a note to company staff stressing confidentiality, it may be that many staff had concerns regarding the intentions of their management in permitting a d encouraging the study, if not initiating it. While the sample contained a dearth of young scientists, it contained several senior staff, including the Vice President for Research and Development.

There had been a further concern regarding the reliability of this data from the outset, owing to the fact that the questionnaire was not written in the native language of the respondents. This issue had been discussed at the planning stage but the person liaising with us had felt that English was sufficiently well understood in Denmark for a translation to be unnecessary. Nevertheless, the possibility remained that some phrases might be mistranslated by some respondents, thus leading to erroneous data. One difference between the British and Danish questionnaire returns lay in the amount of omissions. In the British data, omissions were virtually on-existent; in the Danish data, although far from numerous, they did occasionally reduce the effective sample size. One can only speculate on the reason for what appears to be a random omission, but it might be uncertainty in understanding the meaning of a question expressed in a foreign language. Taken together, these concerns led to the conclusion that the Danish data should be excluded from the initial development of the thesis.

In the present chapter, characteristics of the Danish sample will be reviewed in comparison with the British samples. Although concerns about compatibility between the two sets of data cannot be entirely dispelled, there is no evidence to strongly deny the validity of merging the data sets, and so the principal features of the characterisation developed in Chapter Seven are tested in relation to the augmented sample, n=119.

8.2 COMPARISON OF DANISH AND BRITISH SAMPLES

Personal data

Table 8.1 shows age profiles of the two samples, from which can be seen the dearth of young scientists in the Danish sample.

Table 8.1 Age profiles of the British and Danish groups

Age group	<25	25-29	30-34	35-39	40-44	>=45
British sample	10	23	19	19	8	14
Danish sample	0	1	6	8	6	5
Total sample	10	24	25	27	14	19

The differences in age profiles are statistically significant (chi-square, $p < .05$). Nevertheless, it should be recalled that significant differences were found within the three British company samples (Table 4.1). The Danish sample is similar in age profile to Company B (mean ages are 39 years and 40 years, respectively).

Table 8.2 shows the distribution according to sex.

Table 8.2 Sex of respondents

	Male	Female	Totals
British sample	71 (76%)	22 (24%)	93
Danish sample	17 (65%)	9 (35%)	26
Total sample	88 (74%)	31 (26%)	119

Differences in the ratio of the sexes are not significant statistically, though significant differences were found between the three British samples (Table 4.3). The Danish sample resembles the Company A sample in terms of the sex ratio, though not in terms of the age profile.

Table 8.3 shows the distribution between research and evelopment work in the careers of the respondents. Although a bias towards research is evident in the case of the Danish sample, it is much less strong than the research bias found in the British sample. Whereas differences between the three British firms were non-significant in this respect (Table 4.4), the differences in Table 8.3 are significant (chi-square, $p < .05$). The difference may reflect a difference in the mix of work between the Danish and British companies, but this point cannot be checked.

Table 8.3 R/D profiles of the British and Danish groups

	All Res.		About equal		All Dev.
British sample	48	22	13	9	1
Danish sample	6	8	9	3	0
Total sample	54	30	22	12	1

Table 8.4 shows the profiles of the two groups regarding the level of qualifications. Following the experience of the British sample where almost all of the respondents were graduate staff, it had been agreed that the Danish sample should be restricted to graduate staff.

Table 8.4 Level of qualifications

	First degree	Masters	Doctorate
British sample	37	8	48 (52%)
Danish sample	4	15	7 (27%)
Total sample	41	23	55 (46%)

The differences are highly significant statistically chi-square, $p < .001$) and presumably reflect different educational traditions in Denmark. No differences between the sexes in level of qualifications were found in the Danish sample.

KAI data

Data on total KAI scores and the separate sub-scales are given in Table 8.5.

Table 8.5 KAI data for the British and Danish groups

	British (n=93)		Danish (n=26)		Total sample (n=119)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
'O'	43.3	7.2	42.3	6.7	43.1	7.1
'E'	18.5	4.6	17.8	3.7	18.3	4.4
'R'	36.7	6.6	35.0	6.2	36.4	6.6
KAI	98.5	14.9	95.1	11.7	97.8	14.3

Several features of the data were of interest, though the differences involved were small and need to be treated with caution. Firstly, the total KAI score and all three separate sub-scales were lower with the Danish sample. The Danish KAI was virtually identical with the KAI reported by

Kirton (1976) for a general population. The mean KAI score of the British sample, as noted previously (Section 4.2), was slightly lower than that reported by Keller and Holland 1978), mean KAI = 100.9, but the Danish sample gave an even lower mean. If, as Keller and Holland suggest, and the KAI literature might lead one to expect, research scientists should have on average KAI score on the Innovator side of the neutral point, why was the Danish sample out of step ? Sampling error with a sample size of only n=26 could account for most if not all of the difference (standard error of the mean = 2.3). This simple e planation was not strongly convincing, however, in view of a further unusual feature, the low variability of the Danish KAI data. Comparing the British and Danish samples using the variance ratio test, the difference in variances just failed to be statistically significant (p = .06). Comparing the Danish and Kirton reference samples, the difference was highly sigificant (F-ratio, p < .01). It had been clear from a cursory examination of the Danish data that the KAI measurements were spread over a restricted range, no one in the sample justifying the description of an extreme Adaptor or extreme Innovator. Only one respondent lay outside the range given by the mean ± 1 SD in the Kirton general population sample. In seeking to account for this feature, it could be argued that the use of a foreign language in the test instrument might lead to more cautious, less extreme, responses.

In view of this doubt about the accuracy of the KAI data, it was felt to be remarkable, particularly with a fairly small sample, that the unusual sub-scale patterns already identified (Section 4.2) were observable in the Danish data. That is to say, with a mean KAI at about the general population norm, the 'O' sub-scale was slightly above the norm, the 'E' sub-scale was slightly below the norm, while the 'R' sub-scale was almost exactly on the norm. It had been the recognition of these (admittedly weak) patterns at the outset of the data analysis that had led to the central thesis concerned with the need to utilise the sub-scales separately. To find a similar pattern in a fourth independent sample provided further evidence for the pervasiveness of this characteristic in a group of scientists. It was a characteristic which received no comment from Keller and Holland (1978), though observable in their published data, and indeed has no reference in the A - I literature.

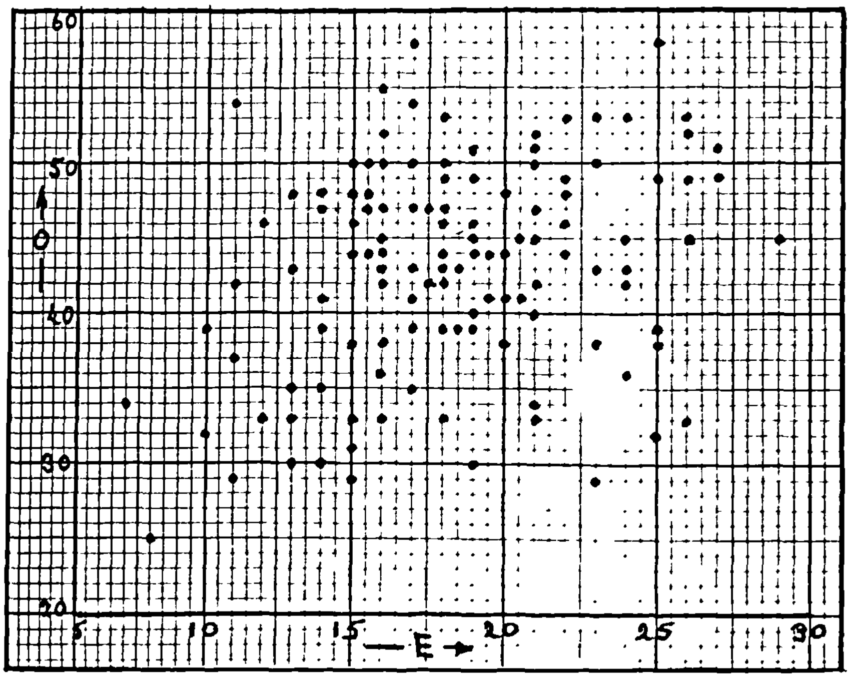
Inter-correlations between the sub-scales are shown in Table 8.6, figures for the Kirton reference sample being given for comparison. Correlation between 'E' and 'R' were identical in the Danish and British samples, but the remaining inter-correlations were lower with the Danish sample. Figures for the consolidated sample were quite close to the Kirton reference sample.

Table 8.6 KAI sub-scale inter-correlations

	'O' sub-scale				'E' sub-scale			
	Kirt.	n=93	n=26	n=119	Kirt.	n=93	n=26	n=119
'O'	-	-	-	-				
'E'	.36	.37	-.06	.30	-	-	-	-
'R'	.47	.56	.30	.52	.42	.39	.39	.39

Further comment is hardly justified, however, since none of the differences were statistically significant, such is the magnitude of the sampling error of the Pearson correlation coefficient with n=26. Nevertheless, taking the consolidated sample, n=119, the scatter diagram of the 'O' / 'E' plane shown in Figure 8.1, exhibits perceptibly more scatter than is seen in Figure 6.1.

Figure 8.1 Scatter in the 'O' / 'E' plane, n=119



Differences between the sexes in KAI and its sub-scales are shown in Table 8.7.

Table 8.7 KAI data: differences between the sexes (means)

	British		Danish		Total sample	
	Male	Female	Male	Female	Male	Female
'O' scale	43.6	42.0	41.9	43.0	43.3	42.3
'E' scale	18.9	17.2	18.7	16.2	18.8	16.9
'R' scale	37.7	33.8	34.8	35.3	37.2	34.2
Total KAI	100.2	93.0	95.4	94.6	99.3	93.5

Whereas the British sample was closely in line with the Kirton reference sample in terms of differences between male and female sexes, the Danish sample was not. Danish males were lower on 'O' and 'R' than Danish females. However, none of the differences reach statistical significance because of the small sample sizes involved (Danish: males, 17; females, 9). Further comment is hardly justified, therefore, but the unusual patterns do leave some slight concern about the Danish KAI data.

When the Danish KAI data was analysed according to level of qualification, further differences were found. The breakdown is given in Table 8.8.

Table 8.8 KAI data: differences between educational levels

	British			Danish			Total sample		
	Bach	Mast	Doct	Bach	Mast	Doct	Bach	Mast	Doct
'O'	41.0	39.4	45.6	39.3	41.6	45.6	40.8	40.8	45.6
'E'	16.5	21.4	19.5	19.0	17.7	17.6	16.8	19.0	19.3
'R'	34.1	38.3	38.6	37.0	35.3	33.1	34.4	36.3	37.9
KAI	91.6	99.0	103.8	95.2	94.5	96.3	92.0	96.1	102.8

With the British sample, significant correlations between level of qualifications and KAI and its three sub-scales had been found [correlation coefficients ranged from 0.24 ('R' sub-scale) to 0.34 (KAI)]. With the Danish data, none of the correlations were significant statistically, two of them ('E' and 'R' sub-scales) being negative. Only in the case of the 'R' sub-scale was the difference between the British and Danish samples close to statistical significance. One can speculate that the reason for the lower 'R' sub-scale measures with the Danish doctoral respondents may lie in the attitude to organisational rules of very senior staff.

A further check on the comparability of the Danish data was made by carrying out an item analysis of the 32 items in the KAI inventory. Table 8.9 lists the correlations between the total scale and each item, and provides a comparison of the Danish and British samples with the data given by Kirton (1977) for his reference sample. Moderately strong correlations, r >= .40, are marked with an asterisk to facilitate a comparison.

Table 8.9 Item correlations with total KAI scale

Item	Kirton n = 532	British n = 93	Danish n = 26	Total n = 119
2	.45*	.41*	.56*	.44*
3	.26	.44*	.06	.36
4	.26	.30	.39	.30
5	.32	.34	.39	.35
6	.28	.33	.21	.31
7	.49*	.40*	.26	.36
8	.47*	.47*	.25	.44*
9	.45*	.43*	.20	.35
10	.34	.28	.47*	.30
11	.34	.29	.57*	.33
12	.46*	.49*	.36	.47*
13	.48*	.43*	.33	.42*
14	.34	.25	-.21	.19
15	.55*	.55*	.33	.52*
16	.39	.48*	.11	.41*
17	.35	.30	.08	.27
18	.28	.24	.44*	.28
19	.28	.41*	.24	.35
20	.28	.29	.45*	.32
21	.41*	.51*	.60*	.52*
22	.33	.38	.20	.34
23	.37	.45*	.40*	.42*
24	.47*	.51*	.31	.48*
25	.47*	.49*	.31	.47*
26	.49*	.56*	.51*	.55*
27	.51*	.63*	.61*	.63*
28	.26	.36	.39	.36
29	.48*	.57*	.41*	.54*
30	.51*	.48*	.58*	.50*
31	.40*	.46*	-.09	.37
32	.39	.42*	.33	.41*
33	.51*	.52*	.54*	.53*

Very few indeed of the differences even approached statistical significance. Overall, the British data showed very similar correlation patterns to the Kirton reference sample and although the Danish figures are much less in line, the consolidated sample also follows the Kirton data closely. Comparing the consolidated sample, n=119, with the Kirton figures, only four items had correlations differing by more than 0.1, and none differed by more than 0.15.

Summarising, the foregoing comparison of the Danish and British samples has revealed some differences which give concern about the compatibility of the Danish and British questionnaire data, but very few differences were statistically significant. Inevitably, small real differences will fail to be detected with confidence by small samples, but nevertheless, the comparison needed to be made. It can be concluded that the strength of the evidence against the Danish data is not such as to deny a consolidation of the British and Danish samples.

8.3 A REVIEW OF THE CONSOLIDATED SAMPLE

The essence of the characterisation developed in Chapter 7 lay in the patterns of associations found in the detailed analysis presented in Chapter 5. In order to seek confirmatory evidence in the Danish sample, the consolidated sample was subjected to correlation analysis, a comparison being made between the n=93 and n=119 samples. (Throughout this Chapter, the consolidated sample will be referred to as n=119, though with some variables the sample size was slightly reduced owing to non-response in the Danish sample.) Pearson correlation coefficients were calculated taking KAI and its sub-scales in turn with each of the variables *concerned with measures of environment*, job needs / satisfactions, and performance. The comparison is summarised in Tables 8.10 to 8.14.

Table 8.10 Collaboration: KAI correlations; n=93, n=119

	KAI		'O'		'E'		'R'	
	n=93	n=119	n=93	n=119	n=93	n=119	n=93	n=119
W.S.I.	-.03	-.04	.13	.11	-.18	-.18	-.07	-.08
O.A.C.	.01	-.00	.17	.14	-.28	-.25	.04	.01
K.B.R.T.	.12	.09	.25	.22	-.24	-.24	.17	.13
Coll. Index	.04	.02	.22	.19	-.29	-.28	.05	.02

There were no major differences between the two samples, the largest difference in correlation being r=0.04. In seeking any patterns of differences, it was noted that there was a tendency for correlations to be very slightly weaker with n=119, this pattern being most apparent with the 'O' sub-scale correlations. There was nothing to suggest any difference between the three measures of collaboration in this respect.

Table 8.11 Management style: KAI correlations; n=93, n=119

	KAI		'O'		'E'		'R'	
	n=93	n=119	n=93	n=119	n=93	n=119	n=93	n=119
P.A.R	-.21	-.16	-.06	-.01	-.26	-.22	-.22	-.18
W.P.	.02	.04	.04	.07	-.08	-.13	.07	.09
L.	-.26	-.22	-.12	-.05	-.29	-.25	-.25	-.26

The greatest of the correlation differences with the management style variables was r=0.07, but this was in connection with a non-significant correlation. Again, there is some evidence of a tendency for correlations to be weaker (positive and negative) with n=119, but this is not uniform throughout the table. No further comment seems justified.

Table 8.12 Job needs: KAI correlations; n=93, n=119

	KAI		'O'		'E'		'R'	
Needs	n=93	n=119	n=93	n=119	n=93	n=119	n=93	n=119
Profession.	.06	.04	.16	.14	-.14	-.14	.06	.03
Job condit.	-.30	-.31	-.07	-.13	-.27	-.24	-.41	-.37
Status	.02	.02	.17	.13	-.09	-.09	-.07	-.02
Self act.	.39	.36	.51	.49	.05	.01	.29	.25

Patterns in the correlation differences are not readily apparent. Although there was a slight weakening of the correlation in several cases, the greatest difference, r=0.07, was in the reverse direction. The most notable features of this data, relating to job conditions needs and self actualisation needs, remained unchanged by the small changes in correlations.

Table 8.13 Job satisfactions; KAI correlations; n=93,n=119

	KAI		'O'		'E'		'R'	
Opportunity	n=93	n=119	n=93	n=119	n=93	n=119	n=93	n=119
Profession.	.04	.01	.16	.11	-.14	-.13	.01	-.01
Job cond.	-.04	-.00	.10	.10	-.07	-.02	-.14	-.10
Status	.07	.05	.16	.13	.03	-.03	-.04	-.02
Self act.	.03	.02	.25	.23	-.11	-.13	-.12	-.12
Job Sat Ind	-.04	-.03	.15	.14	-.14	-.13	-.15	-.12

Little comment seems warranted in the face of small changes in weak correlations (maximum diference, r=0.05). The Job Satisfaction Index remained uncorrelated with KAI, but showed continued evidence of weak correlations of differing sign with the sub-scales.

Table 8.14 R&D Performance: KAI correlations; n=93, n=119

	KAI		'O'		'E'		'R'	
Performance	n=93	n=119	n=93	n=119	n=93	n=119	n=93	n=119
Creative	.46	.45	.59	.58	.10	.07	.32	.30
Skills	-.13	-.16	-.05	-.06	-.33	-.36	-.01	-.04

This table of correlations was probably the most important of the series in view of the central place in this thesis of performance correlations. Differences were again small and hardly justify comment. The prominent patterns found with n=93 were also shown by n=119. Although the slight weakening of positive correlations found in Tables 8.10 to 8.13 might still be discerned, negative correlations were marginally stronger. The distinction between the 'O', 'E' and 'R' sub-scales of KAI remained just as clearly with n=119 as with n=93.

CHAPTER 9 TOWARDS A MODEL OF RESEARCH PERFORMANCE

9.1 PERSONALITY AND RESEARCH PERFORMANCE

It was noted in Chapter Two that Roe (1952), in her study of 64 eminent scientists, concluded that personality differences were more crucial than differences in intelligence. She noted also the importance of the quality of persistence. This can be seen as consistent with the need for 'perspiration' in the models of Green (1964) and Koestler (1969). Cattell and Drevdahl (1955), in their study of eminent scientists, concluded that creative scientists were uniformly lower on almost all the elements of extraversion. However, in later work, Cattell and Butcher (1968) noted that the general tendency to introversion did not apply to all components, but was largely concentrated in the 'A' factor; viz. that scientists were skeptical, withdrawn, and precise. Regarding the 'H' factor, the eminent scientists were <u>not</u> low on that scale and displayed resourcefulness, adaptability and adventureness. Reading these accounts, one detects what could be regarded as conflicting characteristics. Turning to the work of Kuhn (1963), there is specific reference to such a conflict. There is an "essential tension" according to Kuhn, which requires a successful scientist in his thinking to display simultaneously the characteristics of both the traditionalist and the iconoclast.

The notion of an essential tension is of particular interest in the context of some of the results of the present research. The data presented in Chapter Seven points to the Type II scientists as the most outstanding, being in general high on both creative and skills performance, and also on perceived collaboration. These scientists can be regarded as hybrids, having some of the characteristics of the Innovator and the Adaptor. They have a high 'O' sub-scale score, signifying a predisposition to proliferate ideas, yet they also have a low 'E' sub-scale score, signifying a predisposition to attend to detail and a concern for precision. It is not difficult to recognise the characteristics of a low 'E' score in the 'precision' noted by Cattell and Butcher, the 'persistence' recorded by Roe, the 'intensive thinking' hypothesised by Green and Koestler, and the traditionalism postulated by Kuhn. Similarly, a parallel can be drawn between the characteristics of a high 'O' score and the 'iconoclast' of Kuhn, the 'accumulator of ideas' of Green and Koestler, and the 'resourcefulness' and 'adventureness' of Cattell and Butcher.

It is hypothesised therefore, that the contrasting characteristics postulated or actually found in the personality of outstanding researchers in several classic studies spanning three decades, are approximated by the characteristics of Type II scientists defined in this thesis.

For this hypothesis to be supported it is necessary that other characteristics found by Roe (1952) and Cattell and Butcher (1968) in outstanding scientists should be demonstrated in Type II scientists. A feature of some prominence is the introversion tendency found in both studies. Were it possible to show that Type II scientists tended to introversion, the hypothesis would be much strengthened. Unfortunately, the question of introversion-e traversion must remain unresolved by the present study because no appropriate measure was incorporated in the research methodology. Kirton and de Ciantis (1985) have carried out some work concerned with relating KAI to the Cattell 16 PF inventory, but their sample was specified simply as "professional staff, aged 25-40 in two companies, one a multinational oil company, the other a U.K.-based chemical company". The correlation coefficients found between introversion / extraversion and KAI and all three sub-scales were all non-significant statistically. Support, or otherwise, for the hypothesis must await future research, therefore.

9.2 A DOUBLE-MODEL HYPOTHESIS

At the outset of the present research, the simple model based on the literature which formed a starting position was that shown in Figure 9.1.

Figure 9.1 An outline model of research performance

ORGANISATION CLIMATE		INDIVIDUAL CHARACTERISTICS
Supportive	INDIVIDUAL PERFORMANCE	Personality
Communication		Needs
Risk taking	TEAM PERFORMANCE	Ability
Opportunities		Satisfaction

Reference has already been made to work published in the past decade or so which has, in various ways, sought to amplify aspects of the above model. The following are examples : Farris, 1972; Payne et al, 1976; Pelz and Andrews, 1976; Aram and Morgan, 1976; Osbaldeston et al, 1978; Keller and Holland, 1978a. Aram and Morgan in particular attempted the difficult task of identifying the direction of causality between factors in the model. They were especially concerned with relationships between three variables: collaboration, job satisfaction, and individual performance. However, they came to the conclusion that although each pair of variables was significantly correlated, the relationships among the three were more complex than could be accounted for by their study.

Early in the course of the present research it was felt that the work of Aram and Morgan, in common with that of other workers in this area, suffered from the treatment of individual performance as a single dimension. It was also felt, just as importantly, that their work was hampered by the omission of any measure of personality. This view was based not only on a reading of earlier empirical work by Roe (1952), Cattell and Drevdahl (1955) and Cattell and Butcher (1968), and on the work of writers such as Green (1964) and Koestler (1969), but also on discussion with senior managers at the outset of this research and on the writer's own personal experience of work in a research laboratory.

In seeking to further explore a model of what is acknowledged to be a highly complex situation, the 'O' and 'E' KAI sub-scales were used as a contribution towards personality dimensions, and the distinction was made between creative and skills performance. Thus the correlation matrix shown in Table 9.1 was assembled from data presented in earlier chapters of this thesis.

Table 9.1 Correlation matrix of performance model variables

(Consolidated sample, n=119)

	1	2	3	4	5	6
1 Creative performance						
2 Skills performance	.13					
3 'O' Sub-scale	.58$	-.06				
4 'E' Sub-scale	.07	-.36$	.30$			
5 Job satisfaction	.15	.21**	.14	-.13		
6 Educational level	.30**	.01	.31$	.25**	.28**	
7 Collaboration	.10	.28**	.19*	-.28**	.48$	.17*

* p <.05 ** p <.01 $ p<.001 (two-tail tests)

Some remarkable distinctions between the correlatives of creative performance and the correlatives of skills performance have already been noted in Chapter Five. The data given in Table 9.1 revealed further distinctions. Job satisfaction correlated significantly with skills performance (though not strongly) but not with creative performance. Educational level correlated with creative performance but not with skills performance. Collaboration correlated with skills performance but not with creative performance.

It must be re-emphasised that the range of educational level covered by the sample is a very restricted one; all respondents were graduate scientists and the distinction in educational level was between batchelor, master and doctorate degrees. With so few respondents in the masters category, the educational level could be regarded as effectively a dichotomy: those with and those without a doctorate.

The cumulative effect of the data in the first two columns of Table 9.1 is to reinforce the already strong evidence that creative performance and skills performance are distinctly different attributes. Such had been the concept in mind at the outset when the two dimensions of performance had been somewhat tentatively defined on the basis of personal experience of working in scientific research. If there are two distinctly different dimensions of research performance as suggested above, it is not surprising that studies in which performance has been taken as a single dimension have led to inconclusive results.

Owing to this distinction, and in particular because the two performance dimensions were not significantly correlated (r= .13, Table 9.1) two models are postulated as in Figure 9.2. The name 'two-model' is strictly a misnomer because three of the variables appear in both 'halves'. The two parts of the mod could perhaps be better imagined fused, one above the other, out of the plane of the paper.

Figure 9.2 A two-model hypothesis of research performance

Figure 9.2(a) Creative performance

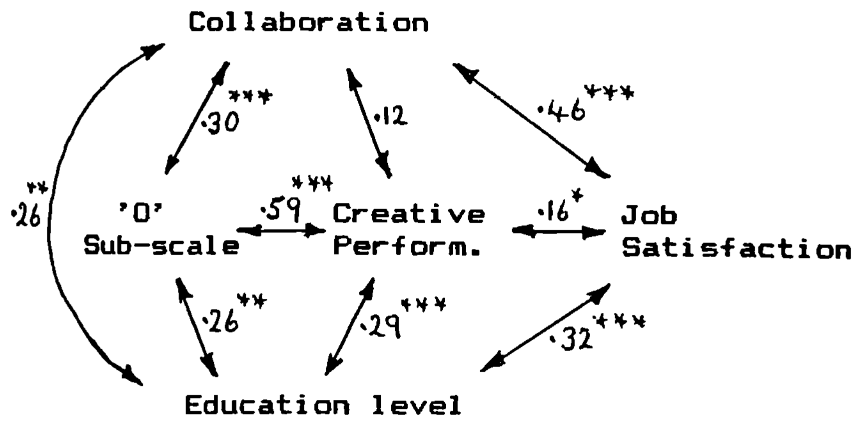
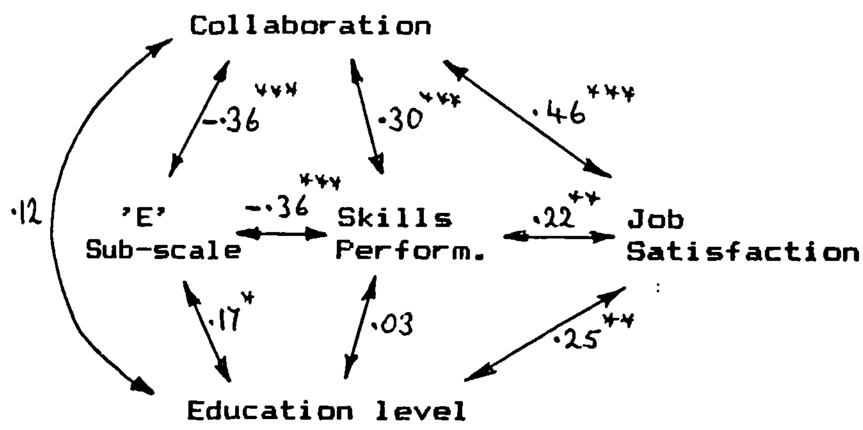


Figure 9.2(b) Skills performance



* p< .05 * p< .01 *** p< .001

Since the 'O' and 'E' sub-scales have been presented in a mutually exclusive way in this model, the correlation coefficients have been partialled with respect to the alternate sub-scale. That is to say, in that part of the model concerned with creative performance, all the correlation coefficients are partialled with respect to the 'E' sub-scale (creative performance and the 'E' sub-scale are not correlated). Similarly, in that part concerned with skills performance, all the correlation coefficients are partialled with respect to the 'O' sub-scale (skills performance and the 'O' sub-scale are not correlated).

No attempt has been made to suggest direction of causality in the model. In some relationships, a priori reasoning would indicate the direction, in others, the question is likely to be complex and not to be resolved by correlation analysis.

Several features of the model have been commented upon in earlier chapters of this thesis when the particular relationships were first identified, for example, relationships involving the two sub-scales and performance measures. These were explored in the KAI taxonomy. No further comment will be made here on such issues.

However, two features are felt to be worthy of further comment. Firstly, is the absence of correlation between collaboration and creative performance, and the existence of a highly significant and moderate correlation between collaboration and skills performance. In view of the emphasis placed upon collaboration in R & D literature, especially in inter-disciplinary research, it is a remarkable result. Why should self-assessed creative performance find no correlation with perceived collaboration? No firm answer can be given on the basis of the present data, but it would appear that there are other much more important factors that determine the level of creative performance. The data suggests that the generation of novel ideas and hypotheses is not associated with the level of collaboration with colleagues, though the skilful, perceptive development of them is associated in this way. Using the models of creativity of Koestler (1969) and Green (1964), one could find support for the idea that creative performance, involving 'bisociation' or 'linking systematic and intuitive thinking', is essentially a very personal matter. That is to say, the intense cogitation is at a personal rather than a group level. The data suggest that the 'creative loner' concept of Rogers (1959) may still have applicabiity even in interdisciplinary research. However, the final word must be one of caution, bearing in mind the nature of the collaboration measure used.

A second feature of particular interest concerns job satisfaction. The strongest correlative of job satisfaction was collaboration, and this can be readily understood. One could presume that a high degree of perceived collaboration would have a role in meeting many of the job needs, with the exception perhaps of status needs which were ranked of lowest importance overall. It was the weak correlations of job satisfaction with the performance measures that were not readily explained, and were thus most intriguing. Further probing revealed that the correlations of job satisfaction with creative performance and skills performance, r= .15 and r= .21 respectively, concealed the fact that the lowest job satisfaction was <u>not</u> to be found among those who were low on both performance measures. However, the converse was true: that is to say, highest job satisfaction was found among those who were high on both performance measures. When the total sample was divided into four quadrants on the basis of creative and skills performance, the quadrant <u>lowest</u> on job satisfaction was that which was high on creative performance but low on skills performance. The data are summarised in Table 9.2.

Testing for differences between mean levels of job satisfaction in the four quadrants using t-tests revealed significant differences between Quadrant I and each of the other three quadrants. The difference between means of Quadrants III and IV were not significant, and the difference between Quadrants II and III just failed to be significant statistically.

Table 9.2 Job satisfaction related to performance measures

Quadrant II (n=21)	Quadrant I (n=36)
High creative / Low skills	High creative / High skills
Mean : 97.4 S.D. : 17.5	Mean : 114.5 S.D. : 14.5
Quadrant III (n=26)	Quadrant IV (n=35)
Low creative / Low skills	Low creative / High skills
Mean : 106.9 S.D. : 17.4	Mean : 106.5 S.D. : 10.5

That performance in one's job can be associated with job satisfaction is easily understood, but some of the features of Table 9.2 are not readily explained. Even though the difference in means between Quadrants II and III was just non-significant (p=.06), some comment is justified on this surprising comparison. The question can be phrased as follows: taking that half of the total sample which is below average on skills performance, why should that fraction with higher creative performance record lower job satisfaction? So far no firm suggestion has emerged from a scrutiny of the present research data. It is notable that Pelz and Andrews (1976) found no clear relationship between performance and job satisfaction. As both Kirton (1976) and Davies (1985) have remarked, there is a tendency for Adaptors (Dinosaurs) to be associated with the establishment, and the Innovators (Dynamos) "....have to be prepared for a harder life," (Davies). Perhaps there is an element of this phenomenon in the lower satisfaction to be found among those individuals in Quadrant II of Table 8.2. Of the four Quadrants, it is Quadrant II which approximates most closely to the description of Dynamos given by Davies.

Whatever the reasons, the evidence of Table 9.2 suggests some interaction, if indirect, between creative performance and skills performance. Some doubt is thus cast on the validity of the double model concept in Figure 9.2. Nevertheless, it is suggested that the model represents a useful step forward from models regarding performance as a single dimension. Through this distinction, and through the taxonomy of researchers developed on the basis of the KAI sub-scales, the present research has provided new frameworks for guiding the management of the most crucial resource in industrial scientific research.

CHAPTER 10 A CRITICAL EXAMINATION OF KAI

10.1 THE KAI: COGNITIVE STYLE OR COGNITIVE LEVEL

Cognitive style has been defined as 'consistent individual differences in preferred ways of organising information' (Messick et al, 1976). Defined in this way, cognitive style provides a hypothetical mediator between stimulus and response (Goldstein and Blackman, 1978). Cognitive styles are seen as stable over time and different situations, and this stability suggests that cognitive style is related to underlying personality traits, whereby a 'personality space' is suggested which links the concepts. Thus cognitive style theories mention personality dimensions as part of their description, as in the concept of field dependence (Witkin et al, 1962; McKenna, 1983).

The A - I theory has followed this pattern. Numerous KAI correlational studies have been carried out (Kirton, 1976, 1977, 1984b) and support for the theory has been gauged by the extent to which strong relationships have been predicted and found, and expected insignificant relationships have been found. Thus extreme Adaptors have been found to be more left-brain dominated, more dogmatic, intolerant of ambiguity and inflexible. They are more introverted, humble, conscientious, controlled, subdued and emotionally tender (Kirton, 1984b).

Of interest in the present context is the concept of hemisphericity or style of processing information in creative functioning. Defined briefly, hemisphericity is the tendency for a person to rely more on one than the other cerebral hemisphere in processing information. The left hemisphere is regarded as specialised for logical, sequential processing of information and deals with verbal, analytical and digital materials. The right cerebral hemisphere processes information non-linearly, holistically and is regarded as specialised for non-verbal, spatial, analogic, emotional and aesthetic materials (Torrance, 1982). As part of his research in hemisphericity, Torrance sought relationships between hemisphericity and measures of creative style; and between hemisphericity and measures of creative ability. One of the measures of creative style selected by Torrance was the KAI, and he found 'a consistent tendency for right hemisphere scores to correlate significantly with the innovative style and for left hemisphere scores to correlate significantly with adaption style' (Torrance and Horng, 1980; Torrance, 1982). Other measures of creative style used by Torrance also correlated positively and significantly with right hemisphere style and negatively with left hemisphere style. The KAI was therefore seen to give similar results to other tests purporting to measure cognitive <u>style</u> (WKPAY, Khatena and Torrance, 1976; SAM, Khatena and Torrance, 1976; Creative motivation, Torrance, 1971; Cue test, Stein, 1975). The KAI was also seen to give different results to those tests purporting to measure creative ability, ie cognitive capacity or level.

The same data matrix (ie scores on the various measures of creative style, including KAI, and on various measures of creative level) was subsequently made available by Torrance to Kirton who factor analysed the scores. Table 10.1 shows the results of extracting two factors.

Table 10.1 Factor analysis (Kirton, 1987) of Torrance data

Measure	Author	Factor One	Factor Two
Left hemis. style of thinking	Torrance et al	.84	-
Right hemis. style of thinking	Torrance et al	.76	-
Creative personality (WKPAY)	Khatena & Torrance	.72	-
KAI	Kirton	.66	-
Creative self perception	Khatena & Torrance	.57	-
Creative motivation	Torrance	.56	.33
Cue test	Stein	.42	-
Originality (Rorschach)	Hertz	.35	-
TTCT Fluency	Torrance	-	.87
TTCT Originality	Torrance	.35	.84
TTCT Flexibility	Torrance	.33	.69
TTCT Elaboration	Torrance	.35	.67
Possible jobs	Gershon & Guilford	-	.41
Similies	Schaefer	-	.36
Movement (Rorschach)	Hertz	-	.31

Only loadings >= .30 are shown (hence some tests not given)

The KAI loaded heavily into Factor 1 which, Kirton (1987) argues was essentially concerned with measures of cognitive style; but not into Factor 2, which contains the tests measuring level of creativity. The factor pattern thus offers support for the level / style distinction and locates the KAI as a measure of the latter.

Nevertheless, the evidence is less convincing than might be imagined from the factor analytic study. Correlation coefficients between KAI and the battery of tests used by Torrance (1980) ranged from -0.03 to 0.59, and while the greatest coefficients were found with measures of style, some notable correlations were found with measures of creative level, as Table 10.2 shows.

Table 10.2 KAI correlations with creativity measures

[Torrance and Horng (1980)]

Measure	Corr. Coeff.
Creative personality (WKPAY)	0.59
Right hemis. style of thinking	0.53
Left hemis. style of thinking	-0.49
Creative motivation	0.46
TTCT Originality	0.43
Creative self perception(SAM)	0.41
TTCT Fluency	0.36
TTCT Creative strengths check list	0.36
Cue test	0.35
TTCT Flexibility	0.34
Rorshach Movement	0.32
Rorshach originality	0.29
TTCT Elaboration	0.26
Seeing problems	0.17
Similies	0.16
Possible jobs	0.06
Integrated style of thinking	-0.03

For example, the correlation between KAI and the TTCT test of originality was 0.43. It is not clear whether this is an indication that the TTCT test of originality is contaminated by 'style' or that the KAI is contaminated by 'level', or whether some other explanation accounts for the observed association. As far as the writer is aware, this particular correlation has not been discussed in the literature.

In asserting that KAI measures style rather than level of creativity, Kirton had, earlier, published the results of a study aimed to clarify the issue (Kirton, 1978a). The evidence was based on the use of a test battery containing tests purporting to measure level of creativity together with KAI. An absence of a significant correlation in this study was taken as evidence that KAI does not measure the level of creative ability. However, the research sample used by Kirton was limited to sixth form pupils, whereas KAI is an instrument intended for use with adults. The strength of such evidence is also weakened by the criticism directed at many tests of creative ability developed in the 1960's (see, for example, the criticisms of Barron (1969) already discussed in Chapter Two). The fact that different tests purporting to measure creative ability (level) are very weakly correlated leaves the nature of what is measured in doubt, and thus weakens such correlational evidence. It would be fair to conclude that, taken together, the correlational evidence though far from conclusive, does offer support for the style / level argument, with KAI more likely a measure style.

That issues of cognitive style and cognitive level have been confused and may not be easily or quickly resolved is e emplified by recent work in connection with Witkin's field dependence theory. Witkin (1950) found consistent individual differences in the ability to locate a simple figure embedded in a more complex field in his Embedded Figures Test. He used this and other tests to define collectively the personality dimension of field dependence/independence. Witkin and others have since developed this purely perceptual dimension at the cognitive level. For a considerable time the standard interpretation of these measures was that they were measures of cognitive style, but in a recent paper, McKenna (1983) has subjected the question to a re-examination. He found that correlations between field dependence and standard measures of ability were substantial and consistent. On this and other grounds McKenna concluded that measures of field dependence are more appropriately regarded as measures of cognitive ability than as measures of cognitive style. It is notable that, some years earlier (ie before McKenna's work), Kirton (1978c) had concluded that there was a theoretical overlap of concepts between Witkin's field dependence and his A - I theory. To what extent, it may be questioned, if the conclusions of McKenna are accepted, does this overlap imply that KAI is partly a measure of level of cognitive ability.

A further aspect of the difficult question of whether the KAI measures a cognitive style or a cognitive ability concerns the the place of intelligence in the conceptual framework. In work spanning several decades it has been held that in the population as a whole there is a positive correlation between creative ability (level) and intelligence. Since performance in intelligence tests and in creative work both involve intellectual activity, a positive correlation would be expected. The nature of that relationship appears to be complex, however. It is generally held that while an imperfect linear correlation exists between intelligence and level of creative ability (however measured) over much of the ability range, the relationship at higher intelligence levels is weak or non-existent. Nevertheless, given a positive correlation between intelligence and level of creativity <u>in the population as a whole</u>, a positive correlation would be expected between the KAI and intelligence if the KAI were a measure of level of creativity as opposed to a measure of style. No evidence of even moderate correlations between KAI and intelligence has been obtained taking samples from the general population spanning a wide range of intelligence. Table 10.3 gives data compiled by Kirton (1987) on this question. (Sample sizes were not given, but all coefficients were stated to be non-significant.)

Table 10.3 Intelligence and KAI: correlations (Kirton, 1987

Test		Correlation
PH2 General	(a)	0.12
GT90B Verbal	(a)	0.12
EA2A Arithmetic	(a)	0.09
VMD Diagrams	(a)	0.04
OTIS Higher	(b)	0.00
GT70B Non-verbal	(a)	-0.01
CT82 Shapes	(a)	-0.01
Shipley	(c)	-0.01
English exam	(b)	-0.03
Shipley	(c)	-0.04
Shipley	(c)	-0.11
Shipley	(c)	-0.14

(a) Flegg, 1983 unpublished
(b) Kirton, 1978
(c) Gryskiewicz, 1982

A set of correlations ranging between -0.14 and +0.12 is strong evidence for the absence of any correlation between KAI and intelligence *in the general population. In as* much as 'level of creativity' is modestly correlated with I.Q., the data is supportive of the assertion that KAI is a measure of cognitive style rather than level in the general population. The support does not apply, however, with respect to that part of the population which is well above average in intelligence and creative ability, and that part which , in the main, is to be found in scientific research work.

The issue is thus not clearly resolved, and it would be wrong to imply that the doubt centres only around the KAI, which has been the focus of this study. The fact that different measures of creative ability may be very weakly correlated throws doubt on the clarity of the concept of level of creativity, certainly as far as measurement is concerned. In a recent paper, Payne (1987) quoted concerns expressed over twenty years ago by Wallach and Kogan (1965) who found an average correlation between tests of creativity (possibly, but not certainly, <u>level</u>) of around 0.2. Payne added that 'the kind of creative ability tapped can be rather test specific', which is a disappointing reflection of the uncertainty still surrounding measures of creativity after three decades of research. It may be, as Wallach and Kogan argued, that part of the confusion stems from tests of 'creativity' having poor psychometric properties, but it is also possible that there has been, and still is, confusion because tests are neither 'purely' measures of cognitive ability (level) nor 'purely' measures of cognitive style.

Consequently, it is bound to be difficult to be conclusive on the evidence cited as to whether the KAI is <u>purely</u> a measure of cognitive style. It must remain at this point an issue open to doubt, but further reference to the matter will be made later in this Chapter, when empirical evidence from the present research will be presented.

10.2 CONCEPTS UNDERLYING THE THREE SUB-SCALES

A reading of the historical development of the KAI (Kirton, 1977, 1987) clearly indicates that the inventory was developed as a single dimension of cognitive style. An argument that KAI is a single measure could be based on two points. Firstly, it has a high internal reliability, replications by many researchers having yielded reliability coefficients (Cronbach's alpha and KR-20) in the range 0.80 to 0.90. This can be interpreted as evidence of a high degree of self-consistency. Secondly, the finding that none of the 32 items loaded less than 0.30 on the first unrotated factor (loadings varied between 0.30 and 0.61, Kirton, 1976). This further supports the notion that the inventory is a common pool of items.

Throughout the ten years of use of KAI, the inventory has almost always been used in this way, ie as a single scale. Used this way, considerable evidence for the validity of the KAI has accumulated. It appears to distinguish between occupational groups whose roles would suggest different requirements in terms of innovative behaviour. For example, in the study by Kirton and Pender (1982), which summarised data from 15 studies involving 2375 subjects, the mean KAI score for apprentices was 86, while for R & D personnel it was 102 (for the general population, 95).

Nevertheless, from the outset, factor analysis of the KAI by many researchers (see Table 10.4), has afforded ample evidence for the extraction of three or more factors. Following Kirton (1976) with only one exception, three factors have been characterised, and the degree of consistency has been remarkably high. Table 10.4 summaries the published work and also includes the present work.

Table 10.4 Factor analysis of KAI: published replications

Author	Sample details: Nature	Size	Origin	No. of factors	Consistency cf. Kirton
Kirton (1976)	General population	286	UK	3	
Beene & Zelhart (1986)	Undergrads.	289	USA	3	97
Goldsmith (1985)	General population	270	USA	3	94
Taylor (1987)	Research scientists	119	UK	3	88
Mulligan/Martin (1980)	Sixth form students	303	New Zealand	3	84
Hammond (1986)	Sixth form students	374	Ireland	3	84
Prato Previde * (1979)	General population	835	Italy	3	81
Pulvino (1979)	Teachers	431	USA	3	75
Keller/Holland (1978)	R&D staff	256	USA	2 **	77

* Italian translation
** Methodology not clear from published account

The column headed 'consistency cf Kirton' gives the percentage of the 32 items appearing in the same factors as allocated by Kirton (1976). In spite of the evidence that three factors have been consistently extracted, very few researchers have quoted sub-scale data, and none to the writer's knowledge have used the separate sub-scales in a research study, until the present one.

Having identified three factors before his initial publication, Kirton (1976) went on to interpret these factors as described earlier in Chapter 2. In the KAI Manual (Kirton,1977), norms for the three sub-scales were also published. Since some doubt remains from the discussion in Section 10.1 about the extent to which KAI is a measure of style, it is necessary to examine the same issue in relation to the separate sub-scales.

Taking first the 'R' sub-scale, a scrutiny of the items gives no suggestion of any connotation of cognitive ability. While admitting that it is unwise in evaluating a psychometric test to place much reliance simply on the face validity of the items, the 'R' sub-scale items are seen to be behavioural descriptions and there is nothing to suggest that level of ability is measured by them. The description of the 'R' sub-scale as a measure of non-conformity appears well founded, and as Payne (1987) in a recent commentary on the KAI suggested, the 'R' sub-scale appears to be what it is purported to be, a measure of style.

Regarding the 'E' sub-scale, the items have face validity as a measure of 'methodical Weberianism' to use Kirton's description. There can be little doubt that the 'E' items measure (inversely) a person's disposition towards disciplined, diligent attention to detail that Weber saw as a characteristic required by and rewarded in bureaucratic organisations. Payne (1987), in his review, suggested that the 'E' dimension was concerned with 'attitudes and values about being efficient in resource utilisation', and this could be said to be concomitant with Kirton's description of 'Weberianism'. There is nothing in any of these descriptions with connotations of cognitive ability and, as Payne concludes, on face validity the 'E' sub-scale is a measure of style. In the present research, the 'E' sub-scale was found to correlate with skills performance, and with its connotations of precision and thoroughness this is not surprising.

It is with the 'O' sub-scale that the problems lie. Some of the items, such as 'prefers changes to occur gradually'; 'would sooner create something than improve it'; 'likes to vary set routines at a moment's notice', and 'is able to stand out alone in disagreement', are behavioural descriptions much as the 'R' items are. Like the 'R' items, they have no connotations of cognitive ability and there is face validity as a measure of cognitive style. The position is different, however, with other 'O' items such as 'has original ideas' and 'has fresh perspectives on old problems'. Persons who affirm that it would be easy to present themselves consistently according to these descriptions must be persons who perceive themselves as having original ideas and fresh perspectives. If this self perception is at all near the truth (the long-standing methodology of personality measurement by means of questionnaire inventories relies on that) then such people must possess a high level of ability in idea generation. The issue, for the moment, is not whether the ideas and perspectives are 'good' in some fruitful way, but simply whether or not a person generates original ideas sufficiently abundantly to make the response 'easily' to the questionnaire item.

It is notable that the 'O' sub-scale was labelled by Kirton at the outset of his work on A - I theory as 'Originality'. More recently that label has been amended to 'SO-PO', viz. 'sufficiency of originality- proliferation of originality'. To be fair, the concept of sufficiency / proliferation was present in A - I theory from the outset and one can presume that Kirton has felt the more cumbersome label necessary to inhibit 'misinterpretations'. (See, for example, Mulligan and Martin (1980), and Kirton's reply (Kirton, 1980b). That is to say, a high 'O' score is, according to A - I theory, indicative of a tendency to proliferate ideas, while a low 'O' score is indicative of a tendency to produce only a sufficiency. The theory asserts that the low 'O' scorer could, if the situation demanded, produce more ideas but as a preference chooses not to do so. This thesis suggests that this notion is the essence of the conceptual problem surrounding A - I theory. It can be asserted, contrary to Kirton, that low 'O' scores can and will identify people who do have a dearth of ideas and fresh perspectives, as well as those who could produce a plethora of ideas but 'choose' not to do so owing to their cognitive make-up. A low 'O' score could thus indicate one of two very different types of person. No research, as far as the writer is aware, has offered evidence regarding the contribution of these two types in low 'O' scores.

Logically, it must be admitted that there are individual differences in the ability to generate original ideas and fresh perspectives. Those people who are weak in this cognitive ability (labelled 'level of idea generation') are bound to score low on the 'O' sub-scale, assuming it is a valid measure. The fact that those high in this ability might not proliferate ideas, by preference owing to their cognitive style, and thus gain a low 'O' score, does not destroy the argument. This thesis asserts that some of the items in the KAI 'O' sub-scale are bound, to some extent, to measure 'level of idea generation'. It is argued, therefore, that the 'O', (or 'SO-PO'), sub-scale is contaminated as a measure of cognitive style. On face validity it would seem that at least half of the 'O' items fall into the category which has been labelled 'level of idea generation'.

To the extent that ideas generated are 'good' ideas, and to the extent that measures of creative ability are valid measures, one can expect a correlation between the 'O' sub-scale and creative performance measures. However, if credence is given to the theories of Koestler and Green (see Chapter Two), there is rather more to creative performance in scientific research than the previous sentence might be taken to imply. Fecundity in idea generation is by no means all. Consequently, only moderate correlations might be expected between the 'O' sub-scale and creative performance. Thus the rather strong correlations (eg. $r = 0.59$) found in the present research present a problem and need further comment.

It is suggested that just as the 'O' sub-scale is contaminated as a measure of cognitive style, it may well be that the measure of creative performance in the present research is also contaminated, though by a 'style' component. That is to say, when a respondent attempts to assess, via a questionnaire, his / her level of creative performance, it may be very difficult for that person not to assess the sort of person they feel they could or ought to be, given their self perception. In other words, a perceived 'creative style', whether or not fully realised in practice for many reasons, may influence a person in assessing their performance. There is evidence from the work of Kirton and McCarthy (1985), that even a brief account of A - I theory is sufficient for many people to estimate the KAI score of themselves and others. The placing of the KAI inventory at the beginning of the research questionnaire may possibly have sensitised respondents to such self perception.

The concerns expressed above about the conceptual nature of the 'O' sub-scale will receive further attention subsequently, following factor analytic studies in the next Section.

10.3 RELIABILITY AND FACTOR ANALYTIC STUDIES

In view of the concerns expressed in the previous sections of this chapter regarding the composition and interpretation of the three KAI sub-scales, and because of the central place in this thesis of the use of KAI sub-scales, it was felt desirable to carry out factor analytic studies on the KAI item data. It is acknowledged that the sample size was small for such studies. While most researchers would agree that the absolute minimun sample size should be three times the number of items in the scale, many would advocate a sample size of at least five times the number of items, and ten times the number is often regarded as desirable. Nevertheless, in carrying out the factor analytic studies to be described in this section using SPSSX, on no occasion was the warning of an ill-conditioned matrix generated by the programme. Initially, reliability studies were carried out with the British (n=93) and Danish (n=26) samples taken separately, but for practically all of the factor analytic work the consolidated sample (n=119) was used.

<u>Reliability studies</u>

Using SPSSX, Cronbach's alpha was computed for the total scale and for the items grouped into the three sub-scales as defined by Kirton. The analysis was repeated using the British, Danish and consolidated samples, giving the results shown in Table 10.5

<u>Table 10.5 Cronbach's alpha (32 item KAI inventory)</u>

	British (n=93)	Danish (n=26)	Total (n=119)
O	.82	.80	.82
E	.78	.70	.77
R	.82	.80	.81
KAI	.89	.83	.88

These results appeared to be very satisfactory in terms of their magnitude (well above .70 with only one exception, and that related to the small Danish sample) and also in terms of a comparison with published data. Kirton (1976) has quoted a Cronbach's alpha = .88 for the total KAI scale using n=532. Using the KR-20 statistic, Kirton gave the reliability data shown in the following table.

Kirton (n=532)	KR-20
O	.81
E	.76
R	.82
KAI	.88

Subsequent published reliability analyses for KAI by several researchers is given below.

Keller and Holland	(n=256)	KR-20	= .88
Goldsmith	(n=214)	KR-20	= .86
Prato Previde	(n=835)	Alpha	= .87
Hammond	(n=376)	Alpha	= .76

The present data from a sample of scientists (like that of Keller and Holland) can be seen to be closely in line with larger scale published studies. The one study out of line, that by Hammond (1986), was carried out with Irish sixth-formers. In view of the fact that the KAI inventory is intended for mature subjects, it is perhaps not surprising that the Hammond results contrast with the others.

The inter-item correlation matrix is shown in Table 10.6

Table 10.6 Inter-item correlation matrix for KAI (n=119)

KAI item data (n=119) Correlation matrix

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	--															
3	21	--														
4	06	-06	--													
5	12	17	17	--												
6	37	09	07	-01	--											
7	32	10	18	06	46	--										
8	40	17	14	14	35	45	--									
9	24	12	04	23	14	19	26	--								
10	10	14	05	19	10	18	11	18	--							
11	-04	37	-04	10	01	12	04	00	22	--						
12	25	21	05	14	14	15	15	41	04	01	--					
13	17	18	06	27	-04	-10	13	22	05	16	57	--				
14	-00	-05	45	08	14	-02	10	09	05	-16	07	09	--			
15	18	22	15	22	11	12	10	12	19	28	26	34	16	--		
16	12	27	02	26	-09	07	10	04	17	29	21	22	-15	23	--	
17	21	-08	29	05	29	25	15	25	09	-16	25	04	37	20	-14	--
18	31	25	08	06	26	22	22	02	26	23	-02	-07	-16	06	20	-10
19	06	32	12	24	-03	-05	17	13	30	35	11	23	-09	26	29	-14
20	30	08	-03	10	19	13	18	17	09	01	32	23	-02	21	16	10
21	22	36	09	33	04	10	15	11	15	59	15	27	-08	30	42	-03
22	17	10	55	19	-00	16	13	08	14	05	03	08	38	28	06	18
23	06	36	13	25	07	04	08	09	16	50	13	22	03	23	44	-00
24	07	16	13	28	-03	05	18	08	13	24	23	39	12	39	64	09
25	18	06	45	17	17	12	27	13	10	04	17	17	63	31	15	38
26	25	21	12	17	27	29	34	13	20	34	37	19	-01	30	31	12
27	32	23	24	15	23	37	32	20	26	21	36	16	09	34	34	25
28	06	09	23	14	12	10	22	34	20	02	27	16	40	23	06	25
29	25	19	11	13	24	30	36	32	19	23	26	14	07	26	24	14
30	60	26	05	11	40	30	27	21	04	29	30	17	-07	14	24	15
31	14	10	18	19	-01	04	08	13	-09	09	45	53	06	35	24	14
32	24	20	04	-00	31	28	20	19	21	20	29	25	-04	44	14	13
33	38	18	21	22	12	22	30	16	08	19	38	35	16	38	19	12

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
18	--															
19	28	--														
20	21	-03	--													
21	31	43	09	--												
22	09	06	06	17	--											
23	28	51	07	62	09	--										
24	-05	22	13	33	21	33	--									
25	-01	04	-01	16	36	15	42	--								
26	29	27	14	52	-03	33	20	20	--							
27	24	10	28	31	28	15	35	40	49	--						
28	-03	15	08	08	15	11	26	43	13	25	--					
29	15	17	22	31	19	14	36	22	45	52	39	--				
30	30	06	37	35	11	15	22	15	30	39	03	35	--			
31	-07	11	17	18	22	10	29	21	19	22	03	17	21	--		
32	21	12	27	13	02	11	08	07	35	34	02	29	25	18	--	
33	09	18	25	19	26	09	25	28	28	38	18	29	41	35	32	--

Note : decimal points omitted

A visual comparison of this data with that published by Kirton (1976) is difficult to achieve. Nevertheless, a scrutiny of the two correlation matrices showed that of the 25 strong inter-item correlations (r > .45) in the present study, 20 (80%) of the equivalent inter-item correlations in the Kirton reference sample gave r >.30. An alternative comparison is achieved by comparing item correlations with the total KAI. This is shown in table 10.7.

An attempt has been made to facilitate a comparison by marking the strong correlations (r > .40) with an asterix. Inevitably the small Danish sample showed many discrepancies, but the two larger samples (n=93 and n=119) of the present study showed similar patterns to the Kirton reference sample.

Table 10.7   Item correlations with total KAI

ITEM	Kirton (n=532)	British (n=93)	Danish (n=26)	Total (n=119)
2	.45*	.41*	.56*	.44*
3	.26	.44*	.06	.36
4	.26	.30	.39	.30
5	.32	.34	.39	.35
6	.28	.33	.21	.31
7	.49*	.40*	.26	.36
8	.47*	.47*	.25	.44*
9	.45*	.43*	.20	.35
10	.34	.28	.47*	.30
11	.34	.29	.57*	.33
12	.46*	.49*	.36	.47*
13	.48*	.43*	.33	.42*
14	.34	.25	-.21	.19
15	.55*	.55*	.33	.52*
16	.39	.48*	.11	.41*
17	.35	.30	.08	.27
18	.28	.24	.44*	.28
19	.28	.41*	.24	.35
20	.28	.29	.45*	.32
21	.41*	.51*	.60*	.52*
22	.33	.38	.20	.34
23	.37	.45*	.40*	.42*
24	.47*	.51*	.31	.48*
25	.47*	.49*	.31	.47*
26	.49*	.56*	.51*	.55*
27	.51*	.63*	.61*	.63*
28	.26	.36	.39	.36
29	.48*	.57*	.41*	.54*
30	.51*	.48*	.58*	.50*
31	.40*	.46*	-.09	.37
32	.39	.42*	.33	.41*
33	.51*	.52*	.54*	.53*

* Correlations where r >= .40

Preliminary Factor analysis

The initial runs were carried out in order to check the extent to which the KAI item data of the present study fitted the three factor model desribed by Kirton (1976) and others. Using SPSSX, three factors were extracted using the method of maximum likelihood and rotation was carried out using the varimax procedure. Parallel runs using the British data (n=93) and the consolidated sample (n=119) were made. The factor structure using the 'O', 'E' and 'R' labels is given in table 10.8, which also shows the Kirton factor structure for comparison. To facilitate a comparison, loadings of 0.30 or greater are shown, though 'near-misses' are given in parentheses where this is felt to be helpful.

Not suprisingly in view of earlier comparisons, the two samples, n=93 and n=119, show extremely similar factor structures. What was felt to be remarkable, partly because of the small sample size and partly because of the special nature of the sample (unlike the general population sample of Kirton), was the very close similarity of the factor structure found with the present data compared with that of Kirton. Just four of the thirty two items were 'misplaced' with respect to Kirton and all four of these 'misplaced' items were in the lower half of Kirton's ordered lists of loadings (all had loadings of less than .5).

Table 10.8 Three-factor KAI models : a comparison

ITEM	Kirton (n=532)			Taylor (n=93)			Taylor (n=119)		
	O	E	R	O	E	R	O	E	R
21	.77			.76			.76		
23	.74			.72			.71		
19	.64			.63			.59		
16	.60			.63			.61		
3	.52			.47			.45		
5	.52			.36			.36		
11	.51			.69			.66		
26	.47			.42		.50*	.46		.45
12	.37					.53*			.42*
24	.36			.48	.35		.51	.36	
18	.34		.30	.32			(.28)		.35*
31	.33			.31			(.25)		
13	--			.32			.36		
14		.77			.83			.78	
22		.75			.59			.48	
25		.74			.80			.79	
4		.63			.60			.57	
15	.35	.48		.48*	(.26)		.39*	.32	
17		.35			.45	.35		.46	.30
28		--			.49			.51	
30			.75			.67			.65
2			.68			.65			.65
20			.60			.42			.44
8			.57			.51			.51
7			.54			.58			.57
6			.51			.61			.57
29			.48	.35		.48			.48
33			.44			.41			.44
32			.36			.52			.48
9			.34			.46			.35
27			.30	.35		.50			.35
10			--	(.25)*			(.24)*		

* Misplaced relative to Kirton

The four 'misplaced' items were as follows.

Item 10 : Holds back ideas until obviously needed

Item 12 : Likes to vary set routines at a moment's notice

Item 15 : Is a steady plodder

Item 18 : Can stand out in disagreement against a group

Item 10 could be regarded as an unsatisfactory item on several criteria. It failed to achieve a loading of 0.3 on any of the three factors in Kirton's analysis and also in the present analysis. Conceptually it has a connection with ideas, which might give it a place on the 'O' scale if one argues that sufficiency / proliferation of ideas would have a bearing on the readiness with which ideas were put forward of held back. On the other hand it clearly relates to group interaction and might be determined by the level of group conformity. It could therfore gain a place on the 'R' scale. Either way it is likely to be an item which reduces the orthogonality of the factors, and makes a poor contribution to the reliability of the scale on which it is placed. (With Item 10 on the 'R' scale, as specified by Kirton, the reliability of the 'R' scale in the present study could be <u>raised</u> from .815 to .821 by its <u>exculsion</u>).

Item 12, specified by Kirton as an 'O' scale item, had a loading of only .19 on the 'O' factor, compared with a loading of .42 on the 'R' factor. Conceptually, it could be argued that a propensity to vary set routines could be determined in part by sufficiency / proliferation of ideas, ie. by a wish to follow up ideas regardless of agreed plans. However, it could also be argued that varying routines at a moment's notice is also determined by a person's degree of non-conformity. Item 12, like Item 10, does not have an unequivocal place on either scale.

Item 15 had not greatly dissimilar loadings on both the 'O' and 'E' factors in the Kirton study, and the same was found in the present study, except that the ordering of the loadings was reversed. Conceptually, Item 15 might be regarded as ambiguous by some respondents, who may view the two descriptors 'steady' and 'plodding' as indicative of different characteristics. Some may feel it easy to affirm stability (steady) yet not wish to affirm a plodding disposition, and so this item would seem to be unsatisfactory, both conceptually and from the fact that it loads significantly on two factors. Scrutiny of the correlation matrices of Kirton and of the present study reveal a large number of significant inter-item correlations involving Item 15. In the factor analysis of Hammond (1986), Item 15 loaded most heavily on neither 'O' nor 'E', but on the 'R' factor. Altogether, there is much evidence that this is an unsatisfactory item if the objective is three orthogonal factors.

Item 18 would seem to be a good item conceptually. It has face validity as an item to tap the dimension of rule / group conformity (non-conformity). In the present study (n=119) the greatest loading was found, as would be expected, on the 'R' factor. Nevertheless, it is apparent that it also loads on the 'O' factor (Kirton and Hammond as well as Taylor) and one may suppose that there is 'wobble' from one sample to another. From the standpoint of factor orthogonality, Item 18 is a poor candidate.

It can be seen from the above comments on the four 'misplaced' items, that all four items are unsatisfactory to some extent. It still remains to question the other twenty eight items which were 'correctly' allocated to the 'O', 'E' and 'R' schema of Kirton. This will be dealt with subsequently.

Questioning the number of factors

A reading of the KAI Manual (Kirton, 1976) suggests that the inventory was initially perceived as a uni-dimensional scale. Indeed, the unrotated first factor quoted by Kirton showing significant loadings for all thirty two items could be taken as evidence for an underlying unity. Nevertheless, Kirton went on to identify three factors which he was able to interpret in relation to the literature, and several workers, cited elsewhere, have since replicated his factor analytic studies. Keller and Holland (1978), however, used a two-factor model, while more recent work by Hammond (1986) has queried whether three factors are sufficient. Hammond noted that three factors only accounted for 30% of the item variance and he suggested that a Scree Test (Cattell, 1966) could lead to the conclusion that a four-factor model or even a five-factor model would be more appropriate.

A Scree Diagram summarising the factor analysis of the present data is given in Figure 10.1. A discontinuity is apparent at factor five, and since the eigen value of the fifth factor is well in excess of 1.0, this test confirms that up to five factors could be extracted from the 32 items of KAI. Accordingly, two further factor models were investigated using the consolidated sample (n=119):

(i) a four-factor model

(ii) a five-factor model

In each case the same procedure was used as with the three-factor model described earlier, i.e. maximum likelihood extraction followed by varimax rotation. The factor structure of these models is given in Table 10.9.

Figure 10.1 Scree Diagram for KAI (n=119)

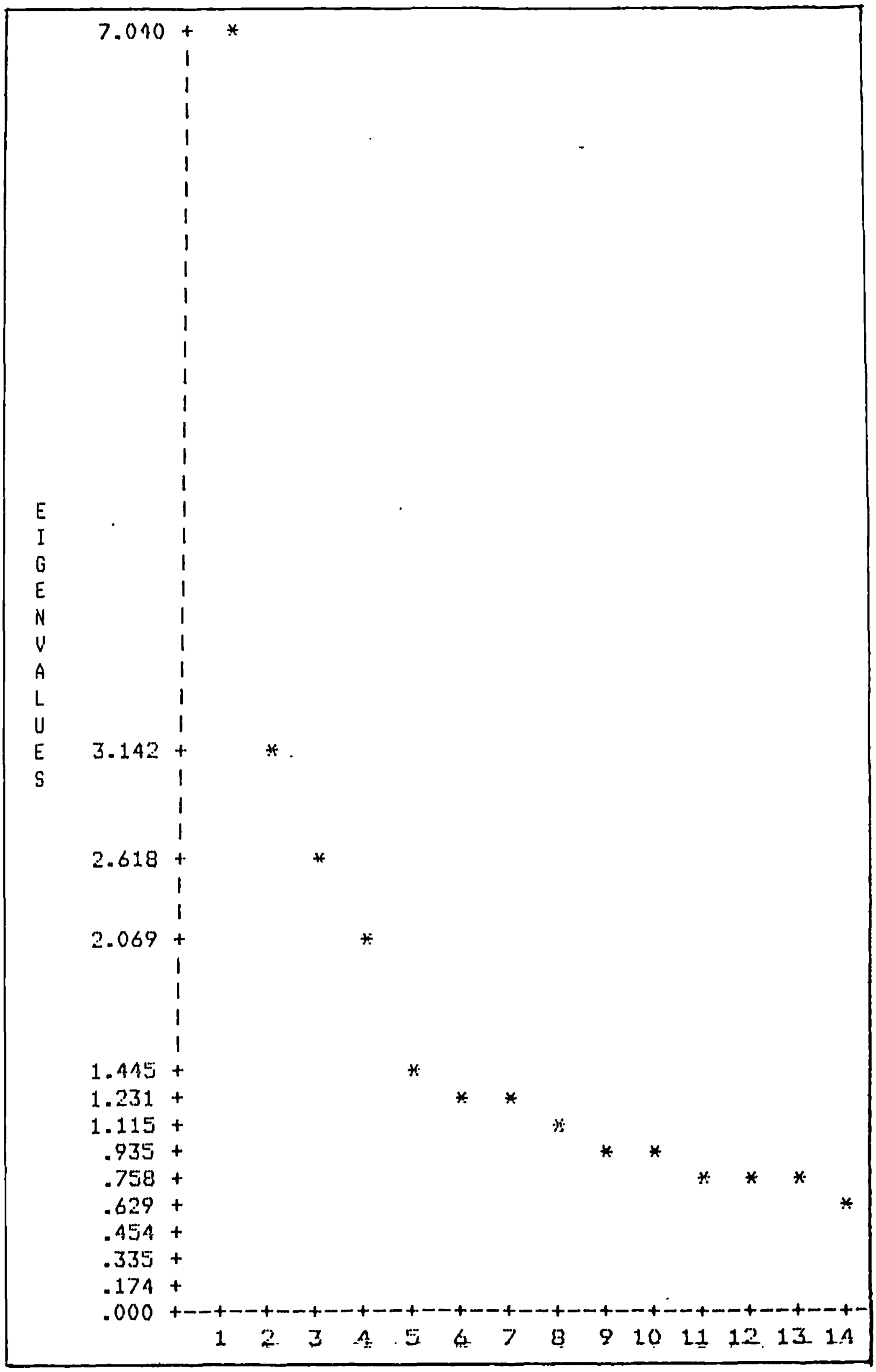


Table 10.9 Four- and five-factor models of KAI

Four-factor model

Item	'O'	'E'	'R'	1V
21 (O)	.78			
23 (O)	.72			
11 (O)	.69			
19 (O)	.59			
16 (O)	.56			.24
3 (O)	.44			
24 (O)	.43	.31		.36
5 (O)	.32			
10 (R)	.26		.20	
7 (R)			.63	
6 (R)			.61	
2 (R)			.61	
30 (R)			.61	
27 (R)	.27	.29	.53	
8 (R)			.52	
29 (R)	.27		.46	
26 (O)	.44		.45	
32 (R)			.44	.26
18 (O)	.36		.42	
20 (R)			.37	.31
9 (R)			.30	.29
25 (E)		.79		
14 (E)		.79		
4 (E)		.60		
22 (E)		.50		
28 (E)		.49		
17 (E)		.45	.29	
13 (O)				.77
12 (O)			.28	.70
31 (O)				.61
33 (R)			.35	.41
15 (E)	.32	.27		.35

Five-factor model

Item	'O'	'E'	'R'	1V	V
21 (O)	.78				
23 (O)	.73				
11 (O)	.68				
19 (O)	.60				
26 (O)	.45		.44		
3 (O)	.45				
18 (O)	.41		.40		
5 (O)	.30				
10 (R)	.26				
7 (R)			.64		
2 (R)			.60		
30 (R)			.60		
6 (R)			.58		
27 (R)		.25	.56		
8 (R)			.52		
29 (R)			.49		.24
32 (R)			.43	.28	
20 (R)			.37	.30	
14 (E)		.83			
25 (E)		.77			
4 (E)		.60			
22 (E)		.49			
28 (E)		.48			
17 (E)		.45	.28		
13 (O)				.79	
12 (O)			.27	.72	
31 (O)				.60	
33 (R)			.35	.41	
15 (E)	.28	.26		.34	
9 (R)			.29	.31	
24 (O)	.23	.24		.23	.91
16 (O)	.44				.57

Parentheses show the Kirton classification of items.

Examination of the four-factor model showed three factors which were essentially the 'O', 'E' and 'R' factors of Kirton. The five items comprising the fourth factor were as follows.

Item 13 (O) Prefers changes to occur gradually

Item 12 (O) Likes to vary set routines at a moment's notice

Item 31 (O) Needs the stimulation of frequent change

Item 33 (R) Is predictable

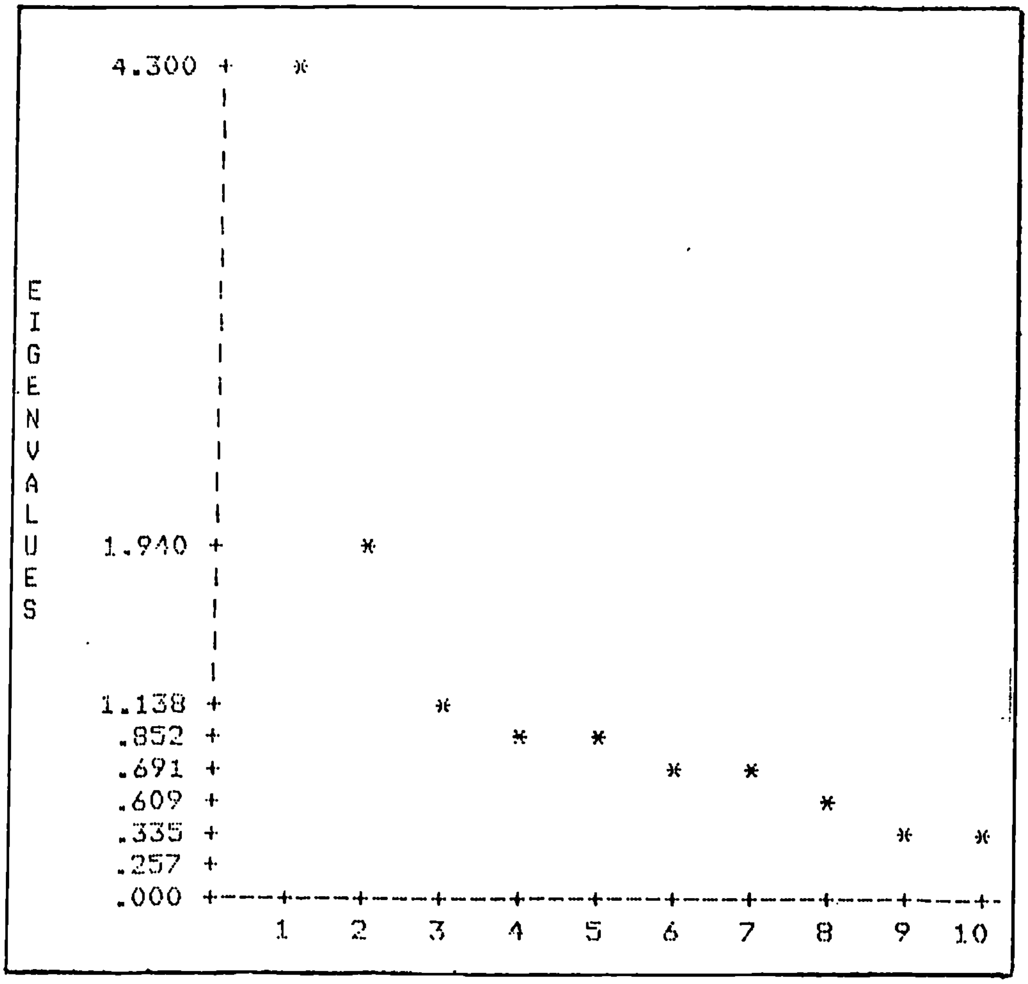
Item 15 (E) Is a steady plodder

It can be seen that the three 'O' items are all concerned with attitudes to change (rate of change). Item 33, the 'R' item, also has connotations of change (absence of change) since predictability implies stability over time. Item 15, the 'E' item, also has connotations of slow change. It is notable that the three former 'O' items failed to have a significant loading on the revised 'O' factor, and one can suppose that the nature of this factor has changed considerably by the removal of the three items. As for Item 15, once again it is found to have loadings on three factors.

If one wishes to attach a label to the fourth factor it could be dubbed 'preference for stability / change'. As for the revised 'O' factor of ten items, it has clearly moved in a direction such that the label 'level of idea could presume that a person who shunned the protection of precise instructions was a person who wished to be free from restraint in a conceptual sense, and hence free to deal with a multiplicity of ideas as they occurred. In the process of identifying a fifth factor, the five-factor model further reduced the list of Kirton 'O' scale items and strengthened the claim to label the shortened list as 'level of idea generation'.

Summarising, the four- and five-factor models of the KAI inventory have reinforced doubts expressed earlier about the homogeneity of the 'O' sub-scale of Kirton. It was felt to be desirable therefore to subject the Kirton 'O' scale items alone to factor analysis, specifying (i) a two-factor model and (ii) a three-factor model. The Scree Diagram resulting (Figure 10.2) lends support to the extraction of up to three factors, though the eigen value of the third factor extracted was only a little in excess of 1.0.
[Taking the whole of the KAI inventory, extraction of five factors was statistically significant (chi-square, p=.02), but taking just the 13 'O' items, a three factor model was not statistically significant (chi-square, p=.2) and must be treated with caution. However, extraction of two factors from the 13 'O' items was significant (chi-square, p=.02).]

Figure 10.2 Scree Diagram for the 13 KAI 'O' items (n=119)



The factor structure of the two- and three-factor models are given in Table 10.10. Both models are notable for the very small number of items which have significant loadings on more than one factor. Moreover, the items culled from the Kirton list of 13 'O' items to form additional factors were identical to those removed when the entire list of 32 KAI items was used (Table 10.9). There was considerable support, therefore, for the view that the 13 items of the KAI 'O' sub-scale are not uni-dimensional. With items

Table 10.10 Two- and three-factor models of the 13 'O' items

2 Factor model

Item	Factor 1	Factor 2
21	.80	
23	.75	
11	.67	
19	.56	
16	.50	.30
26	.49	(.25)
3	.45	
18	.43	
5	(.29)	(.27)
13		.79
12		.69
31		.66
24	.34	.44

3 Factor model

Item	Factor 1	Factor 2	Factor 3
21	.79		
23	.71		(.25)
11	.65		
19	.55		
26	.51	(.27)	
18	.47		
3	.46		
5	(.26)	(.22)	
12		.75	
13		.75	
31		.63	
24		(.24)	.97
16	.36		.59

forming the two additional factors removed, the residual primary factor, listed below, has much face validity as a measure of 'level of idea generation'.

Item 21 Has original ideas

Item 23 Proliferates ideas

Item 11 Has fresh perspectives on old problems

Item 19 Is stimulating

Item 16 Copes with several ideas / problems at same time

Item 26 Often risks doing things differently

Item 18 Can stand out in disagreement against a group

Item 3 Will always think of something when stuck

Item 5 Would sooner create than improve

Only Item 18 appears misplaced and, as already noted, this item was not placed in the 'O' factor by the present study. (As in the Kirton sample, this item had significant loadings on 'O' and 'R', but the relative magnitudes were different, Kirton finding a greater 'O' loading.)

A similar investigation to test a two-factor model of the seven KAI 'E' sub-scale items gave results of some interest, though the model failed to achieve statistical significance. Table 10.11 gives details of the rotated factor solution.

Table 10.11 A two-factor model of the 7 KAI 'E' scale items

	Item	Factor 1	Factor 2
25	Is methodical and systematic	.78	(.27)
14	Is thorough	.70	.30
28	Imposes strict order within own control	.53	
17	Is consistent	.46	
22	Masters details painstakingly		.99
4	Enjoys detailed work	.41	.50
15	Is a steady plodder	(.25)	(.26)

Although the model failed to achieve statistical significance and has other unsatisfactory features (low eigen values; items loading on both factors) it is interesting to note that the factors can be given an interpretation. Factor 1 could be labelled 'propensity for disciplined methodology', and Factor 2 (with the exception of rogue Item 15) could be called 'concern with detail'.

A similar investigation to test a two-factor model of the twelve KAI 'R' sub-scale items also gave a result which was non-significant statistically, and the second factor had an eigen value well below 1.0. For the sake of completeness the model is given in Table 10.12. To some extent there is a suggestion that the items are split into those concerned with group conformity and those concerned with rule conformity, but the matter will not be pursued.

Table 10.12 A two-factor model of the 12 KAI 'R' scale items

	Item	Factor 1	Factor 2
30	Fits readily into the system	.76	
2	Conforms	.76	
6	Prudent dealing with authority	.45	(.26)
33	Is predictable	.44	.31
20	Readily agrees with the team	.39	
29	Likes protection of precise instructions	(.25)	.63
27	Works without deviation in prescribed way	.32	.63
7	Never acts without authority	.34	.44
32	Prefers colleagues who never rock the boat	(.26)	.41
8	Never seeks to bend or break the rules	.37	.41
10	Holds back ideas until needed		.36
9	Likes bosses and work to be consistent	(.22)	.33

The cumulative effect of the work presented in this chapter has been to seriously challenge the assertion that the KAI is purely a measure of cognitive style. This is not to deny the value of the sub-scales, but to argue a re-appraisal of their conceptual nature. The work of the present chapter has further underlined the necessity of considering the three sub-scales as separate measures. In the final chapter of this thesis the study will be extended to a revision of the KAI inventory, and further evidence on the nature of the 'O' sub-scale will be presented.

CHAPTER 11 DEVELOPING A REFINED KAI INVENTORY

Stemming from the conclusions of the critical review of the KAI inventory in Chapter 10, the present chapter had several objectives. Firstly, to seek to improve the KAI by removing 'poor' items from the inventory. The criteria used were that the sub-scales should be made as orthogonal as possible by using three sets of questionnaire items which were homogeneous conceptually. At the same time, concern was given to the question of test reliability, using the criterion that Cronbach's Alpha must not fall below 0.7. Given a 'reduced' KAI inventory of suitable characteristics the second objective was to evaluate this KAI in relation to the principal variables of this research. Thirdly, using a fresh sample of data obtained from mature students on management courses, new items devised in the light of work in Chapter 10 were tested with a view to including 'good' items with the better existent items in a revised KAI.

11.1 TEST RELIABILITY AND INTER-FACTOR CORRELATION

Preliminary identification of poor items

A scrutiny of the 32 KAI item , taking into account the factor analytic work of Kirton (1976) and that already described in Chapter 10, identified seven poor items for removal. These were as follows.

Item 10 'Holds back ideas until obviously needed.' This item was critically reviewed in Section 10.3. Conceptually, it has a connection with ideas which might give it a place on an 'O' sub-scale concerned with sufficiency / proliferation of ideas, but not on an 'O' sub-scale concerned with level of idea generation. It also has a connection with group interaction and might be determined by the level of group conformity. It could therefore have a place on a 'R' sub-scale. It failed to achieve a loading of 0.3 on any scale with Kirton (1976) and with Taylor (n=119). In the present study it had its greatest loading (0.24) on the 'O' factor, but it had several correlations with 'R' items of r > 0.2, and in the Kirton study its greatest loading was on the 'R' factor (loading not given).

Item 12 'Likes to vary set routines at a moment's notice.' This item was also critically reviewed in Section 10.3. Specified by Kirton as an 'O' sub-scale item, it achieved a loading of only 0.19 on the 'O' factor in the present study, with its greatest loading (0.42) on the 'R' factor. It could be argued that varying routines at a moment's notice is determined to some extent by a person's degree of non-conformity, and so a loading on the 'R' factor is not surprising. Perhaps this item could be justified conceptually as belonging to an 'O' sub-scale as defined by Kirton, but its link with level of idea generation would seem to be too tenuous for it to be retained in the present context.

Item 15 'Is a steady plodder'

This item has already received much adverse comment in Chapter 10. As noted there, it could be ambiguous to respondents, 'steady, reliability' being seen as quite different from a 'plodding disposition'. It is difficult to interpret this item conceptually. In the factor analytic work of both Kirton and Taylor (n=119) it loads significantly on the 'O' and 'E' factors. In both studies it has numerous significant correlations with other items. It is distinguished by having the highest loading of all items in Kirton's (1976) first unrotated factor. In seeking factor orthogonality this item must be avoided. (Removing this item from the 32-item KAI increases the value of Cronbach's Alpha for the 'E' sub-scale.)

Item 18 'Can stand out in disagreement against group.'

Quite remarkably, this item was listed as an 'O' sub-scale item by Kirton (1976), achieving only a subsidiary loading on what would seem conceptually to be the obvious place for it, the 'R' factor. In the present study (n=119), where it loaded most heavily on the 'R' factor, it also had many correlations with 'O' items, and loaded 0.28 on the 'O' factor. Thus, although it would seem to be, prima facie, a satisfactory 'R' concept, it must be deleted in the interest of factor orthogonality.

Item 26 'Often risks doing things differently.'
Although this item can be connected conceptually with 'originality', and achieved its greatest loading on the 'O' factor with Kirton and with Taylor (n=119), it clearly has conceptual connections with group (non-) conformity. Not surprisingly, in the present study it loaded practically as heavily on the 'R' factor as on the 'O' factor. It had several correlations (r > 0.2) with 'R' items in the Kirton study, but no loading was given. It is clearly unsatisfactory if one wishes to define usable sub-scales. (It might have been better had it been worded 'Often does things differently'.) It is another item with a high loading on Kirton's (1976) first unrotated factor.

Item 29 'Likes protection of precise instructions'.
Conceptually, this item would appear to be a useful item to tap the rule conformity / non-conformity dimension. In Kirton's data as well as in the present study, however, there were several weak correlations with 'O' sub-scale items. This item was probably the least bad of the group, but was removed in the interest of factor orthogonality.

Having deleted the above seven items, the residual scale of 25 items was subject to factor analysis, specifying three factors. (In this and all subsequent factor analyses, factors were extracted by the method of maximum likelihood and rotation was carried out using the varimax procedure, all within the SPSSX programme, and with n=119.) The factor structure is given in Table 11.1.

Table 11.1 Factor structure of a 25-item KAI scale

ITEM	O	E	R
21 Has original ideas	.76		
23 Proliferates ideas	.72		
11 Has fresh perspectives on old problems	.65		
16 Copes with several new ideas at same time	.62		
19 Is stimulating	.58		
24 Prefers to work on one problem at a time	.52	.32	
3 Will always think of something when stuck	.46		
5 Would sooner create than improve	.38		
13 Prefers changes to occur gradually	.37		
31 Needs stimulation of frequent change	(.26)		
14 Is thorough		.81	
25 Is methodical and systematic		.79	
4 Enjoys detailed work		.59	
28 Imposes strict order within own control		.50	
22 Masters all details painstakingly		.48	
17 Is consistent		.46	
2 Conforms			.73
30 Fits readily into the system			.71
6 Is prudent when dealing with authority			.56
7 Never acts without proper authority			.52
8 Never seeks to bend or break the rules			.49
33 Is predictable			.45
20 Readily agrees with the team at work			.43
32 Prefers colleagues who never rock the boat			.41
9 Likes bosses/work patterns to be consistent			.32

Notes. (i) All loadings greater than .25 are shown.
(ii) Classification of items into the three factors was exactly in accord with Kirton (1976).

This factor structure was much more satisfactory than that found when the full 32-item KAI was subject to factor analysis (Table 9A.4). Only one item loaded greater than 0.3 on two factors. Reliability analysis is given in Table 11.2. For comparison, the same analysis is also given for the full 32-item KAI inventory.

Table 11.2 Reliability analysis of a 25-item KAI scale

	KAI		O		E		R	
No. of items	32	25	13	10	7	6	12	9
Scale mean	97.8	74.6	43.0	33.3	18.3	15.4	36.4	25.9
Scale S.D.	14.3	10.7	7.1	5.8	4.4	3.9	6.6	5.1
Mean inter-item correlation	.18	.17	.26	.30	.33	.37	.27	.28
Cronbach Alpha	.88	.84	.82	.81	.77	.78	.81	.78

The change from a 32-item to a 25-item scale resulted in appreciable increases in the inter-item correlation of the 'O' and 'E', indicating more homogeneous scales. Particularly notable is the effect brought about by the removal of just one bad item (No 15) from the 'E' scale, when Cronbach's alpha increased marginally.

Inter-factor correlations are shown in Table 11.3, figures in parentheses giving comparable data for the full KAI scale as reported by Kirton (1976).

Table 11.3 Inter-factor correlations with a 25-item scale

Pearson correlation coefficients		
'O' v 'E'	.19	(.36)
'O' v 'R'	.33	(.47)
'E' v 'R'	.27	(.42)

Although the lower inter-factor correlations represented useful progress, the differences between the latest figures and the Kirton data just failed to be statistically significant. It was felt to be desirable therefore to explore the possibility of further reducing the number of items in the KAI. The same criteria were used, and the results were monitored in the same way.

Data for KAI scales of 20 items (7 'O'; 6 'E'; 7'R') and 17 items (6 'O'; 5 'E'; 6 'R') are given in Tables 11.4, 11.5 and 11.6.

The results were very encouraging indeed. They showed that it was possible by careful selection to render each of the three sub-scales more homogeneous conceptually, and thereby to derive very sharply defined factor structures. All items had loadings in excess of .30 on one factor only. Although the scales became very much shorter, the inter-item correlation within each sub-scale increased sufficiently to prevent a serious fall in the test reliability.

Table 11.4 Factor structures of 20- and 17-item KAI scales

20-Item Scale (7,6,7)

Item	'O'	'E'	'R'
21	.80		
23	.75		
11	.68		
19	.59		
16	.54		
3	.47		
5	.34		
14		.82	
25		.77	
4		.60	
28		.49	
22		.49	
17		.46	(.29)
2			.72
30	(.26)		.71
6			.59
7			.53
8			.48
20			.42
32			.39

17-Item Scale

Item	'O'	'E'	'R'
21	.79		
23	.76		
11	.70		
19	.58		
16	.53		
3	.46		
14		.83	
25		.77	
4		.60	
22		.49	
28		.49	
2			.75
30	(.27)		.73
6			.55
7			.50
8			.48
20			.41

All loadings in excess of 0.25 are shown.

Table 11.5 Reliability analyses of 20- and 17-item scales

	KAI		'O'		'E'		'R'	
No. of items	20	17	7	6	6	5	7	6
Scale mean	59.8	50.8	24.0	20.6	15.4	13.1	20.5	17.1
Scale S.D.	8.4	7.5	4.2	3.8	3.9	3.6	4.3	3.8
Mean inter-item correlation	.16	.17	.36	.41	.37	.40	.32	.34
Cronbach Alpha	.79	.78	.79	.81	.78	.77	.76	.75

Table 11.6 Inter-factor correlations using 20 & 17 items

	20 Items	17 Items
'O' v 'E'	.10	.09
'O' v 'R'	.24	.21
'E' v 'R'	.21	.19

Furthermore, the objective of reducing inter-factor correlations to a very low level was also achieved. The correlations in Table 11.6 are all significantly lower statistically than the corresponding inter-factor correlations published by Kirton (1976).

It was notable that, in the main, the process of refining the KAI inventory conceptually had resulted in the removal of items which had relatively low loadings on the three sub-scales as determined by Kirton. Without exception, the top four items (in loading order) on each of Kirton's three scales appeared in the refined scales listed in Table 11.4.

Although the refinement of the sub-scales achieved in the 20-item KAI scale was felt to meet the first of the objectives outlined at the beginning of this Chapter, further reduction of the KAI inventory was continued on an exploratory basis as far as a 12-item scale. In this stage of the research, the aims were to further reduce inter-factor correlations with the minimal loss of test reliability. A summary of the findings is given in Tables 11.7, 11.8 and 11.9.

Table 11.7 Factor structure of 15- and 12-item KAI scales

15-Item Scale (5,5,5)

Item	'O'	'E'	'R'
21	.80		
23	.76		
11	.69		
19	.58		
16	.52		
14		.83	
25		.77	
4		.60	
22		.49	
28		.49	
30			.81
2			.72
6			.52
7			.43
20			.42

12-Item Scale (4,4,4)

Item	'O'	'E'	'R'
21	.81		
23	.75		
11	.70		
19	.57		
14		.84	
25		.77	
4		.55	
28		.50	
30			.78
2			.73
6			.54
7			.46

All loadings in excess of 0.25 are shown

Table 11.8 Reliability analyses of 15- and 12-item scales

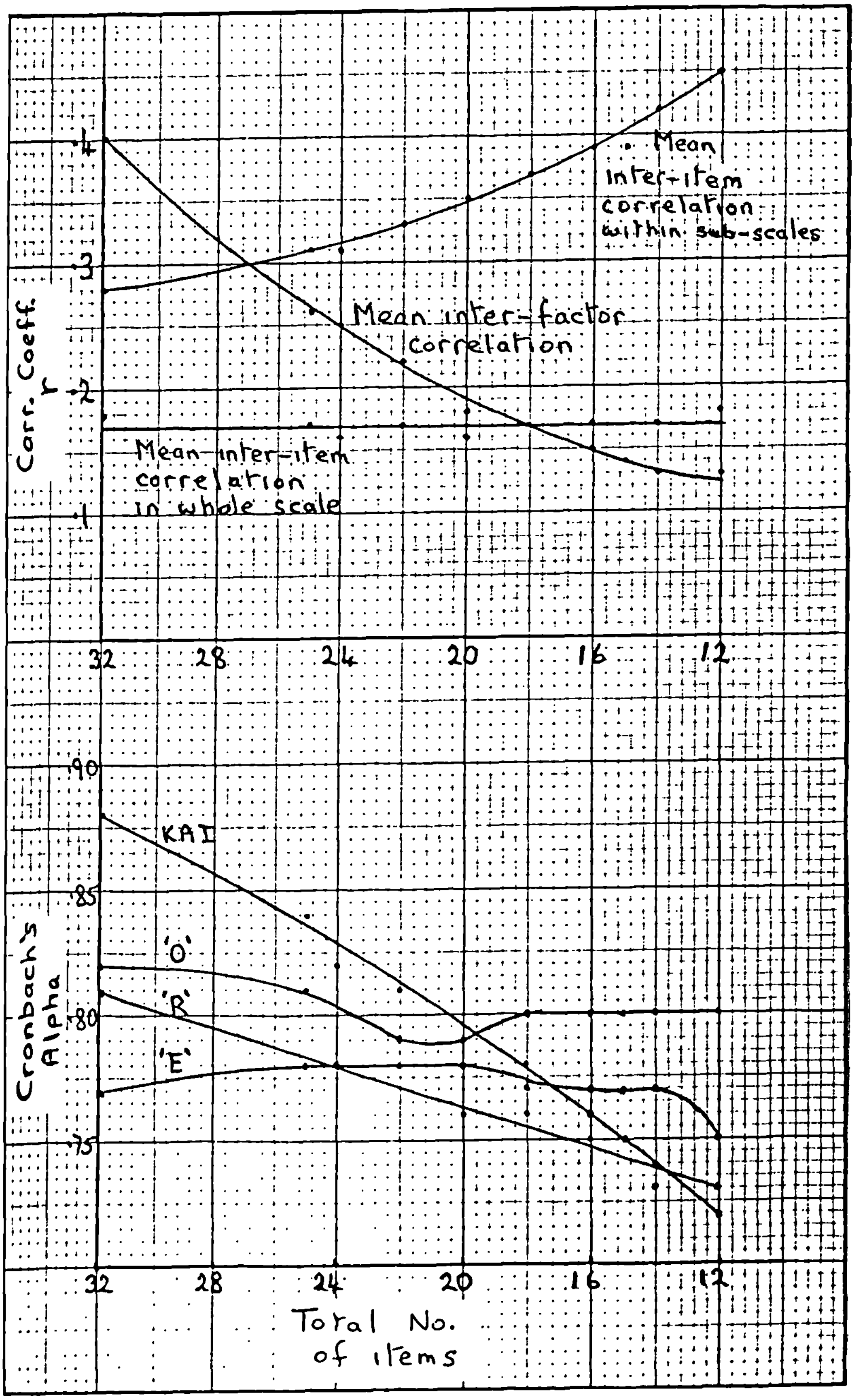
	KAI		'O'		'E'		'R'	
No. of items	15	12	5	4	5	4	5	4
Scale mean	44.2	34.5	16.9	13.3	13.1	10.0	14.1	11.2
Scale S.D.	6.7	5.6	3.4	2.9	3.6	3.0	3.2	2.8
Mean inter-item correlation	.16	.18	.44	.50	.40	.43	.34	.41
Cronbach Alpha	.75	.72	.80	.80	.77	.75	.73	.73

Table 11.9 Inter-factor correlations using 15 & 12 items

	15 Items	12 Items
'O' v 'E'	.09	.08
'O' v 'R'	.17	.16
'E' v 'R'	.15	.15

A graphic summary encompassing the whole series of analyses starting with the full 32-item KAI inventory is given in Figure 11.1. This shows, very clearly, the beneficial trade-off achieved by successive pruning out of potentially ambiguous and conceptually contaminated items. Although the mean inter-item correlation in the whole scale remained unchanged throughout (there was, throughout, a roughly constant mix of the three different entities) within each of the sub-scales the mean inter-item correlation increased as poor items were removed to give a more homogeneous scale. It might have been expected that so drastic a reduction from 32 to 12 items would weaken the test reliability well below acceptable levels, but this is seen not to be the case. The total KAI scale, being an amalgam of three concepts clearly suffers most. The 'O' sub-scale, probably the most heterogeneous of the three at the outset, had most to gain by a refinement process and its reliability held up remarkably well. The 'kink' in the 'O' reliability curve is presumably a peculiarity due to the particular order with which items were removed.

Figure 11.1 Reducing the KAI inventory: a summary



One further point, not apparent in the data presented in the above tables, is that while four factors (or even five) were justified with the 32-item scale, only three factors achieved statistical significance with the reduced scales of 20 items or less. The percentage variance of the items in the scale which was accounted for by the three factors also increased substantially from 34.1% (with 32 items) to 48.3% with 12 items. (It had been a point of concern in the paper by Hammond (1986) that only approximately 30% of the item variance was accounted for by the use of three factors.)

The summary given in Figure 11.1 suggests that the optimum trade off was achieved in the region of 18 to 20 items. In this region all of the Cronbach alphas were in excess of .75, and the inter-factor correlations had been reduced to a level well below the Kirton (1976) levels (statistically significant). The inventory of 20 items was accordingly chosen for the further evaluation to be described in the next Section. The list of items was as follows.

21 Has original ideas
23 Proliferates ideas
11 Has fresh perspectives on old problems
19 Is stimulating
16 Copes with several new ideas at the same time
3 Will always think of something when stuck
5 Would sooner create than improve
. . . .

Continued over page

14 Is thorough
25 Is methodical and systematic
4 Enjoys detailed work
28 Imposes strict order on matters within own control
22 Masters all details painstakingly
17 Is consistent

. . . .

2 Conforms
30 Fits readily into the system
6 Is prudent when dealing with authority
7 Never acts without proper authority
8 Never seeks to bend or break rules
20 Readily agrees with the team at work
32 Prefers colleagues who never rock the boat

11.2 EVALUATION OF A REDUCED KAI INVENTORY

Using the 20-item inventory described in the previous Section, total KAI scores and sub-scale scores were computed for the consolidated sample (n=119). These new KAI measures were then analysed in relation to the research variables described in Chapter 4. The comparison of the full 32-item KAI with the reduced 20-item inventory was made by means of a comparison of the Pearson correlation coefficients between the KAI scores and the array of research variables. At the outset, it was anticipated that the refined sub-scales, particularly the 'O' and 'E' sub-scales, now practically orthogonal, would give more sharply defined differences. Nevertheless, it is acknowledged that a sample size of 119 is insufficient to detect with confidence small differences in correlations, say differences of the order of r = 0.1. Furthermore, in referring to statistical significance in the present context, it is acknowledged that the two entities are not independent samples. Thus the normal statistical approach for comparing differences is not valid and would be prone to give an over-cautious response to significance.

Personal variables

It has been established (Kirton, 1976,1984b) that in general males have greater KAI scores than females, and this was found to be the case with the present data, both for the full and reduced inventories. Using Pearson correlation coefficients (male = 1, female = 2) the male / female difference was slightly greater with the reduced scale. This increased difference (comparing sexes) was due entirely to a greater difference (comparing full and reduced KAI) on the 'O' sub-scale as Table 11.10 shows. On the full inventory one could conclude that females had lower KAI scores owing to a greater tendency to Weberian efficiency and rule / group conformity. On the reduced form, a lower level of idea generation has a greater part.

With regard to age, very small positive correlations (non-significant) had been found with the 32-item KAI. With the reduced KAI the 'E' and 'R' correlations were virtually unchanged, but once again the 'O' correlation was increased slightly (from .05 to .15). The same was also observed with 'length of work experience'. Further comment is hardly due in the face of such weak correlations. (See Table 11.10.)

In connection with R / D orientation, no difference was found between the full and reduced inventories, as Table 11.10 shows. The same could also be said of 'level of qualifications', though with this variable highly significant correlations had been found.

Table 11.10 Comparison of 32- & 20-item KAI: personal data

Pearson correlation coefficients

	KAI		'O'		'E'		'R'	
No. of items	32	20	32	20	32	20	32	20
Sex	-.18	-.25	-.06	-.12	-.19	-.19	-.20	-.21
Age	.09	.14	.05	.15	.07	.07	.10	.06
Work experience	.07	.14	.01	.11	.03	.04	.12	.14
R / D orient.	-.01	-.00	-.03	-.06	-.04	-.06	.03	.11
Qualifications	.34	.32	.31	.30	.25	.18	.24	.17

Organisation environment (See Table 11.11)

With all three collaboration measures (warm sympathetic integration, open authentic communication, knowledge-based risk taking) there was little difference between the full and reduced scales, except for some indication that the negative correlations with the 'E' sub-scale were stronger. There was no evidence at all that the refined 'O' scale gave different measures in this context. With all three management style measures (personal autonomy and responsibility, work pressure, quality of leadership) there were no clear patterns among the small differences between the full and reduced inventories.

Table 11.11 Comparison of 32/20-item KAI: environment data

Pearson correlation coefficients

	KAI		'O'		'E'		'R'	
No. of items	32	20	32	20	32	20	32	20
W.S.I	-.04	-.14	.11	.08	-.18	-.25	-.08	-.13
O.A.C.	-.00	-.09	.14	.16	-.25	-.32	.01	-.04
K.B.R.T.	.09	.02	.22	.22	-.24	-.28	.13	.08
COLL. INDEX	.02	-.09	.19	.19	-.28	-.35	.02	-.04
P.A.R.	-.16	-.24	-.01	-.04	-.22	-.24	-.18	-.21
Work pressure	.04	.03	.07	.07	-.13	-.11	.10	.09
Qual. of leadr.	-.22	-.31	-.05	-.06	-.25	-.27	-.26	-.29

Job needs and satisfactions (See Table 11.12)

Regarding job needs, two of the categories, professional needs and status needs, showed very similar patterns of correlations with both of the KAI inventories. Some comment seems justified, however, with regard to job conditions needs and self actualisation needs. Job conditions needs showed a negative correlation with all three sub-scales when using the full KAI. That is to say, the 'conformers', the 'efficient' and the 'satisficing originators' all tended to rate job conditions needs low. (See Section 5.2 for comment.) With the 20-item KAI, however, correlations with the 'O' and 'R' sub-scales were much reduced. It is difficult to understand the difference, assuming that it is more than sampling aberration (a point by no means clear). The two 'R' sub-scales are not really different in concept, whereas the two 'O' sub-scales are. With self actualisation needs, a similar pattern of differences was found, the 'O' scale correlation being most weakened when using the 20-item inventory. It could be inferred that a stronger correlation exists with the items eliminated from the 'O' scale than with the items remaining. That is to say, self actualisation needs may be more strongly correlated with the 'O' items having connotations of 'propensity for change' than with 'O' items measuring 'level of idea generation'. This would make sense conceptually.

Turning to job opportunities, it was possible to make a generalisation covering all four types of needs. Using the full inventory, there had tended to be a pattern of weak positive correlations with the 'O' sub-scale and weak negative correlations with the 'E' sub-scale. Using the 20-item inventory, this pattern was repeated, but slightly accentuated. The same comment applied to the job satisfaction index (JSI), which aggregated the various opportunities. This sort of result can be accounted for in terms of a slightly greater discriminating power brought about by 'cleaner' sub-scales. Table 11.12 gives the data.

Table 11.12 Comparison of 32/20-item KAI: job needs data

Pearson correlation coefficients

	KAI		'O'		'E'		'R'	
No. of items	32	20	32	20	32	20	32	20
Prof. needs	.04	-.01	.14	.16	-.14	-.19	.02	-.00
Job cond needs	-.31	-.26	-.13	-.03	-.24	-.24	-.37	-.26
Status needs	.03	.02	.13	.13	-.09	-.11	-.02	.01
Self act. needs	.36	.27	.49	.39	.01	-.05	.25	.19
Prof. opportun.	.01	-.02	.11	.15	-.13	-.16	-.01	-.04
Job cond opport	-.00	-.03	.10	.12	-.02	-.07	-.10	-.12
Status opportun	.05	.02	.13	.15	-.03	-.06	-.02	-.04
Self act opport	.02	-.04	.23	.26	-.13	-.18	-.12	-.18
Job Satis Index	-.03	-.07	.14	.18	-.13	-.18	-.12	-.15

Performance measures (See Table 11.13)

It was with the two performance measures, creative performance and skills performance, that the most remarkably strong and contrasting correlations with KAI sub-scales had been found in the work described earlier. Using the 20-item inventory, correlations with the 'R' sub-scale and with the total KAI remained virtually unchanged, as did all of the correlations with skills performance. That is to say, the only differences of note between the full and reduced inventories were in connection with creative performance, and involved the 'O' and 'E' sub-scales. The differences were not great however. The already very strong correlation between creative performance and the 'O' sub-scale increased from 0.59 to 0.62 while the very weak (non-sig.) correlation with 'E' diminished to zero.

The direction of these results was certainly in accord with expectation, ie. a sharper distinction between 'O' and 'E' sub-scales where their correlates were very different. The differences were small, but a stronger correlation between creative performance and any variable could hardly be expected, ie. many factors impinge on the level of performance of a scientist, and no single variable could be expected to account for the majority of the variance.

The absence of any substantial differences in connection with skills performance was, perhaps, disappointing. Nevertheless, such very small difference as there were, lay in the expected direction, viz. correlation with 'O' even closer to zero; and the negative correlation with 'E' (positive correlation with Weberian efficiency) , stronger. Table 11.13 gives the data.

Table 11.13 Comparison of 32/20-item KAI:performance data

Pearson correlation coefficients

	KAI		'O'		'E'		'R'	
No. of items	32	20	32	20	32	20	32	20
Creative perf.	.45	.46	.58	.62	.07	.00	.30	.28
Skills perf.	-.16	-.19	-.06	-.04	-.36	-.37	-.04	.02

In summing up this comparitive evaluation of the reduced KAI inventory, it must be admitted that the differemces found between the two versions of KAI were smaller than anticipated. Nevertheless, with very few exceptions, such differences as were found were intelligible conceptually. Furthermore, it must be remembered that the items with the principal loadings on the Kirton 32-item inventory were, without exception, retained in the 20-item version. The reduction should be viewed as a refinement rather than a reconstruction. Certainly, the concepts underlying the 'E' and 'R' sub-scales remained unchanged. It was only with the 'O' sub-scale that a change of concept was involved and, as noted above, the items used to operationalise the new concept were the heavily loading items on the old inventory. Correlations between the equivalent subscales in the 32- and 20-item inventories were all 0.90 or greater. The full matrix of correlations is given in Table 11.14.

Table 11.14 Correlations between the two inventories

		20-Item Inventory			
		KAI	'O'	'E'	'R'
	KAI	.95	.66	.55	.71
32-Item	'O'	.75	.90	.20	.40
Inventory	'E'	.68	.18	.97	.26
	'R'	.80	.35	.33	.92

11.3 TOWARDS A NEW KAI INVENTORY

Methodology

The remarkable clarification of the factor structure that could be achieved by removing 'poor' items was demonstrated in Section 11.1. The present Section describes the work which attempted to supplement the better KAI items with additional, newly devised, items. Since fresh data was needed to do this, and since a sample size of the order of n=200 could be regarded as a minimum for factor analytic work involving 40+ items, a sample of mature students of management was the only feasible prospect in the timescale available. With n=200 seen as a realistic, though not easy, target sample size, it was decided to restrict the total number items to 44, ie. to restrict the number of new items to twelve, four to each of the three sub-scale concepts. The following lists give these new items.

(A) 'O' Sub-scale. Concept: level of idea generation.

A person who:

(i) Enjoys toying with ideas.

(ii) Never tires of making suggestions for new approaches to questions.

(iii) Prefers to work with practicalities rather than theoretical ideas (scored negatively).

(iv) Will readily produce several explanations of new events.

(B) <u>'E' Sub-scale. Concept: Weberian inefficiency, the antithesis of precision and thoroughness.</u>

A person who:

(i) Always works with precision (scored negatively).

(ii) Can be relied upon for very careful work (scored negatively).

(iii) Is often regarded as an undisciplined person.

(iv) Becomes bored with meticulous work.

(C) <u>'R' Sub-scale. Concept: Non-conformity</u>

A person who:

(i) Is reluctant to break with established methods (scored negatively).

(ii) Is inclined to argue about anything

(iii) Has little or no regard for conventional attitudes

(iv) Will face up to anyone, including the boss.

An inventory incorporating these twelve items randomly amongst the 33 KAI items (Item 1 being a blank) was compiled. All students attending classes at the Department of Management Studies, Sheffield City Polytechnic, during the last week of term, December 1986, were invited to complete the inventory. As far as the writer is aware, no student declined to participate, but a considerable number were absent that week. As a result, the sample size was 165. One student kindly volunteered to ask his management colleagues to complete the inventory, and this brought the total to 181. At a little over four times the total number of items in the inventory, it was felt to be just sufficient to support factor analytic work.

Factor analysis of the 44-item inventory

Although it was anticipated that the twelve 'poor' items deleted from the KAI inventory in Section 11.1 would again be deleted (ie. the new items would supplement the 20-item inventory), a factor analysis was first of all run on the complete 44-item inventory. Specifying three factors, the factor structure shown in Table 11.15 was obtained. [As might be anticipated from the Scree Diagram shown in Figure 11.2, four factors could be extracted with a high degree of statistical significance (chi-square, $p < .001$)].

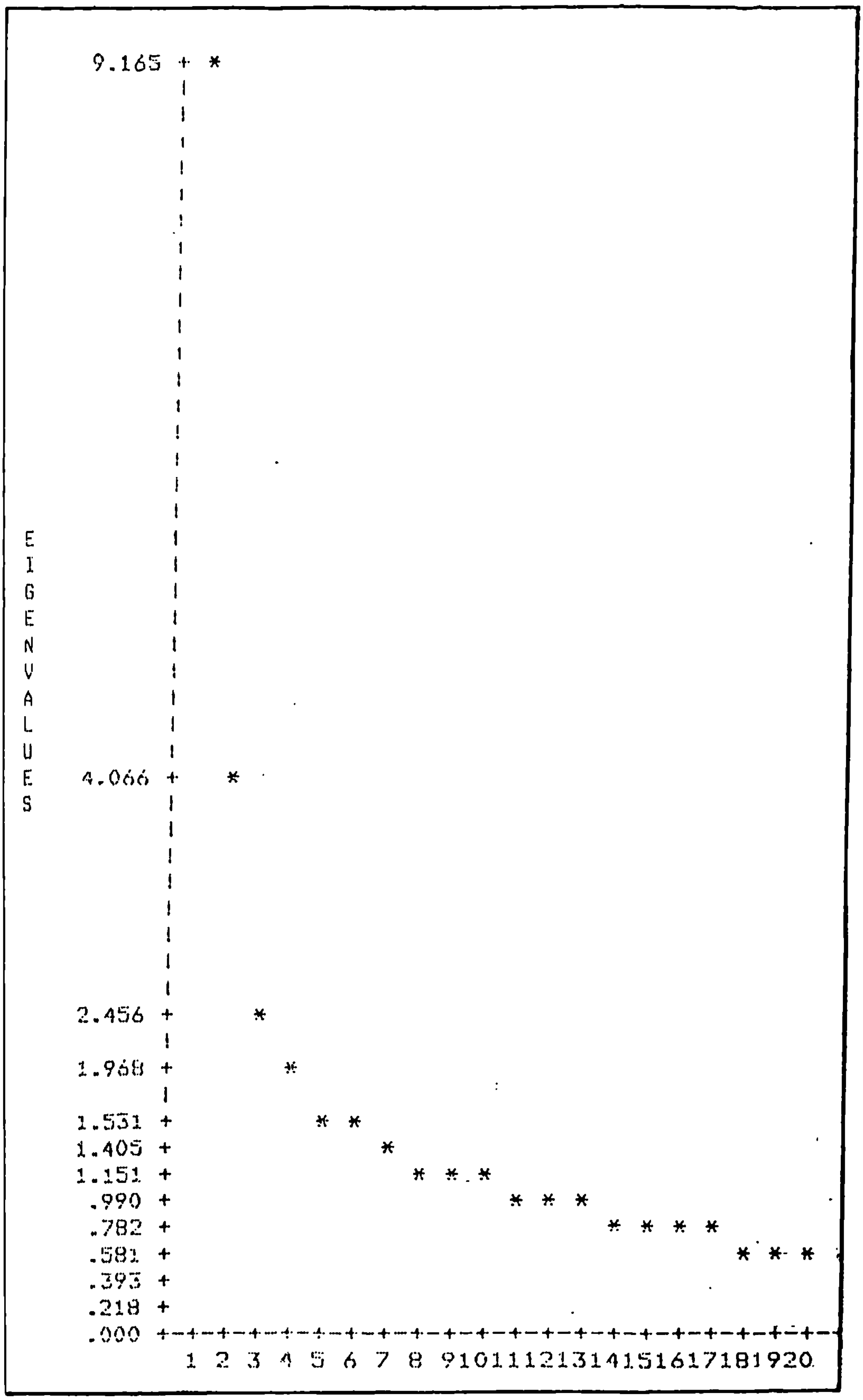
In each of the factors, the items with the greater loadings were all correctly located, ie. existing items were in line with the Kirton classification and new items were as specified beforehand. Furthermore, only four items had loadings exceeding 0.30 on more than one factor. To this extent the factor structure was encouraging. However, lower down the loading lists several items were 'misplaced' and there were 13 items with a second factor loading in the range 0.20 to 0.30.

Table 11.15 Factor structure of a 44-item inventory

ITEM		'O'	'E'	'R'
32 Proliferates ideas	(O)	.72		
17 Has fresh perspectives on old problems	(O)	.68		
14 Never tires of making suggestions	(O*)	.65		
24 Copes with several new ideas	(O)	.64		
30 Has original ideas	(O)	.63		
3 Enjoys toying with ideas	(O*)	.59		
36 Often risks doing things differently	(O)	.56	.35	
27 Is stimulating	(O)	.54		
26 Able to stand out in disagreement	(O)	.51		.30
43 Needs stimulation of frequent change	(O)	.49	.30	
39 Will readily produce explanations	(O*)	.48		
44 Prefers colleagues who never rock	(R)	.47	.22	.21
6 When stuck will always think of some..	(O)	.45		
16 Holds back ideas until obviously needed	(R)	.45		.23
23 Is a steady plodder	(E)	.42		.29
40 Likes the protection of precise instr.	(R)	.41	.28	.31
37 Works without deviation in a	(R)	.39	.39	.27
34 Prefers to work on one problem	(O)	.37		
8 Would sooner create than improve	(O)	.34		
45 Is predictable	(R)	.31		.29
28 Is reluctant to break with established.	(R*)	.31		.24
35 Is methodical and systematic	(E)		.76	
4 Always works with precision	(E*)		.75	
22 Is thorough	(E)		.73	.22
31 Masters all details painstakingly	(E)		.65	
7 Enjoys detailed work	(E)		.61	
42 Can be relied upon when very careful..	(E*)		.54	
38 Likes to impose strict order on	(E)		.44	
12 Becomes bored with meticulous work	(E*)		.42	
10 Prefers to work with practicalities ..	(O*)		.24	
2 Conforms	(R)			.63
41 Fits readily into the system	(R)		.23	.57
9 Is prudent when dealing with authority.	(R)			.53
33 Has little regard for conventional ...	(R*)			.53
25 Is consistent	(E)		.43	.50
11 Never acts without proper authority	(R)			.49
18 Is regarded as rather undisciplined	(E*)		.39	.49
20 Will argue with anyone, including boss	(R*)	.26		.44
13 Never seeks to bend or break the rules	(R)	.23	.22	.37
29 Readily agrees with the team at work	(R)	.22		.29
19 Likes to vary set routines	(O)		.22	.29
15 Likes bosses/ work patterns consistent	(R)			.26
5 Is inclined to argue about anything	(R*)			.24
21 Prefers changes to occur gradually	(O)			.21

Parentheses denote Kirton classification, *denotes new item

Figure 11.2 Scree Diagram for 44-Item Inventory (n=181)



Moreover, several of the 'better' items (ie. items included in the 20-item inventory evaluated earlier) gave disappointing results. Particularly notable was Item 25, 'Is consistent', which in this latest sample loaded more heavily on 'R' than on 'E', and also Item 44, 'prefers colleagues who never rock the boat', which loaded more heavily on 'O' than on 'R'. Regarding the new items, most but not all appeared on the factors anticipated. Three out of four of each group of new items were 'correctly' placed.

Following this preliminary analysis, the next factor analysis was carried out with the 20-item list developed earlier supplemented by the twelve new items, ie. an inventory of 32 items. Table 11.16 gives the factor structure. Although this was a considerable improvement over the 44-item inventory, there were still five misplaced items, three of them being new items (*misplaced as in the* previous factor analysis). There was clearly no justification for retaining the three misplaced new items, Items 10, 17 and 28. Each of these items had similar loadings on at least two factors. Nor was there justification for retaining Item 25 (Kirton No. 17, 'E') and Item 44 (Kirton No. 32, 'R'). It is interesting to note that although these two items had been on the 20-item inventory, they had the lowest loadings on their respective factors. In the case of Item 25, a significant though smaller, 'R' loading had been found with the n=119 sample.

Table 11.16 Factor structure of a 32-item inventory (n=181)

Item No.	Kirton ref.	Type	'O'	'E'	'R'
32	23	'O'	.76		
17	11	'O'	.71		
14	--	'O'*	.68		
30	21	'O'	.63		
3	--	'O'*	.61		
24	16	'O'	.58		
27	19	'O'	.54		
39	--	'O'*	.48		
6	3	'O'	.46		
44	32	'R'	.44	.22	.20
8	5	'O'	.36		
28	--	'R'	.26		.21
35	25	'E'		.76	
4	--	'E'*		.76	
22	14	'E'		.73	.22
31	22	'E'		.64	
7	4	'E'		.63	
42	--	'E'*		.55	
38	28	'E'		.43	
12	--	'E'*		.42	
10	--	'O'*		.24	.20
2	2	'R'			.62
41	30	'R'		.23	.60
9	6	'R'			.56
33	--	'R'*			.52
18	--	'E'*		.38	.50
11	7	'R'			.49
25	17	'E'		.42	.47
20	--	'R'*	.25		.45
13	8	'R'		.22	.37
5	--	'R'*			.28
29	20	'R'			.25

An asterisk indicates a new item.
All loadings in excess of 0.20 are shown.

With these items removed, an inventory of 27 items (ten 'O' eight 'E' and nine 'R') was factor analysed. Not surprisingly, all items were correctly placed. With loadings less than 0.30 removed, the factors have an extremely clear structure, but in Table 11.17, which gives details, loadings down to 0.20 have again been included to illustrate the point that several items had a second loading bordering on significance.

Table 11.17 Factor structure of a 27-item inventory (n=181)

Item No.	Kirton ref.	Type	'O'	'E'	'R'
32	23	'O'	.77		.20
17	11	'O'	.71		
14	--	'O'*	.66		
30	21	'O'	.63		
3	--	'O'*	.61		
24	16	'O'	.57		
27	19	'O'	.52		
39	--	'O'	.48		
6	3	'O'	.46		
8	5	'O'	.37		
4	--	'E'*		.76	
35	25	'E'		.75	
22	14	'E'		.73	.21
31	22	'E'		.64	
7	4	'E'		.64	
42	--	'E'*		.56	
12	--	'E'*		.43	
38	28	'E'		.42	
2	2	'R'			.60
41	30	'R'		.23	.60
9	6	'R'			.54
11	7	'R'			.53
20	--	'R'*	.22		.51
33	--	'R'*			.48
13	8	'R'		.23	.40
5	--	'R'*			.30
29	20	'R'			.29

All loadings of 0.20 and greater are shown.

These weak secondary loadings reflect weak correlations with items in other sub-scales and do not augur well for low inter sub-scale correlations. Furthermore, none of the

'R' items had loadings in excess of 0.70, in contrast to the n=119 sample, and two items had weak loadings around 0.30. These features are reflected in the lower reliability coefficient for the 'R' sub-scale, as shown below.

Table 11.18 Reliability coefficients: 27-item inventory

(n=181)	Cronbach's Alpha
Total scale	0.85
'O' Sub-scale	0.84
'E' Sub-scale	0.83
'R' Sub-scale	0.74

These reliabilities were regarded as very satisfactory. What was felt to be much less satisfactory were the inter-factor correlations as shown below.

Inter-factor correlations

'O' v 'E'	r = 0.20	(27-item inventory)
'O' v 'R'	r = 0.33	(n=181)
'E' v 'R'	r = 0.27	

These correlations were disappointingly large in comparison with those of the 20-item inventory discussed in Section 11.1, with which it had been anticipated they would be of comparable magnitude. They were in fact similar to the inter-factor correlations of the 25-item inventory based entirely on Kirton KAI items (see Table 11.3). However, the reliabilities in the present case were in general better (see Table 11.2).

A scrutiny of the correlation matrices of the two samples (n=119 and n=181) showed some interesting differences. Taking key items on a particular sub-scale (ie. items loading very heavily), it was noticeable that in general correlations with key items on one of the <u>other</u> sub-scales were greater with the student sample (n=181) than with the scientist sample (n=119). For example, let us take the 'O' item No. 23 (Kirton), 'proliferates ideas', and two 'R' items, No. 2, 'conforms' and No. 30, 'fits readily into the system'. The correlations between them with the two samples were as follows.

	Sample n=119	Sample n=181
No. 23 v No. 2	.06	.16
No. 23 v No. 30	.15	.25

In both cases these correlation coefficients were within sampling error of each other. Nevertheless, the effect of several such differences <u>involving key items</u>, rendered it virtually impossible to derive scales for the n=181 sample which approached the degree of orthogonality of the n=119 sample. It was by no means clear which sample was closer to the 'truth'. Implicit in the effort to derive orthogonal sub-scales is the hypothesis that the concepts are unrelated. Such evidence as is available from the present research suggests that 'O' and 'E' concepts may well be unrelated (non-significant correlations were reached with the n=119 sample as the weaker loading items were progressively removed). There is the prospect that better measures than have presently been used could lead to orthogonal 'O' and 'E' scales of very high reliability. The pervasive small (individually non-significant) positive correlations between 'O' and 'R' items and between 'E' and 'R' items suggested otherwise. That is to say, there may be, inherently, a slight tendency for those people fertile in idea generation to be non-conformers, the very fact that they persistently view situations from new and different perspectives may make it difficult for them to conform. Similarly, those for whom regular, painstaking work is not to their inclination may be seen (and be perceived as being seen) as non-conformers.

A final attempt to reduce inter-factor correlations, yet maintain test reliability, was made by removing five items which had low loadings on their principal factor and secondary loadings in the range 0.13 to 0.18. Several 'R' items having secondary loadings in the range 0.20 to 0.23 were nevertheless retained because of their greater primary loading and because they were felt to be central to the concept being operationalised. This gave a 22-item inventory; eight 'O', six 'E' and eight 'R'. The factor structure, specifying three factors, is given in Table 11.19. It was very much as anticipated, having a remarkably clear factor structure, especially when compared to the published Kirton (1976) KAI factor structure.

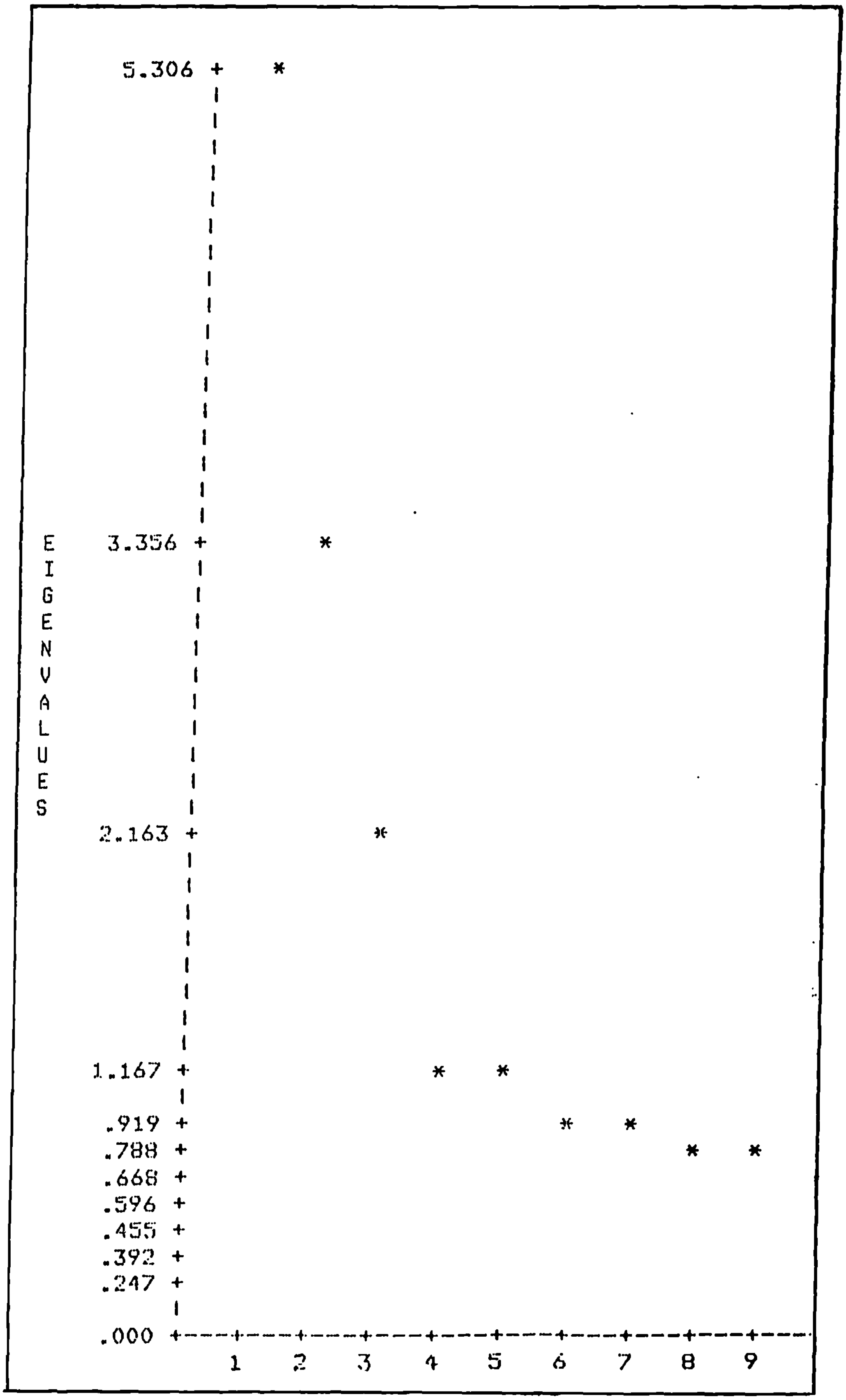
Table 11.19 Factor structure of a 22-item inventory (n=181)

ITEM	'O'	'E'	'R'
32(23) Proliferates ideas	.78		
17(11) Has fresh perspectives on old problems	.70		
14(--) Never tires of making suggestions	.67		
30(21) Has original ideas	.63		
3(--) Enjoys toying with ideas	.59		
24(16) Copes with several new ideas	.57		
27(19) Is stimulating	.53		
39(--) Will readily produce explanations	.49		
4(--) Always works with precision		.76	
35(25) Is methodical and systematic		.75	
22(14) Is thorough		.73	.20
7(4) Enjoys detailed work		.64	
31(22) Masters all details painstakingly		.63	
42(--) Can be relied upon when very careful..		.57	
2(2) Conforms			.61
41(30) Fits readily into the system		.23	.58
11(7) Never acts without proper authority			.56
9(6) Is prudent when dealing with authority			.54
33(--) Has little regard for conventional ...			.49
20(--) Will argue with anyone, incuding boss	.23		.48
13(8) Never seeks to bend or break the rules		.22	.43
29(20) Readily agrees with the team at work			.29

All loadings of 0.20 and greater are included.
Parentheses indicate Kirton KAI reference numbers.

The Scree Diagram, given in Figure 11.3, showed a much sharper discontinuity than the Scree Diagram for the 44-item inventory (Figure 11.2), and there was no longer a case for entertaining a four or five factor model. Whereas the three factor model was highly significant statistically (chi-square, p=.004), a four factor model was not significant (chi-square, p=.21). [The fourth factor of a four factor model comprised a single item, No. 13, the rest of the structure being unchanged.]

Figure 11.3   Scree Diagram for a 22-item inventory (n=181)



The reliability coefficients of this 22-item inventory were also satisfactory as Table 11.20 shows. Cronbach's alpha for the total scale was marginally reduced compared to the 27-item inventory, but with the sub-scales Cronbach's alpha was either unchanged ('O' and 'R') or marginally increased ('E'). Once again this work has demonstrated that it is possible to make the reliabilities of the sub-scales as high as the total scale, a feature which does not apply to the published KAI inventory.

Table 11.20 Reliability coefficients: 22-item inventory

(n=181)	Cronbach's Alpha
Total scale	0.83
'O' Sub-scale	0.84
'E' Sub-scale	0.84
'R' Sub-scale	0.74

Regarding the inter-factor correlations, there was the anticipated substantial reduction in the 'O' v 'E' correlation (the deletion of items had been carried out with this as the primary objective), but only a marginal reduction in the other correlations, as Table 11.21 shows.

Table 11.21 Inter-factor correlations: 22-item inventory

(n=181)	'O' v 'E'	$r = 0.11$	(non-sig.)
	'O' v 'R'	$r = 0.31$	
	'E' v 'R'	$r = 0.26$	

Nevertheless, all three correlation coefficients were significantly lower than the inter-factor correlations given by Kirton (1976), (for the 'O' v 'E' correlation, $p < .01$, for the other two, $p < .05$). Thus the 22-item inventory listed in Table 11.19, containing 15 items from the published KAI and supplemented by 7 new items, can be regarded as useful progress towards an inventory with high sub-scale reliability and very low inter sub-scale correlations. It offers the best combination of properties that it has been possible to devise in the present research. Table 11.22 gives further statistics relating to this inventory.

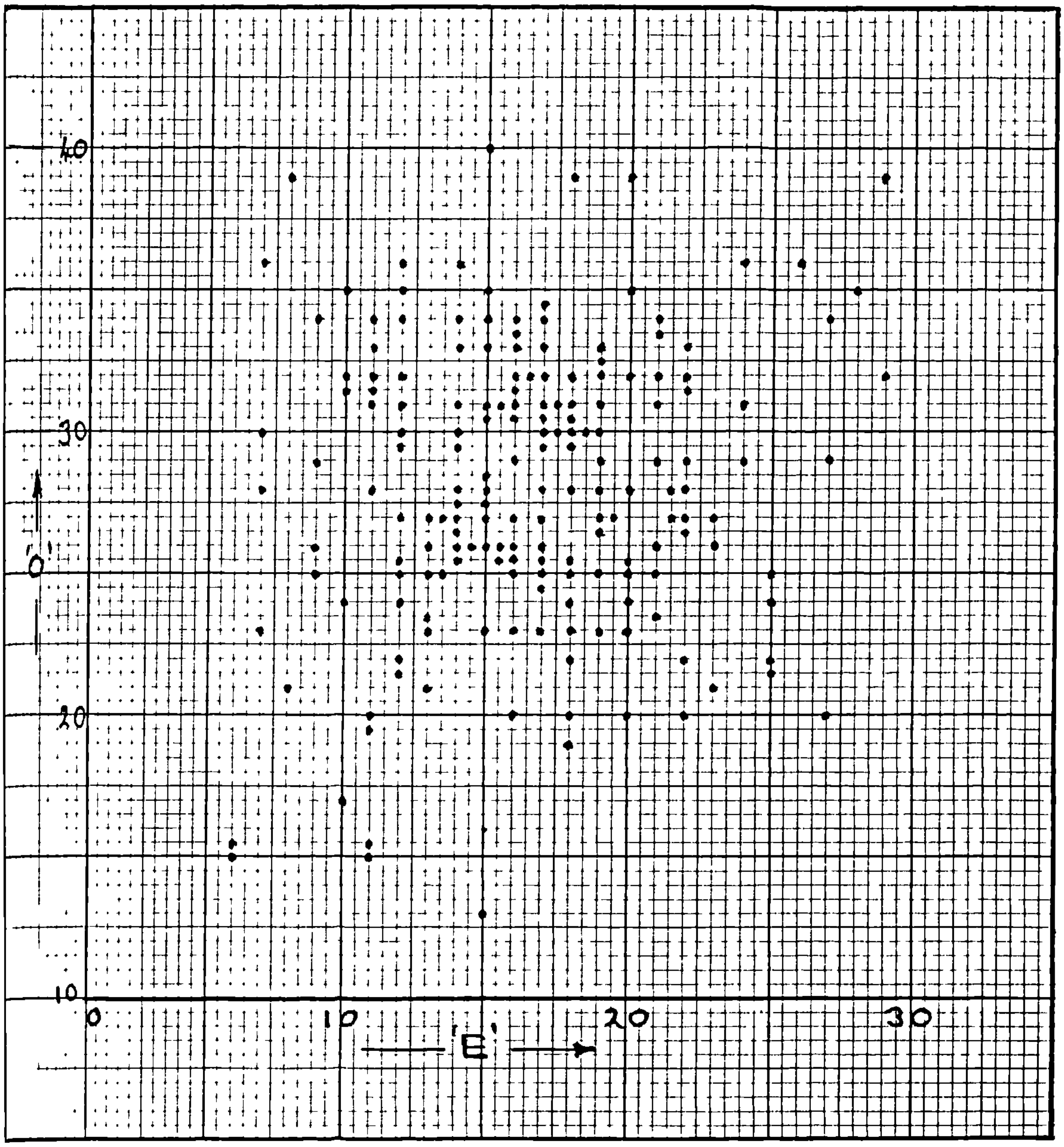
Table 11.22 A new 22-item 'KAI': scale statistics

	Total	'O'	'E'	'R'
No. of items	22	8	6	8
Scale mean	69.3	28.1	16.5	24.7
Scale S.D.	10.5	5.1	4.8	5.2
Inter-item corr.	0.18	0.39	0.47	0.27
Item means: min.	2.4	3.3	2.4	2.6
max.	3.7	3.7	3.3	3.6

Finally, a graphic illustration of the virtually orthogonal nature of the 'O' and 'E' sub-scales, is given in Figure 11.4. This illustrates, rather more powerfully than does the correlation coefficient $r = 0.11$, the scatter in the two dimensions.

Figure 11.4 Scatter in the 'O'-'E' plane

22-Item inventory (n=181)



11.4 FURTHER CONSIDERATION OF THE 'O' SUB-SCALE

Doubts about the conceptual status of the 'O' sub-scale were raised in Section 10.2, when it was suggested that at least half of the items were likely to be a measure of 'level of idea generation'. Subsequent factor analysis in Section 10.3 provided support for this hypothesis by showing that two factors could be extracted from the 'O' sub-scale items, and that these two sub-factors were closely in line with expectation. That is to say, there was a major factor comprising nine items (level of idea generation) and a minor factor comprising four items. It is suggested that the latter is a measure of cognitive style and could tentatively be labelled 'attitude to change'. The items of these two sub-factors, with the direction of their KAI scoring, are given below.

Sub-factor 'OA': 'level of idea generation'.

Item 21	Has original ideas	(+)
Item 23	Proliferates ideas	(+)
Item 11	Has fresh perspectives on old problems	(+)
Item 19	Is stimulating	(+)
Item 16	Copes with several new ideas at the same time	(+)
Item 26	Often risks doing things differently	(+)
Item 3	Will always think of something when stuck	(+)
Item 18	Can stand out in disagreement against group	(+)
Item 5	Would sooner create than improve	(+)

Sub-factor 'OB': 'attitude to change'.

Item 13	Prefers changes to occur gradually	(-)
Item 12	Likes to vary set routines at moment's notice	(+)
Item 31	Needs the stimulation of frequent change	(+)
Item 24	Prefers to work on one problem at a time	(-)

(-) negative scoring (+) positive scoring
N.B. all 13 items and the direction of scoring are as specified by Kirton (1977) for the KAI 'O' sub-scale.

Having found a very strong correlation in earlier work between creative performance and the 'O' sub-scale it was of interest to find if the two sub-groups of items had different correlates with creative performance. Table 11.23 gives the results when the creative performance measure was added to the KAI data matrix for the research scientist sample (n=119), and Pearson correlation coefficients were calculated between creative performace and each 'O' sub-scale item.

Table 11.23 Correlations: creative performance v 'O' items

	Item	Corr. coeff.
23	Proliferates ideas	0.62
21	Has original ideas	0.55
19	Is stimulating	0.46
26	Often risks doing things differently	0.40
16	Copes with several new ideas at the same time	0.38
11	Has fresh perspectives on old problems	0.37
3	Will always think of something when stuck	0.37
18	Can stand out in disagreement against group	0.23
5	Would sooner create than improve	0.18
13	Prefers changes to occur gradually	0.28
24	Prefers to work on one problem at a time	0.26
12	Likes to vary set routines at a moment's notice	0.15
31	Needs the stimulation of frequent change	0.13

Although there was some little overlap between the groups, the distinction was remarkable. When the same data matrix was subjected to factor analysis, specifying two factors, it was not surprising to find that the creative performance measure was placed in the factor containing the first group of items. Table 11.24 gives the factor loadings.

Table 11.24 Factor loadings: 'O' items with creative perf.

	Factor 1	Factor2
Item 21	.79	
Item 23	.78	
Creative performance	.68	
Item 11	.65	
Item 19	.57	
Item 16	.50	.30
Item 26	.49	.25
Item 3	.46	
Item 18	.42	
Item 5	.28	.27
Item 13		.79
Item 12		.69
Item 31		.66
Item 24	.34	.44

All loadings of 0.20 and greater are shown.

It may be recalled that it was a similar methodology that Kirton (1987) used to associate the KAI with measures of cognitive style in the data matrix · ˜ Torrance (Table 10.1) In the present case, the factor analysis has served to provide a further pointer towards the conclusion that several of the 'O' sub-scale items are measures of a level of cognitive ability rather than a cognitive style. Item 5 once again had two similar weak loadings (cf. Table 10.10) and it is difficult to place it as an item of 'style' or 'level', though its correlation with creative performance (Table 10.13) would place it as an item of 'style'. It would also appear to have face validity as such.

In view of the sharp distinction between the two sets of 'O' items as demonstrated in Tables 10.13 and 10.14, scores were computed for the separate sub-factors, labelled 'OA' and 'OB'. The research scientist data (n=119) was used for this purpose. (In line with the earlier factor analysis, Table 10.6, Item 5 was included in the 'OA' sub-set although it was anticipated that this might weaken any distinction between the scores.) Correlations were then obtained between both performance measures and the new 'O' sub-set scales. Table 11.25 gives the correlation matrix.

Table 11.25 Correlation matrix involving 'OA' and 'OB'

	1	2	3	4	5	6
1 Creative perf.	1.0	0.13	0.15	0.58	0.62	0.27
2 Skills perf.		1.0	0.21	-0.06	-0.03	-0.09
3 Jot satis. index			1.0	0.14	0.17	0.04
4 'O' sub-scale				1.0	0.91	0.73
5 'OA' sub-set					1.0	0.38
6 'OB' sub-set						1.0

These figures provided confirmation of the sharp contrast between the 'OA' and 'OB' sub-sets, with respect to correlation with creative performance. Although the correlation r = 0.27 (creative performance v 'OB') is statistically significant, the difference between r = 0.62 and r = 0.27 was overwhelming evidence that these two sub-sets of the 'O' sub-scale were measuring different concepts. Interestingly, the correlations with skills performance were similar and non-significant statistically. Also of interest was the relatively low, though significant, correlation (r = 0.38) between the two new scales.

Partialling out the effects of 'OA' and 'OB' in turn further sharpened the distinction between these two sub-scales of the 'O' sub-scale, as Table 11.26 shows.

Table 11.26 Partial correlation coeffs. of 'OA' and 'OB'

	'OA'('OB')	'OB'('OA')
Creative performance	.58	.05
Skills performance	.00	-.08
Job atisfaction index	.16	-.03

* Parentheses denote the variable partialled out.

Thus it can be seen that the correlation between creative performance and 'OA' remained very strong and little changed but the correlation between creative performance and 'OB' which was reduced from 0.27 to 0.05 by the partialling process. The very remarkable contrast between 'OA' and 'OB' shown by Table 11.26 provided very strong support for the argument that the 'O' sub-scale must be regarded as conflating two concepts.

Partial correlatives of 'OA' and 'OB' with the job satisfaction index were much less sharply contrasted, though the correlation with 'OA' (r = 0.16) was just statistically significant (p = .04). Further investigation of job satisfaction was felt to be of interest, however, for another reason. Given the modest correlation between 'OA' and 'OB' (r = 0.38) a substantial amount of scatter in the 'OA'-'OB' plane could be anticipated (cf. scatter in the 'O'-'E' plane which was used to characterise the four Types in Chapter 6). A conceptual framework provided by the 'OA'-'OB' dimensions was thus visualised as shown below.

```
                          HIGH 'OA'
           (2)                 |            (1)
     Stability orientated      |   Change orientated
                               |
     High level of             |   High level of
     idea generation           |   idea generation
LOW  --------------------------|----------------------- HIGH
'OB'       (3)                 |            (4)          'OB'
     Stability orientated      |   Change orientated
                               |
     Low level of              |   Low level of
     idea generation           |   idea generation
                               |
                           LOW 'OA'
```

Category 1 would suggest a consonance between the two attributes, viz. a cognitive style orientated towards change, and an appropriate cognitive ability to complement it. Category 3 also suggested consonance. Although the description of Category 3 looked inappropriate for R & D staff, it is possible that such staff could find an appropriate niche, perhaps in analytical services or in development work where their cognitive style and ability allowed them to achieve a satisfactory performance. Category 2, (a minority given a positive correlation between 'OA' and 'OB') implies redundancy in idea generation. Nevertheless, in a R & D setting the surfeit of ideas would hardly be perceived as a handicap. It was with Category 4 that problems could be foreseen. Persons in this category perceive themselves as change orientated yet lacking in the ability to generate ideas for such change. Category 4 suggested cognitive dissonance, and people in this category could be expected to have low job satisfaction, if employed in R & D.

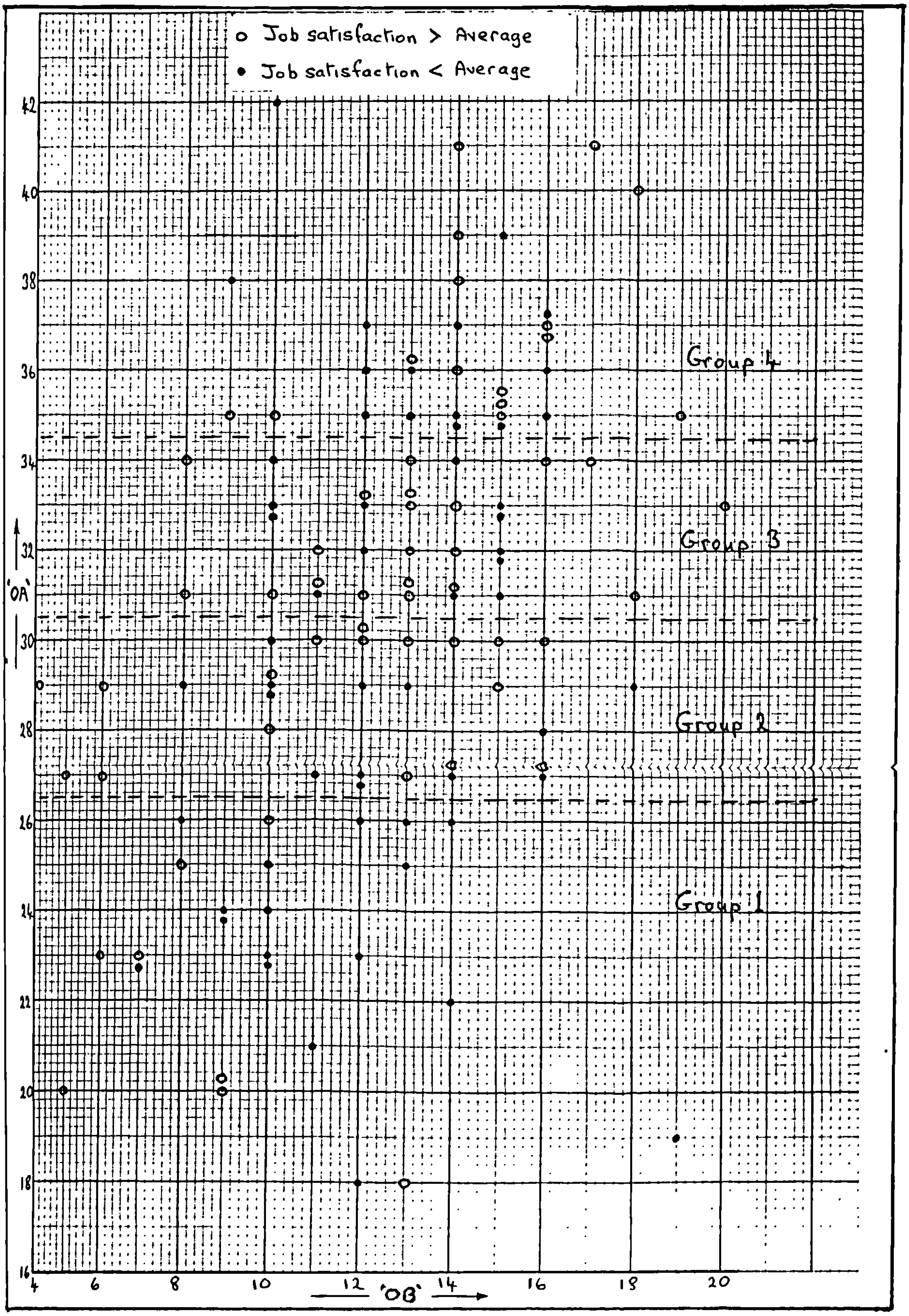
The partial correlation coefficients (Table 11.26) gave very little support for the above hypothesis, the negative correlation between job satisfaction and 'OB' (partialled with respect to 'OA') being far too weak. Expressing the data in visual form as in Figure 11.5, however, offorded a greater insight into the relationships. Over much of the 'OA'-'OB' space, Figure 11.5 suggested a random scattering of people above and below average in job satisfaction. Presumably many other factors are important in determining job satisfaction. However, in the lower right corner of Figure 11.5, a cluster of 'below average' job satisfaction was apparent. In the quadrant defined by the bounds: 'OA' < 27, 'OB' > 9, 13 out of 15 people were below average in job satisfaction. The difference between this proportion and the equal split overall was statistically significant (binomial test, $p < .01$).

With this evidence, the data was further analysed by dividing the total sample (n=118) into four approximately equal sized groups according to their 'OA' score, as follows.

Group 1	'OA' < 27	(n=25)
Group 2	'OA' 27-30	(n=29)
Group 3	'OA' 31-34	(n=32)
Group 4	'OA' > 34	(n=32)

The groups can be visualised as four horizontal strata in the 'OA'-'OB' plane, as shown in Figure 11.5. That is to say, the groups were relatively homogeneous in 'OA' but exhibited the full variability in 'OB'. On the cognitive dissonance hypothesis that low 'OA' combined with high 'OB' should lead to low job satisfaction, a negative correlation between job satisfaction and 'OB' would be expected for Group 1. For the middle groups, no correlation would be expected. The much less serious dissonance of high 'OA' and

Figure 11.5 Job satisfaction and the 'OA'-'OB' plane



low 'OB' (top left in Figure 11.5) might lead to a weaker positive correlation between job satisfaction and 'OB' in Group 4. Table 11.27 shows the results of this analysis.

Table 11.27 Correlation between job satisfaction and 'OB'

	'OB' Mean	S.D.*	Job Satis. Mean	S.D.	Correlation Job sat. v 'OB'
Group 1	10.4	3.0	100.8	10.7	-0.42
Group 2	11.8	3.6	110.8	16.4	-0.04
Group 3	12.9	2.6	108.1	16.2	0.06
Group 4	14.1	2.4	108.8	18.4	0.13

* Taking the whole sample, S.D. = 3.2

The anticipated patterns were well demonstrated. Not surprisingly with such small sub-groups, only the $r = -0.42$ was statistically significant ($p < .05$). Not only did this analysis provide evidence supporting the cognitive dissonance hypothesis, but it also showed that the weak positive correlation between job satisfaction and 'OA' arose only from differences to be found at the lowest levels of 'OA' (ie. with Group 1). Moreover the low level of job satisfaction in this group, according to the present hypothesis, is due to those with high 'OB' rather than low 'OA'. Thus the weak correlation between job satisfaction and 'OA' (both zero order and first order coefficients) was seen to be misleading. The present research suggests that a low level of idea generation, per se, is not linked to low job satisfaction. Rather, it is the relationship between level of idea generation and an aspect of a person's cognitive style that is important. This conclusion parallels the earlier finding of low job satisfaction associated with Type IV scientists. ('OB' was moderately correlated with the 'E' sub-scale, $r = 0.37$, whereas 'OA' was not, $r = 0.17$.)

Taken altogether, the analysis presented in this section provided overwhelming evidence that the 'O' sub-scale is not homogeneous. It gave further support (were it needed) that the KAI inventory cannot be regarded as a uni-dimensional scale, and further support for regarding the majority of the 'O' sub-scale items in the present KAI as measures of level of cognitive ability rather than as measures of cognitive style.

11.5 CONCLUDING REMARKS

Implications for A -I theory

The empirical work in the present research began with the intention of using the KAI as an already validated instrument capable of revealing insights concerned with the question of personality in research performance. In the later stages of the research, concerns about the conceptual nature of the KAI have caused the instrument itself to be a focus of attention. As it presently stands, A - I theory continues to assert that the KAI measures a dimension of cognitive style, and denies that any measure of cognitive ability is involved. The conclusions of the present research thus run counter to one of the basic tenets of A-I theory. This thesis concludes that the KAI is contaminated with 'level' just as Kirton (1987) has suggested that many other tests concerned with creativity have conflated cognitive style and cognitive ability.

Another important conclusion stemming from the present research is the multi-dimensionality of the KAI. The demonstration that the 'O', 'E' and 'R' sub-scales have substantially different correlates and measure different concepts (though relevant to the question of creativity) has seriously undermined the use of the total KAI scale. Since the sub-scales have been recognised from the outset, it seems remarkable that their separate use has not been investigated before the present research, and that the implications of not very strongly correlated sub-scales on the meaning of the total scale have not been recognised. In any case, three measures could be viewed as potentially more valuable than one, but in the present case that one measure becomes confounded, if not invalidated, by the aggregation process.

At the two extremes of the KAI range, say <u>outside</u> the range: mean $\pm$ 1.5 SD (72 to 120), it could be argued that the KAI is capable of an unequivocal interpretation. In these conditions it is very likely that each sub-scale records a fairly extreme measure in the same direction, and so a total KAI score can be reliably interpreted. It is with the great majority of moderate KAI scores that interpretation becomes practically impossible. This thesis has demonstrated, for example, the very great difference between those people with high 'O' and low 'E' and those with low 'O' and high 'E'. Thus moderate KAI scores have no clear meaning. Were the KAI a truly uni-dimensional scale, as it is purported to be, the problem would not arise. Had the KAI been developed as a three dimensional measure, the problem would have been solved in a fruitful way. As this research has demonstrated, the problem is shown to be even more complex by the recognition that the 'O' sub-scale is properly regarded as two sub-scales. Thus to some extent any 'O' sub-scale measures are open to misinterpretation except at the extremes.

The results stemming from the later stages of the present research also have implications for some interpretations placed on earlier work in this thesis. No longer is it satisfactory to refer to 'four cognitive types', based on differences in cognitive style. Nevertheless, the value of the four-fold classification remains. Although it has been acknowledged that many factors impinge on the performance and job satisfaction of scientists, such understanding as the measures used in the present research can give is of value in selection and training, as Keller and Holland (1979) have noted.

Further developments

From the point of view of developing a refined KAI, two approaches are apparent. The first one is that already begun towards the end of the present research and described in Section 11.3. This sought to refine the 'E' and 'R' scales utilising the existing concepts of 'Weberian in-efficiency' and 'non-conformity', respectively, and to refine (and re-define) the 'O' scale utilising the concept of 'level of idea generation'. This process could lead to a KAI whose inventory items were not greatly dissimliar to those of the present KAI. It would no longer be claimed to be a measure purely of cognitive style, nor would it purport to be uni-dimensional. It would be three-dimensional with scales which approached the orthogonality one could expect from the concepts operationalised. With such an instrument there would be the prospect of an 8-fold classification similar to the 4-fold classification found to be valuable in the present research.

A second approach would be to set as the prime objective that of making the KAI more purely a measure of cognitive style. Whereas the first line of development would seek to remove 'OB' items and add 'OA' items to a new 'O' scale, the second approach would seek to remove 'OA' items and add new 'OB' items. From the point of view of A - I theory, which is primarily concerned with cognitive style, the second approach might be preferable.

A third and rather different development, but one which would be more in keeping with the initial objectives of the present research, would be to seek an instrument which would be concerned primarily with characterising R & D staff. Such an instrument might not be concerned as to whether it was 'pure' in the sense of measuring only 'level' or 'style'. It could draw on features of the KAI which have been found to be useful in the present research. It could also develop quite new measures which have potential in understanding the cognitive make-up of R & D staff. Two possible avenues stem from the work of Green and Koestler, which has been referred to repeatedly in this thesis. On the basis of their theories, 'level of idea generation' is likely to be only one, perhaps minor, factor in understanding creative research performance. It is suggested that further research should seek to operationalise the typology of thinking of Green and the bisociation concept of Koestler.

However, in addition to constructing instruments with which to measure what might be called 'predictor variables', there is a need to attend to the question of measuring the crucial 'dependent variable', research performance. It is suggested that the present research has made a useful step forward in distinguishing between creative performance and skills performance. The orthogonal nature of these variables is interesting conceptually and gives encouragement for developing the concepts further. (A variety of objective and subjective performance measures have appeared in the literature; most having modest correlations.) It may be that in all the research in R & D to date, no performance measures have addressed the question of research ability at a fundamental level. The measures used in the present research were crude and further refinement is needed.

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LIST OF APPENDICES

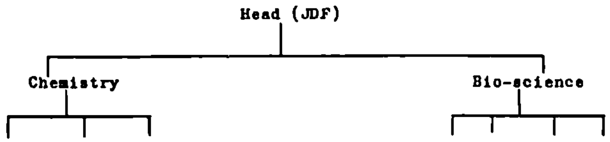
APPENDIX A

VISIT TO ICI PHARMACEUTICALS DIVISION - 2nd June 1982

Discussion with Dr J D Fitzgerald, Head of Research Department II

1. **Organisation Structure**

There are two research departments of very similar structure, differing in the research areas (disease states) in which they specialise. In Research Department II the structure can be summarised as follows:



In addition to the above organisation which is essentially by scientific discipline, staff are organised into project teams and there is therefore a matrix structure. There are seven (approx) project teams (ie research areas or disease states) and each team may work on up to three research topics at any time. (Formerly, teams used to disperse their effort over more than three topics.)

2. **The R & D Process**

The overall process from initial ideas to product launch can be summarised as follows:

1. Inception - essentially the work of the bio-scientists in formulating hypotheses about disease states and possible novel chemo-therapeutic interventions.

↓

2. Integration (Synthesis) - the stage when chemists are brought into the team work to be involved in the synthesis of organic compounds which can be evaluated by the bio-scientists using methods developed by them to test their hypotheses.

↓

3. Development - the long and expensive process of carrying out the range of toxicological and other work needed to meet the requirements of the regulatory authorities.

↓

4. Market launch

The work of the two research departments ends essentially when the decision is reached to proceed with the development phase. Dr Fitzgerald was concerned about the need for an informed discussion at a senior level before the 'Inception' phase began. He argued for a Research Strategy (involving marketing staff) to provide integrated direction at the very outset of research.

3. **Rewards and Promotion System**

Dr Fitzgerald outlined the company-wide scheme involving a 15-point scale. This scheme accommodated posts with salaries up to about £15,000 p.a. at present rates. A discretionary range of 80% to 125% of the median according to merit was felt to be insufficient. The existence of a dual-ladder (managerial/scientific) was confirmed, but Dr. Fitzgerald emphasised that the criteria used for promotion on the scientific ladder were extremely demanding. He is currently giving some thought to proposals for amendments to the 15-point scale.

4. **Research vis a vis Development**

Dr. Fitzgerald's remarks indicated that it is not helpful from a managerial point of view to couple research with development. The nature of the work (level of creativity) and the degree to which planning and control is feasible (the level of uncertainty) differ substantially.

5. **Some concerns of J.D.F**

Reviewing Dr Fitzgerald's comments we list the following:

(i) Strategic planning for R & D (integrating Marketing and ICI overseas units).

* (ii) Managing the 'Prima Donna' tendencies of scientists. *

(iii) The reward system (pay and promotion)

(iv) Allocating resources to projects

Footnote: JDF has been investigating the use of decision analysis in conjunction with L D Phillips of Brunel. Regarding possible collaboration with us, JDF expressed an interest in hearing from us regarding specific proposals concerning objectives and methods.

APPENDIX B

THE MANAGEMENT OF RESEARCH IN THE LIFE SCIENCES

For companies whose business is based upon the life sciences, the effective management of R & D is a crucial element in corporate growth. Management in this context, as in any other, is concerned with the performance of individuals and teams in the pursuit of organisational goals. In recent years the inter-disciplinary nature of research in the life sciences and the implications of this for effective management have begun to be the subject of research.

The present research seeks to probe inter-relationships in a range of variables which are subject to managerial control. The variables have been derived from issues which have been raised in discussion with directors of research. The methodology employed utilises and further develops several approaches which have been described in recent literature. Further details are available on request from Prof. E.A. Lowe, University of Sheffield.

The researchers wish to stress their assurance that the anonymity of respondents will be ensured. Under no circumstances will the data be used in a way that allows individuals to be identified. Those wishing to see the summarised results are invited to request a copy using the envelope provided.

The researchers need a high response if the statistical tests to which the data will be subject are to have the required sensitivity. Please try not to spend more than thirty minutes in completing the questionnaire. Your co-operation will be very much appreciated.

Bill Taylor — Sheffield City Polytechnic

Tony Lowe — Sheffield University

January 1984

APPENDIX B (Continued)

SECTION 1 CLASSIFYING INFORMATION

These questions on personal details are necessary for the purposes of analysis. The researchers wish to stress that none of the data (in this and other sections) will be communicated on an individual basis to any other person by any means. Under no circumstances will the data be used in a way that identifies individuals.

****

PLEASE CIRCLE APPROPRIATE CODES WHERE CODES ARE GIVEN.
RIGHT-HAND COLUMN NUMBERS ARE TO BE IGNORED COL.

1.1. NAME* .... -

1.2. SEX Male 1 Female 2 6

1.3. AGE (years)

<25	25-29	30-34	35-39	40-44	>=45
1	2	3	4	5	6

7

1.4. WORK EXPERIENCE (years in research and/or development)

<1	1-5	6-10	11-15	16-20	>20
1	2	3	4	5	6

8

1.5. RES./DEV. BALANCE (indicate proportion in career to date)

All Res		Equal		All Dev
1	2	3	4	5

9

1.6. QUALIFICATIONS (indicate highest level held)

HNC/HND or lower	1st Deg. or equiv.	Masters Deg.	Doctorate
1	2	3	4

10

1.7. PRESENT DEPARTMENT 11

1.8. PRESENT SECTION 12

1.9. PRESENT PROJECT TEAM 13
(If more than one, state where most of your work is)

1.10. JOB TITLE 14
(Use standard Company nomenclature)

---

* Name is required only to allow a comparison to be made between self-assessment of performance and superior assessment. Name NOT to be recorded on data file.

APPENDIX B (Continued)

* Table 9: FACTOR-TRAIT STRUCTURE OF THE KAI

Item Nos.	A person who:	Loadings (A) of items on the three Factors containing KAI items*			Correlations (B) of each item in a Factor with the rest of the items in that Factor **		
		II	IV	VI			
		Originality	Weberian	Mertonian	Originality	Weberian	Mertonian
21	has original ideas	-.77			.57		
23	proliferates ideas	-.74			.55		
19	is stimulating	-.64			.45		
16	copes with several new ideas at the same time	-.60			.53		
3	will always think of something when stuck	-.52			.46		
5	would sooner create than improve	-.52			.45		
11	has fresh perspectives on old problems	-.51			.42		
26	often risks doing things differently	-.47			.53		
12	likes to vary set routines at a moment's notice	-.37			.41		
24	prefers to work on one problem at a time	-.36			.40		
18	can stand out in disagreement against group	-.34		.30	.37		
31	needs the stimulation of frequent change	-.33			.34		
13	prefers changes to occur gradually	—			.34		
14	is thorough		.77			.60	
22	masters all details painstakingly		.75			.50	
25	is methodical and systematic		.74			.67	
4	enjoys detailed work		.63			.49	
15	is (not) a steady plodder	-.35	.48			.39	
17	is consistent		.35			.39	
28	imposes strict order on matters within own control		—			.33	
30	fits readily into 'the system'			.75			.59
2	conforms			.68			.49
20	readily agrees with the team at work			.60			.39
8	never seeks to bend or break rules			.57			.58
7	never acts without proper authority			.54			.54
6	is prudent when dealing with authority			.51			.32
29	likes the protection of precise instructions			.48			.50
33	is predictable			.44			.48

* See note on page 391

APPENDIX B (Continued)

Item Nos.	A person who:	(A) Loadings of items on the three Factors containing KAI items* II Origin-ality	IV Weber-ian	VI Mert-onian	(B) Correlations of each item in a Factor with the rest of the items in that Factor** Origin-ality	Weber-ian	Mert-onian
32	prefers colleagues who never 'rock the boat'			.36			.46
9	likes bosses and work patterns which are consistent			.34			.45
27	works without deviation in a prescribed way			.30			.45
10	holds back ideas until obviously needed			—			.33

Note The above table replaces the transposed KAI which appeared in the questionnaire.
It is reproduced above from the Kirton Adaption-Innovation Manual by permission of M.J. Kirton, 1987.

APPENDIX B (Continued)

SECTION 3 ORGANISATION ENVIRONMENT

This Section contains statements which may describe the environment in which you work. For each statement please circle a number on the scale from 1 to 5 to indicate your views on the following issues.

(i) The extent to which you agree or disagree that the statement describes the team (those colleagues with whom you are closely associated in day to day work) within which your work is mainly or wholly located.

(ii) The extent to which you agree or disagree that the statement describes the whole R & D organisation, as far as you are aware of it.

N.B. Defining the boundary of your 'team' may be a problem. Please state briefly how you choose to define it, i.e. give staff numbers, whether same Dept., same Project Group, etc.

- -

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

****

	YOUR TEAM	COL	WHOLE R & D	COL
3.1. When difficulties arise, people can count on getting assistance from colleagues	1 2 3 4 5	48	1 2 3 4 5	49
3.2. People share results with eachother on a continuous basis	5 4 3 2 1	50	5 4 3 2 1	51
3.3. Our approach to innovation is taking calculated risks	1 2 3 4 5	52	1 2 3 4 5	53
3.4. People are allowed opportunities to follow up their own ideas	1 2 3 4 5	54	1 2 3 4 5	55
3.5. We are constantly working under pressure	5 4 3 2 1	56	5 4 3 2 1	57
3.6. Leaders/managers take note of what staff have to say	1 2 3 4 5	58	1 2 3 4 5	59
3.7. When a promising but uncertain approach fails, we focus on learning from the failure rather than recriminating	1 2 3 4 5	60	1 2 3 4 5	61
3.8. The way we tend to work is to act as consultants to eachother	1 2 3 4 5	62	1 2 3 4 5	63
3.9. When someone thinks he knows more about an issue than a colleague of higher status, he would argue forcefully rather than defer to him/her	5 4 3 2 1	64	5 4 3 2 1	65
3.10 People have plenty of freedom to organise their work	1 2 3 4 5	66	1 2 3 4 5	67

APPENDIX B (Continued)

SECTION 3 (continued)	YOUR TEAM					COL	WHOLE R & D					COL
3.11 High performance standards are expected	1	2	3	4	5	68	1	2	3	4	5	69
3.12 Bosses are very approachable	1	2	3	4	5	70	1	2	3	4	5	71
3.13 Personal relationships are such that it is as well to assume that others will act to your disadvantage	5	4	3	2	1	72	5	4	3	2	1	73
3.14 When there is a team meeting it is best not to ask a question that might reveal one's ignorance	1	2	3	4	5	74	1	2	3	4	5	75
3.15 After a disagreement over how the team should proceed those who were in the minority find it difficult to contribute	5	4	3	2	1	76	5	4	3	2	1	77
3.16 Management exercises such tight control that people do not have enough responsibility for work	5	4	3	2	1	78	5	4	3	2	1	79
3.17 People do not seem to take much pride in their work	1	2	3	4	5	6	1	2	3	4	5	7
3.18 I don't think leadership is of a high calibre	5	4	3	2	1	8	5	4	3	2	1	9
3.19 People tend to compete for acceptance on personal ideas rather than build on eachother's ideas	1	2	3	4	5	10	1	2	3	4	5	11
3.20 When someone offers praise you can't be sure what he/she is up to	5	4	3	2	1	12	5	4	3	2	1	13
3.21 When we are trying to solve a problem the person having the most to say is the one with the most formal authority	5	4	3	2	1	14	5	4	3	2	1	15
3.22 Personal initiative is highly valued	5	4	3	2	1	16	5	4	3	2	1	17
3.23 There is a relaxed easy-going working climate	1	2	3	4	5	18	1	2	3	4	5	19
3.24 Bosses expect people to carry out instructions without question	1	2	3	4	5	20	1	2	3	4	5	21

PLEASE CHECK THAT YOU HAVE ANSWERED ALL 24 QUESTIONS

APPENDIX B (Continued)

SECTION 4 JOB NEEDS AND JOB SATISFACTION

Different kinds of opportunities which a job might provide are listed below. You are asked to provide the following information about them.

(i) If you were to seek a job, how much importance would you personally attach to each one, disregarding whether or not your present job has them.

(ii) To what extent does your present job actually provide an opportunity regarding each of these factors.

1	2	3	4	5
Very little		Moderate		Very much

****

	HOW IMPORTANT TO YOU					COL.	PRESENT OPPORTUNITY					COL
4.1. To build my professional reputation outside this company	1	2	3	4	5	22	1	2	3	4	5	23
4.2. To earn a good salary	5	4	3	2	1	24	5	4	3	2	1	25
4.3. To advance in administrative status and authority	1	2	3	4	5	26	1	2	3	4	5	27
4.4. To work on difficult and challenging problems	5	4	3	2	1	28	5	4	3	2	1	29
4.5. To contribute to the body of knowledge in my field	5	4	3	2	1	30	5	4	3	2	1	31
4.6. To have security of employment	5	4	3	2	1	32	5	4	3	2	1	33
4.7. To associate with top managers in the company	5	4	3	2	1	34	5	4	3	2	1	35
4.8. To learn new knowledge/skills	1	2	3	4	5	36	1	2	3	4	5	37
4.9. To work with colleagues of high technical competance	1	2	3	4	5	38	1	2	3	4	5	39
4.10 To have congenial co-workers	5	4	3	2	1	40	5	4	3	2	1	41
4.11 To be evaluated fairly in relation to my contribution	1	2	3	4	5	42	1	2	3	4	5	43
4.12 To have freedom to carry out my own ideas	1	2	3	4	5	44	1	2	3	4	5	45

PLEASE CHECK THAT YOU HAVE ANSWERED ALL 12 QUESTIONS

APPENDIX B (Continued)

SECTION 5 ORGANISATION STRUCTURE

The use of multi-disciplinary project teams is an important feature of industrial research in the life sciences, but most companies consider it essential to retain a departmental structure based on a subject or scientific discipline. The following questions are concerned with your response to these two dimensions of organisational structure.

KEY TO QUESTIONS 1 TO 4
1 = Always a member of my project team
2 = Mostly a member of my project team
3 = Members of my project team and department about equally
4 = Mostly a member of my department
5 = Always a member of my department

						COL
5.1. When you have a new idea you wish to discuss with a senior colleague(*), whom do you first consult?	1	2	3	4	5	46
5.2. When you wish to discuss a technical problem with a senior colleague(*), whom do you first consult?	1	2	3	4	5	47
5.3. When you wish to discuss a personal problem with a senior colleague(*), whom do you first consult?	1	2	3	4	5	48
5.4. When the quality of your work is to be assessed, who is the most appropriate person to do it?	1	2	3	4	5	49

* Where the 'senior colleague' is both project leader and departmental head, try to answer by indicating in which capacity you consult him/her.

****

KEY TO QUESTIONS 5 TO 10

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

Answer these questions with reference to your own project group

						COL
5.5. Staff need galvanising to work toward project goals	1	2	3	4	5	50
5.6. Staff tend to be interested in their own specialist goals rather than project goals	1	2	3	4	5	51
5.7. The role of project leader is more that of coordinator than a leader	1	2	3	4	5	52
5.8. The project leader has status and authority by virtue of that position	1	2	3	4	5	53
5.9. The authority of departmental managers is subordinate to project goals	1	2	3	4	5	54
5.10 Project demands are often felt to interfere with departmental activities	1	2	3	4	5	55

PLEASE CHECK THAT YOU HAVE ANSWERED ALL 10 QUESTIONS

APPENDIX B (Continued)

SECTION 6 SELF-ASSESSMENT OF PERFORMANCE

Research staff differ in their research abilities, and in this Section two distinctions are drawn.

(i) Creative performance : the generation of novel ideas, methods, insights and hypotheses in relation to problem issues.

(ii) Skills performance : assiduous, skillful and penetrating work in the testing of ideas and hypotheses.

Please answer the following questions as objectively as you can using the prescribed scale.

1	2	3	4	5
Well below average		average		Well above average

The word 'average' is to be applied in the context of your own company's R & D, i.e. questions are to be answered using intra-company data only.

****

	Creative performance						Skills performance					COL
6.1. In your present job, how do you rank your own performance	1	2	3	4	5	56	1	2	3	4	5	57
6.2. How do you think your immediate superior would rank your performance	1	2	3	4	5	58	1	2	3	4	5	59
6.3. How do you rank the performance of your project group (as in 1.9)	1	2	3	4	5	60	1	2	3	4	5	61
6.4. How do you rank the performance of your department (as in 1.7)	1	2	3	4	5	62	1	2	3	4	5	63

PLEASE CHECK THAT YOU HAVE ANSWERED ALL 4 QUESTIONS

APPENDIX B (Continued)

SECTION 7 ADDITIONAL INFORMATION

Because of the limitations imposed by a questionnaire, you probably feel that some issues have not been adequately dealt with. Perhaps there are some aspects of the organisation of R & D which you feel should have been included but have not. If you wish to add further information/comments please do so in the spaces below.

Personality characteristics...

....

....

....

Organisation environment...

....

....

....

Organisation structure...

....

....

....

Job needs and job satisfaction.......................................

....

....

....

Performance assessment...

....

....

....

Other information/comments...

....

....

....

THANK YOU FOR YOUR HELP

APPENDIX C

SPSSX skeleton command file

```
BLIST BILL SPSSX
FILE: BILL SPSSX B
DATE: 19FEB1986 AT 16:55:44 HRS

TITLE MANAGEMENT OF R & D
FILE HANDLE RESDATA NAME='MANRD DATA B'
DATA LIST FILE=RESDATA/
  SERIAL 1-3 COMPANY 4 SEX 5 AGE 6 WORKEXP 7 RDBAL 8 QUAL 9 DEPT 10 TEAM 11
  KAI 12-14 OSCALE 15-16 ESCALE 17-18 RSCALE 19-20
  WSI 21-22 OAC 23-24 KBRT 25-26 PAR 27-28 WP 29-30 L 31-32 COLL 33-34
  PR1 35-36 PR2 37-38 JC1 39-40 JC2 41-42 ST1 43-44 ST2 45-46 SA1 47-48
  SA2 49-50 JSI 51-53
  CRPERF 54-56 SKPERF 57-59 CRPROJ 60 SKPROJ 61 CRDEPT 62 SKDEPT 63 QUAD 64
VARIABLE LABELS
  SERIAL  'SERIAL NUMBER'
  COMPANY 'NAME OF COMPANY'
  SEX     'SEX OF EMPLOYEE'
  AGE     'AGE OF EMPLOYEE'
  WORKEXP 'WORK EXPERIENCE'
  RDBAL   'R & D BALANCE'
  QUAL    'LEVEL OF QUALIFICATIONS'
  DEPT    'DEPARTMENT NUMBER'
  TEAM    'PROJECT TEAM NUMBER'
  KAI     'TOTAL KAI SCORE'
  OSCALE  'SUB-SCALE O'
  ESCALE  'SUB-SCALE E'
  RSCALE  'SUB-SCALE R'
  WSI     'WARM SUPPORTIVE INTEGRATION'
  OAC     'OPEN AUTHENTIC COMMUNICATION'
  KBRT    'KNOWLEDGE-BASED RISK TAKING'
  PAR     'PERSONAL AUTONOMY & RESPONSIBILITY'
  WP      'WORK PRESSURE'
  L       'QUALITY OF LEADERSHIP'
  COLL    'COLLABORATION INDEX'
  PR1     'PROFESSIONALISM: IMPORTANCE'
  PR2     'PROFESSIONALISM: OPPORTUNITIES'
  JC1     'JOB CONDITIONS: IMPORTANCE'
  JC2     'JOB CONDITIONS: OPPORTUNITIES'
  ST1     'STATUS: IMPORTANCE'
  ST2     'STATUS: OPPORTUNITIES'
  SA1     'SELF-ACTUALISATION: IMPORTANCE'
  SA2     'SELF-ACTUALISATION: OPPORTUNITIES'
  JSI     'JOB SATISFACTION INDEX'
  CRPERF  'CREATIVE PERFORMANCE'
  SKPERF  'SKILLS PERFORMANCE'
  CRPROJ  'CREATIVITY OF PROJECT TEAM'
  SKPROJ  'SKILLS OF PROJECT TEAM'
  CRDEPT  'CREATIVITY OF DEPARTMENT'
  SKDEPT  'SKILLS OF DEPARTMENT'
  QUAD    'KAI TYPE'
VALUE LABELS
  COMPANY 1 'S.K.& F.' 2 'GLAXO' 3 'I.C.I.'/
  SEX     1 'MALES' 2 'FEMALES'/
  AGE     1 '<25' 2 '25-29' 3 '30-34' 4 '35-39' 5 '40-44' 6 '>44'/
  WORKEXP 1 '<1' 2 '1-5' 3 '6-10' 4 '11-15' 5 '16-20' 6 '>20'/
  RDBAL   1 'ALL RESEARCH' 2 'MAINLY RESEARCH' 3 'EQUAL' 4 'MAINLY DEVEL'
          5 'ALL DEVEL'/
  QUAL    1 'HNC/HND & LOWER' 2 'FIRST DEGREE' 3 'MASTERS DEGREE'
          4 'DOCTORATE'/
  QUAD    1 'TYPE 1' 2 'TYPE 2' 3 'TYPE 3' 4 'TYPE 4'/
```

APPENDIX C (Continued)

SPSSX data file for Company A

```
DATA FILE FOR SPSSX.......COMPANY A  SAMPLE   (N=45)

00111344411 9144163118151617141749121215141512121312 87.16.733332
00212122211103471640151415181518441 2 8131011 815121025.16.744442
0031212121111253184119181717131754 910131211 614131105.15.743332
00411331211 92541127151514161314441 4 9121214111411 1058.18.734342
00511233211 94421834181814131517501 1 91313 7 913151257.18.735552
0061134141110046153917161416171847141 1121110 915141207.18.734342
0071233221110445194015171617121648 B 81111 7 71010 977.16.743332
008115624111115018431718171715165211 91[illegible] 91[illegible] 81312 996.16.744442
00912122211 9947173518181317161549 13 81211 7 51412 996.14.734242
01011221211 934317331616151615164710101 21210 912101055.16.744342
0111133441110650154116151416181845131313131212141 31299.16.734452
0121222321110146193617171617151450 14 912 810 91511 965.17.734342
01312232411 934612351616161316164814131110131015121177.14.743332
01412221311 80311534181818181417 54 8 81414 9 810101105.16.733343
01511221211 94391045141315151716 4211 911 9 6 414 8 816.15.754443
01612341211 61291121201813181518 51 9 8151512 810 91105.17.733343
01712233211 79381625151411161217 4010 9151111 61411 986.14.733333
01811335211 8335133515151114151441 1210141512 811111165.18.743343
01911124211 883318371812111314164112 6131211 511 4 792.13.755553
02012121211 743514251918101815164712 91411 8 614111015.15.745333
02111231311 8933164010111116111332111 0141111 813101015.16.743343
02211442411 70301426141514161515431413141113121212 1205.16.744443
02311443311 974019381515121411134213 710 7 9 613 9 768.15.733443
02411344211 9539144213151213141340121111 1110 813 6 877.16.733333
02511443411 863019371617131415164611 81111101010 8 934.16.734333
02612113211 6332102113161519131944131311111512131 31244.13.744333
02711234211 803711321914151415174813 8141213 813111025.15.733443
02811231211 9241203116141416161744121212111211131 31207.16.744441
0291112121111148204 3 91111 912113110 8101011 91410 947.14.733341
0301145141111953234317161617151749131211 1110 912121159.18.744441
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03211662411106422143141512171814411212121213101110 1106.15.733441
0331221141111245264114141717131745121012131011141 31205.14.743331
034114413111174529431214101214 936 9 910 8 7 712 8 816.14.724331
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03611334411110512138161717151116501013131311121313 1285.14.734331
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0381222241111048224018141016161642 10 61013 71015 6 818.14.744331
03911223411121492745191616171717511310 812 81214101067.15.724451
040114434111234925491215 91118153611101112111015101047.14.724241
04111221411 94412033181811161418471 3 9121112 913111006.14.744441
04212223311 903820321915101616174412 9121310 611 91015.16.744334
04312121211 883624281414151515 84311 712 9 9 61210 864.14.744334
04411121211 95382334161310161317 39 6 5 911 9 61110 875.14.734234
04511334211 963925321411141314163912 8101012 81510 904.15.743334
```

APPENDIX C (Continued)

SPSSX data file for Company B

```
DATA FILE FOR SPSSX........COMPANY B  SAMPLE     (N=18)

04621452211 924117341615151317144611 91311 9 812101005.76.644442
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0482155141111052164217191616161952l2 915131511151312O7.76.622442
04921121211101421841131514141315421l 9141312 712101035.74.634442
05022441411 5625 823202018192020581l 91312 71012121124.78.645443
05121331211 762915321616131512l645 9 91212 9 713121085.74.644443
05221662411 853917291313141314154O 9 91212 7 711101033.76.634343
05321451211 6334 7221717131515164710101311 9 712111044.77.644333
0542156241111250233914101211121136111010121112131311197.74.644441
05522552211120532443202016171618561212l113 91114131255.76.655441
0562166141110245213616171413171647111113111011l2131165.74.644241
05721661411103522130151613161215441l 9131310 811101076.74.633441
05821431211 984420341315121214124013 712 711 512 7 684.74.634331
05921321411115522637l1 713 415 431 7 514 713 313 5 536.73.622331
06021651411124582541181816181415521314141415101414l248.75.644551
06121443411105462237121513151217407 813141111110111197.76.643341
06221662211 9840213713151415151542131213l115 813111005.76.644344
06321662411101332147131215111413401011 5 6 81112101013.78.643334
```

APPENDIX C (Continued)

SPSSX data file for Company C

```
DATA FILE FOR SPSSX........COMPANY C  SAMPLE     (N=30)

06431554211103501637171716171517501111131111 912121105.56.233442
0653145131110244193914141517161443 8 81112 8 914131135.58.233332
06631331411122491954131314 615 54013 9 8 9 7 414 9 856.54.253342
06731332411120541749161817171914511011121313 915141207.56.243432
0683123121110044183815151516111545 7101011 7 613121053.56.233332
06931551411106471742161918191719531111111151212111148.56.244442
070314414111025016361816162017195011121314101415151406.56.244442
071312314111084618442018182015185612111114111115141264.56.234552
07231664411110471449192018191517571510 91013 51410 904.56.234232
0733123221110849184118161412161648 9 8121010 611 8 846.54.244442
074326614111054814431815151411144812101211 7 61310 988.58.234342
0753222141 1 894415301820181917185613131113101114151366.56.244442
07631551411107481544191815181418521312121110 814 91027.58.244442
077316634111065516351617171813165015141313131315151406.58.244442
078313424111024416421516181715144910111311111011121106.56.244442
0793222121 1 8743133113141715161844 91011111111112121136.56.243342
0803132141 1 933919351313131713163911 8121110 910 8 935.55.234333
0813145121 1 7333122813131216121638 8 9131110 714141125.54.233333
0823166221 1 813315331617151714164811121311 8 710111094.56.244433
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0843166321 1 903815371616131515164511 91311 81012101026.56.244443
08531661411103452137161713151516461314131310 913141326.56.243341
0863143141111849264316131614131445 9101211111013121117.56.243331
0873122141111453263520171116141848 9 9131510 714141246.56.234341
0883145231112551274718171515141650 9 81212 5 814111045.55.244421
089313314111024721341215121114153912 81212 9 713 8 896.55.233331
09031431411116502145181813171217491411151310 915121184.54.223241
0913166141 1 884120271611141916154113141311 81214151345.54.223241
0923154331 1 92332633131211171817361211131112 911 91035.56.243334
0933122241 1 8932253212121214131736 8 71011 9 811 9 924.56.223234
```

APPENDIX C (Continued)

SPSSX data file for Company D

```
FILE: MANRDD   DATA     B   *** VM/SP AT SHEFFIELD CITY POLYTECHNIC

09442453211 97421639151411151616401110121015131412118 4.87.433342
09542543311 95431834201616191520521014111 3 61214141354.84.444542
09641212311 834114281817131614174812111311121014131164.87.433442
0974243441111358173820191818141857 8131012 71314131276.86.443432
09842553411 91481528                                   6.86.433442
0994133231110951193918121616161846101013 12 9 612111075.83.423232
100413223111105017431917142020195014121011101215141268.86.444452
10141521311 834211301816151419184913111410111113121086.86.444442
10241322311 864316271618121811184611101211 9 913131144.86.4  442
103415524111054318441818161915125210101311101211101077.84.433332
10441441311 92451631171715171117491213121 3 81113141328.85.433442
1054165331110244193915171715141849111 1 91211 911 9 996.86.444452
10642423411 894716261515182015204814121211 10 915131196.86.444442
10742323311 99481338 7 9151416 83112 811 810 81310 885.86.433232
10842551311 84331338171918171617541313131211111313125 4.88.433443
10941562411 7835172616151514131446 11 81112 9 9 9 9 974.86.434333
11042443211 753013321815161416124 9 6111310 71011101014.86.433233
11141662311 90391833161616161416481012111 3 7 912121205.87.444443
11241431411 863918291616141610174613111111 8 914121126.86.434443
1134133321110442243810141415151338 8 81211 6 51110 955.85.4  431
11441664211105432339141613141415431 0 712 910 811 8 825.84.433331
115414434111124922411818141617155012101212111014111096.86.433341
1164133231110844224216151416121245131211 11 8 812111116.86.433331
11741661311 772923251716141615174712121411 10 912121134.84.455454
1184266131110838254515141519101744101513 15 91314151484.84.444444
11941424311 92342137141313141413401 3 912 912 712 8 844.86.444334
```

APPENDIX C (Continued)

KAI item data file (n=119)

```
FILE: KAIZ     DATA     B   *** VM/SP AT SHEFFIEL

1014434234234443444344434443443433337.74.61119
1022423332324333223243433332334323335.76.62100
1032444143354552452434353523555255545.76.61125
1043434233243333442443244433423333335.74.61116
1051312222152211131333111112321111114.78.63112
1061515123255123552441534535445123326.74.62107
1073424344155222342442534334333332437.76.62 96
1083333232343432333233343433434234335.76.64100
1092433322424332433433443224325334324.74.61 68
1104445233424444342443554442344444146.73.61 53
1112232233242222222222232112432414425.74.63108
1134513444354332451543434534224334274.76.62120
1143535224144444551455544554534344448.75.61124
1152423231233332332433332322332233333.76.63103
1162412221124221131231313212113223224.77.63104
1173422444451514134524122234555221523.78.64101
1183422213324433442334444532444444347.76.61119
1193324235433243152233343433335234445.74.62103
2012324344332442313121221222211235545.16.73110
2034413443323511232315423115514434436.15.73 81
2042435121122111131224242111111213215.17.73110
2063433322332334324334342233331333327.16.71120
2072323223223333233213232332313324316.14.73 98
2102223233224232442434423424121344447.16.72128
2114512433134121421523334112221325535.18.73116
2124223434222222234424342222223444322.13.73 79
2134324433352552243344333423323244325.16.72102
2144432344244343353434434333423445437.14.71 94
2163435422333442452454443324513255545.15.72110
2172322222112323223232322332222224325.15.73101
2184322434232322232433231233424443335.16.73101
2223222232223222222432223222232221125.16.73120
2231423221245441151452415224335255328.18.72105
2254444333344442443444534444434444439.18.72115
2273415434354332543445444544535445337.16.73 86
2284322122131551542133251422334254435.16.74101
2294435124342222343552323123332333337.18.72125
2304334333443322342434343333444443336.15.71110
2313323322354222333434434332434533328.15.73 76
2323414343344342343223424424424443327.18.72120
2332334222332335232222424523322221324.14.74 86
2342234322343342332323433334442333335.14.74 87
2354423334323433242442332333444434447.16.72 97
2364424434224442242422434445535434446.16.72 99
2373345233343334454223434344453424445.14.71120
2384443451244424445423453345533435536.14.71 81
2393314133443441542433433224433154426.14.72 99
2405413432232232225334222244355534427.16.73 87
2412414233332442242333224433442424235.16.72105
2423423234244441342343434424424444449.16.72129
2433321333342333322324231322443223324.16.73 93
2443434344233233552233443533544244437.16.71123
2453444233334442452334443534423344435.14.71128
2463444232242222324443145444242234245.12.71116
2471343443144433442533344334524355538.14.71 81
```

APPENDIX C (Continued)

KAI item data file (continued)

```
FILE: KAIZ      DATA     B   *** VM/SP AT SHEFFIEL

248321211115411114142143222331111214.13.73124
250454343435433454344244434553513547.15.71106
252341523343343244323343342334434325.17.72 96
253444544544353334344433334545443447.14.71104
254341322234454452224433312213224356.14.71100
255342343323243443332234224434224234.15.74 90
256341332323434123244442432332333427.14.72117
257332312213322124144332221332432345.15.73102
301443424433443224244343432442324325.56.22110
303344544422333234232342243443433335.58.22113
304334332524413521313224324424323235.56.24103
305342422324243232433433332333322435.55.23 93
306243324333422245234344443443432426.56.21132
307454143532354344334244345453445437.56.21111
308551444455553242324353312554555546.54.22 85
310144434425533244345155444454414236.56.21124
311441224454454145334442453553535547.56.22120
313444444434344444344444444444444445.55.21104
316242233333543233323332253443444333.56.22105
317343423324432324234154434333434336.55.21 89
318221334222422123223232222322222325.54.23112
320432532344434244244443344454444444.54.21118
321442534435233325243443443332333338.56.22114
322342423334444134344342432343234426.56.22140
323434324315422144244345241551545444.56.22126
324441544435553313525233315224255444.56.22 90
325333333424443235244443432553333436.54.22 84
328451343334434244244342431442442438.58.22 98
330141422233434234213343341243324326.56.22136
331232323423422222423432123324213 24.56.23109
332442433344354134143443321534443357.58.22102
333244522224324321234245322332223225.54.21134
334351433224543145155243542334433426.58.22140
335243333432332124223222332244322324.56.23118
336242344324422144244443422442433536.56.22110
337342323424322224233332242243433236.56.23102
338243222234323432323324234134313434.56.24 92
339241312223423134143343332342323346.56.22113
401343334433343122354334311332424344.87.42118
407232423334343233224242343444422234.84.42135
408131322233343234223232331323424324.87.42116
410233223213322432222125223223323224.84.44113
411352422335555154255343342532334536.86.42127
412352324554311112154235211232421314.88.43125
413232221223222334224232343222322324.86.43 97
416344334324432324342444334344343225.85.41 95
417334444235422243335343442325522335.84.41 82
420242333235312223233312211112223424.86.43103
421133332433333313155353531413313316.86.42
422242333224422334224233332233323465.87.43120
423253312145554325233454432443452435.83.42107
424444532355433244244244443333343436.86.41109
425324344445231344343334343444532344.84.44138
433434434344344332244243323344434436.86.4[illegible]
435441434425433234244443443543423438.86.4[illegible]
```

APPENDIX C (Continued)

KAI item data file (continued)

```
FILE: KAIZ      DATA      B    *** VM/SP AT SHEFFIE

43634232222232123433434333233332232 6.86.43112
437241333234332214234232331422323226.86.42108
439232434243341342323324323242323434.86.44-84
440332422243244225322233442222214224.86.42114
458332344424423234244344442343441537.84.42107
459342432225333135224243442333222328.85.42132
476343224344422134244243434443333436.86.42 99
477243422212332234233132442532325336.86.42119
479452324423432115134345441342344145.86.42 88
```

APPENDIX C (Continued)

44-item revised KAI data file (n=181)

```
1334135322444425313432342343544315543435225353123001
4243233232234434111132441334434323125243132343716002
3323123232225424211242443243244344243423232443612003
1444344343454133454445545312455353545524424343812004
3231322232333244222132332233342333223322334342623005
3254445344444424432422434434454423334443333433312006
3433332324512333334434434232334343434244335332512007
4444134424444444442434424444444443442442444426 13008
5353344433344424433543433425244342344243244443212009
234333442424442442243254254324532423523432445    6010
2443444154355434443444552434243344545344525443223011
4244444534554252454544454422444454455244545542813012
2341342342233424424441553424454444244243314543312013
5432342332434433343433333531353353353332324324012014
4453444452555525444412532424253441234244422543611015
2323333343334423334323432433223432342334334433251 2016
5134245424213342321234333214323334523323414344116017
4433113322344435253432443423353434234244413314225018
4332134323324434334232433334334333343343324443623019
4443444434324324344434342434333343443333434342811020
4232332344322323312332433433431324323323332333111021
4353243334424433334433443533344434344535324333614022
4254255545353535532532552554315532523555535533214023
3242142432323544231232342433442433243243323433814024
3354244432454434443433444333233443443444334433401 2025
1454433424234445443343343344343442243424444433112026
3233244332424344342342432432343334344424432444013027
2353445534355435533523543545353423354545234533816028
3234444322344413425542442331454333253244335423716029
2432452333425435313431444333243335235344313323516030
5242244413354322423222442433332434334233224323516031
3243344343354243221344343243233144345234325234013032
3332141213332322323443452434333334244134324342916033
2543343342335433443442343434453443254334534543113034
3244543323423424332522442442133322444222334433116035
3532332252435534234443244333443434334533443544251 2036
4332132322344434312431451334432435134242215343213037
3442344432414354423433442442453534343244424334212038
3242134222243315214253453554454423233343344233214039
3342233332444322334222332432333333344243333243026040
2243234232444424322322442234424332244323234432926041
2423443444544334444443443334434343444433324343713042
4552543344443524544551443534442554244151225253712043
1533225344454424255234242232242353454342541352513044
3444443322434443433532342544433343344244424323012045
4343253213434344421532223533344323334254223433423046
2343422125434433314523443434432432344433315533513047
2251442422454423434432252333341424243333224233212048
5252242223424435513521452445343444145334324443312049
3244142423344333424242224244434423324424422444342105 0
1141555511151543525251451544453424253141224333713051
3232332313334433322332322323323223222332321132923052
2222322333223422322332232233232324232223332233281305 3
2222424222435212221412112212324121121121222324413061
3244222322455255421324221543452424442234424443612062
```

APPENDIX C (Continued)

44-item revised KAI data file (continued)

```
FILE: REVKAI   DATA     B   *** VM/SP AT SHEFFIELD CITY

5151241423515515513511551245553545145555515353516063
5343342221244321423422331232434122224444233433513064
3243322423324323222324344243334422324344322433281306 5
2553544453554334323523444534244343443334544344111066
4443432442424424432443453244344424344343444453516067
5142155111223111111111151113111155113111113114026068
5244243421444421433224343542343322325432214433411069
3452451423354345322333552543434434444323334322612070
4233133323233424413142542433433323233343224342812071
4442342521224454424542452432442454244244122443811072
4341151312122452344112311134145411213521214353813073
3253541424243434433222342332344434244334234433626074
4334243223244232434334443424232344445344245443626075
4241332222313425512111351232443415242233124242712076
2552452322555514455542452434443411144245425353212077
2144545312454415512524542454355512455443245323212078
4234424332354322332323332422434322334232224223812079
2443433434344434323222433342443344344424433443913080
5244144421242313425135335141135414524543244244512081
2234245321415555321552242544534413354234444532211082
4233134232434333312121221243332312121322224313013083
3211211322211221212231312233311222111233311233122084
3423231545322424422231143352333533334343341444331408 5
1555343343255244455323343342342343352423232332715086
2331141512111413411142341331134215223422132332316087
4344243444543454354134534434243344344433325442113088
4233124432252233224222232112334232322232323222512089
4343242343444232424243422334442342233442222432111090
4253243333444323431232342544144333242444324342326091
2331443434354344321223453543443451333122225122525092
4443243432435122433423324434444322333242312332511093
4233222332334443422332232233243323244324322322813094
4231341422331433433423351451243431132231314332413095
5342234434434313245423452123243245143141114422612096
3243322432332323222323232332323233224423432212309 7
4324245323414343324443433444335233443322345432313098
3153342111454323422433251351453333323343333222112099
4253542423334453444543544545532424335535525542414100
5243133422424324314342442332344313343233114424022101
2442444442242444345554125534322332234243434223412102
3223322222243225324344432234324222424433233222312103
3243533322242424433433342434333443343343334433816104
3342243422454525432533452532253434353352115313416105
4454145414445454443355553341455445545344245453323106
3342332431525245222342334334344233334234434434013107
5153222323224523434343133243134223225543234433413108
3342342331343544433232442434443343244343234432521109
1343245535454334434443542434434433444524334443712110
3354344224444445434434443444443344444444433444292411 1
4431332333313334313331321232231321132131212133822112
2522353443543544334444344355445434335324343443471211 3
3133144323542322445244424112135222545431425212712114
5344213211532232215421322244324211145322235323513115
5233424322343224224424332423522222234243332324012116
4253543233354533421323552342244454345312315442812121
```

APPENDIX C (Continued)

44-item revised KAI data file (continued)

```
FILE: REVKAI   DATA     B   *** VM/SP AT SHEFFIELD CIT`

44323534332523353134213414334533341333342243333216122
44542535233355255224215535555353533255455225553912123
23441443224444444343224423343343444444444414432812124
43331323245553243251525445355453551552444153534131 25
54421224245255255322212423444534542342443244236121 26
13512413231513122142111414322424211313321143128121 27
53412513232124345121315515513524331533432145335121 28
34531233545344334234424444454444442443454234442121 29
34532445414454544344445345454544314443445352449131 30
22525524223225555445544535552555554524542444411 4131
24412415114244255112113115551512241521422244427221 32
15324324434242343535314423434323431333234244223121 33
42331342232224343142232232343342422422321222343131 34
24424224124525324554534434442444544453434444333231 35
43332422114234444253314513343424342334442233324231 36
52431444415153254442421425542524442445441335241141 37
35431523324355244245424525454434253453444255434231 38
34534525354455455343435524543535454543444344526231 39
42512533224433244443424434445525434452442253425131 40
43535432332424114312432425442434331542533324447121 41
24333543213254244224322525412433423422443242339131 42
43523525122335234223313513433424332432433144331231 43
54432434144454444243324524543434444353444334453013144
43522434332534233344324422423444332342322353433121 45
32113212323112212223313112333212321112232112342121 46
23223323323223324233324332334222322222333223342121 47
42231442234243453222424524234343342443442343336241 51
42443532112343234453424421344424255452442243444231 52
51343452132323425141332423322352234434451243228231 53
21342444222542213551223221322353234322421232140231 54
33222325432232224123325414423443342443332243429141 55
34523434313344354324225315444434444243324125452916156
53234222223332143121221212332322221231322133133121 57
41523423233324234232314413433434331432423243 2  16158
42512324133252332142314423243423342342431154127111 59
24251351334143233441333334344351235245251434527251 60
42434312234344354354313425354434443254344315432526161
23344543134532333355553325333352434343345354432121 62
32422324323223343242223323344323242343322233223121 63
24412322244542352552515344253242342454354154426131 64
22341344244434143245442314452443442444443224437141 65
34553554253535515523155515554554345555554455136141 66
32554454444454535444544434314355532545344455453213167
43424432424444355235435424453424344454444414432912168
44341454345554343433442422253353422444434344336221 69
43433432234445344345433435443333443253544354436111 70
23434254143435254232524435445454343452543345426131 71
21342233222442233222422322342242222424222234422721 72
13324222211452134455314445355224531554352142533161 73
25452553515554144555255555555255555555555255530121 74
25434445435544445443344535443434444354244345442712175
23122222323212212222223122333222332111223112342121 76
42223222323123213122313213322213231212322112229121 77
35533414325144434355235444324434444344344445433426181
14455534444553543345341434214252555554553355233231 82
```

:

APPENDIX C (Continued)

44-item revised KAI data file (continued)

```
FILE: REVKAI    DATA     B    *** VM/SP AT SHEFFIELD CITY

2234144321455244444233243344345342344435335434213183
4333343332332333323433323333333233333233334342823184
5343454443242442344421342444244443334544434433913185
4552131422221433513231352535452344245245115533914186
1553544543415435424532542444442422144144425223813187
5234142433324324224443354322322254244142123224712190
4243233424232334333232443334333313233434224224616191
4333342323223534433452242233343414435342325454416192
4422241321415355345542552431343354351244334444912193
1553452333433435343223334323234232443323544334712194
3353344523435432432434444234444444344343324333812195
4432243232343224432122442333342432234233323345012196
3432342322434324334342243334433343244232324233012197
5243242323233434535151343134243334343334224343423198
2244433323234323433433433433344342334334224433113199
322244132141222321411122321322221223222221234416200
```

APPENDIX D

Example of SPSSX: Breakdown Table

18 FEB 86 MANAGEMENT OF R & D
18:14:26 Sheffield City Polytechnic IBM 4341 VM/SP CMS

- D E S C R I P T I O N O F S U B P O P U L A T I O N S - - - -

CRITERION VARIABLE SKPERF SKILLS PERFORMANCE
BROKEN DOWN BY AGE AGE OF EMPLOYEE

VARIABLE	VALUE	LABEL	MEAN	STD DEV	CASES
FOR ENTIRE POPULATION			6.0247	1.3452	93
AGE	1	<25	4.8900	.9219	10
AGE	2	25-29	5.8522	1.2652	23
AGE	3	30-34	6.2947	1.4935	19
AGE	4	35-39	6.2211	1.3994	19
AGE	5	40-44	6.4125	.9833	8
AGE	6	>44	6.2643	1.3517	14

TOTAL CASES = 93

APPENDIX D (Continued)

Example of SPSSX: Crosstabulation

08 JUL 86 MANAGEMENT OF R & D IBM 4341 VM/SP CMS
10:13:38 Sheffield City Polytechnic

C R O S S T A B U L A T I O N O F QUAD KAI TYPE BY SEX SEX OF EMPLOYEE

QUAD	COUNT / ROW PCT / COL PCT / TOT PCT	SEX: MALES 1	FEMALES 2	ROW TOTAL
TYPE 1	1	24 82.8 33.8 25.8	5 17.2 22.7 5.4	29 31.2
TYPE 2	2	24 72.7 33.8 25.8	9 27.3 40.9 9.7	33 35.5
TYPE 3	3	17 73.9 23.9 18.3	6 26.1 27.3 6.5	23 24.7
TYPE 4	4	6 75.0 8.5 6.5	2 25.0 9.1 2.2	8 8.6
	COLUMN TOTAL	71 76.3	22 23.7	93 100.0

CHI-SQUARE	D.F.	SIGNIFICANCE	MIN E.F.	CELLS WITH E.F.< 5
0.98301	3	0.8054	1.892	1 OF 8 (12.5%)

STATISTIC	VALUE	SIGNIFICANCE
PEARSON'S R	0.07059	0.2507

NUMBER OF MISSING OBSERVATIONS = 0

APPENDIX D (Continued)

Example of SPSSX: Pearson Correlation Coefficients

25 FEB 86 MANAGEMENT OF R & D
18:27:49 Sheffield City Polytechnic IBM 4341 VM/SP CMS

- - - - - - - - - - - - - - - P E A R S O N C O R R E L A T I O N C O E F F I C I E N T S - - - - - - - - - - - - - - -

	SEX	AGE	WORKEXP	RDBAL	QUAL	DEPT	TEAM	KAI	OSCALE	ESCALE	RSCALE
SEX	1.0000 (0) P= .	-.3889 (93) P= .000	-.3657 (93) P= .000	-.0883 (93) P= .200	-.1761 (93) P= .046	. (93) P= .	. (93) P= .	-.2054 (93) P= .024	-.0929 (93) P= .188	-.1506 (93) P= .075	-.2523 (93) P= .007
AGE	-.3889 (93) P= .000	1.0000 (0) P= .	.9169 (93) P= .000	.0138 (93) P= .448	.3694 (93) P= .000	. (93) P= .	. (93) P= .	.1597 (93) P= .063	.1409 (93) P= .089	.0655 (93) P= .266	.1576 (93) P= .066
WORKEXP	-.3657 (93) P= .000	.9169 (93) P= .000	1.0000 (0) P= .	.0342 (93) P= .372	.2425 (93) P= .010	. (93) P= .	. (93) P= .	.1063 (93) P= .155	.1199 (93) P= .126	-.0417 (93) P= .346	.1357 (93) P= .097
RDBAL	-.0883 (93) P= .200	.0138 (93) P= .448	.0342 (93) P= .372	1.0000 (0) P= .	-.1217 (93) P= .123	. (93) P= .	. (93) P= .	-.0568 (93) P= .294	-.1025 (93) P= .164	-.0560 (93) P= .297	.0231 (93) P= .413
QUAL	-.1761 (93) P= .046	.3694 (93) P= .000	.2425 (93) P= .010	-.1217 (93) P= .123	1.0000 (0) P= .	. (93) P= .	. (93) P= .	.3870 (93) P= .000	.3137 (93) P= .001	.2997 (93) P= .002	.3148 (93) P= .001
DEPT	. (93) P= .	. (93) P= .	. (93) P= .	. (93) P= .	. (93) P= .	1.0000 (0) P= .	. (93) P= .	. (93) P= .	. (93) P= .	. (93) P= .	. (93) P= .
TEAM	. (93) P= .	. (93) P= .	. (93) P= .	. (93) P= .	. (93) P= .	. (93) P= .	1.0000 (0) P= .	. (93) P= .	. (93) P= .	. (93) P= .	. (93) P= .
KAI	-.2054 (93) P= .024	.1597 (93) P= .063	.1063 (93) P= .155	-.0568 (93) P= .294	.3870 (93) P= .000	. (93) P= .	. (93) P= .	1.0000 (0) P= .	.8536 (93) P= .000	.6647 (93) P= .000	.8427 (93) P= .000
OSCALE	-.0929 (93) P= .188	.1409 (93) P= .089	.1199 (93) P= .126	-.1025 (93) P= .164	.3137 (93) P= .001	. (93) P= .	. (93) P= .	.8536 (93) P= .000	1.0000 (0) P= .	.3713 (93) P= .000	.5619 (93) P= .000
ESCALE	-.1506 (93) P= .075	.0655 (93) P= .266	-.0417 (93) P= .346	-.0560 (93) P= .297	.2997 (93) P= .002	. (93) P= .	. (93) P= .	.6647 (93) P= .000	.3713 (93) P= .000	1.0000 (0) P= .	.3864 (93) P= .000
RSCALE	-.2523 (93) P= .007	.1576 (93) P= .066	.1357 (93) P= .097	.0231 (93) P= .413	.3148 (93) P= .001	. (93) P= .	. (93) P= .	.8427 (93) P= .000	.5619 (93) P= .000	.3864 (93) P= .000	1.0000 (0) P= .

(COEFFICIENT / (CASES) / 1-TAILED SIG) " . " IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED

APPENDIX D (Continued)

Example of SPSSX: Multiple Regression

06 MAR 86 MANAGEMENT OF R & D
14:34:11. Sheffield City Polytechnic IBM 4341 VM/SP CMS

* * * * M U L T I P L E R E G R E S S I O N * * * *

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. COLL COLLABORATION INDEX

Beginning Block Number 1. Method: Enter

Variable(s) Entered on Step Number
1.. RSCALE SUB-SCALE R
2.. ESCALE SUB-SCALE E
3.. OSCALE SUB-SCALE O

Multiple R	.45715
R Square	.20899
Adjusted R Square	.18232
Standard Error	5.18965

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	633.29267	211.09756
Residual	89	2396.98690	26.93244

F = 7.83804 Signif F = .0001

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
RSCALE	.009621	.100264	.011242	.096	.9238
ESCALE	-.537204	.129335	-.433493	-4.154	.0001
OSCALE	.297395	.092258	.375124	3.224	.0018
(Constant)	41.977109	3.634617		11.549	.0000

End Block Number 1 All requested variables entered.

APPENDIX D (Continued)

Example of SPSSX: Analysis of variance

08 JUL 86 MANAGEMENT OF R & D
10:13:21 Sheffield City Polytechnic IBM 4341 VM/SP CMS

- O N E W A Y -

Variable CRPERF CREATIVE PERFORMANCE
By Variable QUAD KAI TYPE

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	3	44.3811	14.7937	10.5520	.0000
WITHIN GROUPS	89	124.7759	1.4020		
TOTAL	92	169.1570			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
Grp 1	29	6.5345	1.1515	.2138	4.5000	9.1000	6.0965 TO 6.9725
Grp 2	33	6.4576	1.2794	.2227	3.5000	9.1000	6.0039 TO 6.9112
Grp 3	23	5.1609	1.1976	.2497	2.1000	8.1000	4.6430 TO 5.6788
Grp 4	8	4.7250	.7285	.2576	3.7000	5.7000	4.1160 TO 5.3340
TOTAL	93	6.0118	1.3560	.1406	2.1000	9.1000	5.7326 TO 6.2911
FIXED EFFECTS MODEL			1.1841	.1228			5.7679 TO 6.2558
RANDOM EFFECTS MODEL				.4393			4.6138 TO 7.4099

RANDOM EFFECTS MODEL - ESTIMATE OF BETWEEN COMPONENT VARIANCE 0.6099

Tests for Homogeneity of Variances

Cochrans C = Max. Variance/Sum(Variances) = .3322, P = .432 (Approx.)
Bartlett-Box F = .942 , P = .419
Maximum Variance / Minimum Variance 3.084

APPENDIX D (Continued)

Example of SPSSX: Factor analysis

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3
ITEM21	.80116	.08041	.19479
ITEM23	.76094	.15544	-.00672
ITEM11	.68756	-.05378	.08183
ITEM19	.58171	.04651	-.06946
ITEM16	.51965	.00305	.12502
ITEM14	-.17424	.83008	-.04615
ITEM25	.08104	.76922	.15379
ITEM4	.05158	.59738	.03956
ITEM22	.09252	.49408	.11902
ITEM28	.06623	.48680	.03442
ITEM30	.24263	.00263	.80556
ITEM2	.05809	.07196	.71951
ITEM6	-.04785	.15324	.51857
ITEM7	.03497	.08530	.43368
ITEM20	.03770	-.02202	.42064

FACTOR TRANSFORMATION MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3
FACTOR 1	.75586	.36762	.54178
FACTOR 2	-.40860	.91143	-.04839
FACTOR 3	-.51158	-.18479	.83913

APPENDIX D (Continued)

Example of SPSSX: Reliability analysis

24 NOV 86 MANAGEMENT OF R & D
12:16:30 Sheffield City Polytechnic IBM 4341 VM/SP CMS

R E L I A B I L I T Y A N A L Y S I S - S C A L E

£ OF CASES = 119.0

STATISTICS FOR	MEAN	VARIANCE	STD DEV	£ OF VARIABLES		
SCALE	16.9160	11.7556	3.4286	5		
ITEM MEANS	MEAN	MINIMUM	MAXIMUM	RANGE	MAX/MIN	VARIANCE
	3.3832	3.1092	3.6303	.5210	1.1676	.0365
ITEM VARIANCES	MEAN	MINIMUM	MAXIMUM	RANGE	MAX/MIN	VARIANCE
	.8496	.7674	.9808	.2134	1.2780	.0065
INTER-ITEM COVARIANCES	MEAN	MINIMUM	MAXIMUM	RANGE	MAX/MIN	VARIANCE
	.3754	.2525	.5160	.2635	2.0437	.0078
INTER-ITEM CORRELATIONS	MEAN	MINIMUM	MAXIMUM	RANGE	MAX/MIN	VARIANCE
	.4447	.2910	.6177	.3267	2.1226	.0121

ITEM-TOTAL STATISTICS

	SCALE MEAN IF ITEM DELETED	SCALE VARIANCE IF ITEM DELETED	CORRECTED ITEM-TOTAL CORRELATION	SQUARED MULTIPLE CORRELATION	ALPHA IF ITEM DELETED
ITEM21	13.4454	7.5203	.6936	.5119	.7239
ITEM23	13.8067	7.3776	.6979	.4973	.7212
ITEM11	13.5462	8.0127	.5657	.3815	.7643
ITEM19	13.5798	8.4152	.5062	.2849	.7819
ITEM16	13.2857	8.1889	.4562	.2298	.8014

RELIABILITY COEFFICIENTS 5 ITEMS

ALPHA = .7983 STANDARDIZED ITEM ALPHA = .8002