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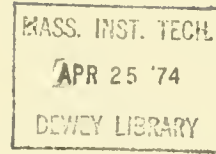
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COGNITIVE STYLE & THE PROBLEM-SOLVING
PROCESS: AN EXPERIMENT

Peter G.W. Keen
March 1974

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The author would like to emphasize the influence and contribution of Professor James McKenney to this paper.

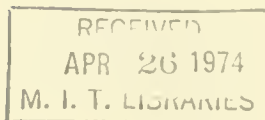
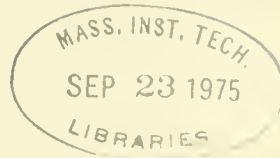
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This paper describes an experiment conducted as part of a wider study of cognitive style. The underlying paradigm is briefly outlined together with the methodology used to classify individuals style. The results of a series of experiments examining the implications of cognitive style are summarized; these focus on career preferences and personality factors.

The body of the paper describes an experiment using a distinctive, small sample of student subjects, which examines in detail the processes of problem-solving. The experiment focuses on the relation between cognitive style and:

- a) problem-choice and performance
- b) strategies of problem-solving
- c) characteristics of verbalization and structure of argument

Some generalizations (and speculations) are drawn from the experiments concerning aspects of management practice where differences in cognitive style seem especially important:

- a) communication and mutual understanding
- b) the design of work teams
- c) the design and use of decision aids, especially computer-based models.

I. Introduction

Most people are fully aware of the degree to which personality affects behavior, and in dealing with other people we generally take differences in character into account. On the whole, we also show tolerance for those differences without necessarily insisting that our own personality is the "right" one. In organizations, groups and marriages, people invest substantial effort in learning to understand and accept each other in this way. By contrast, we seem much less tolerant of other people's ways of thinking. Perhaps we have, for too long, been taught that thinking should be "logical": this implies some single desirable style of thought, marked by rigor, precision, and method. Certainly, when we reach a solution to some problem, our answer is "right" in our own terms; it is the outcome of a process in which we assess evidence and prove a case. We communicate to others in terms of that evidence and proof. In management decision-making, this view of thinking has been reinforced by the distinctly rationalistic approach of most management science techniques (and, on a theoretical level, by the Carnegie School of Research under Cyert, March, and Simon, which has been perhaps the most dominating influence on modern theories of decision-making). A complex OR model, which rigorously defines all the features of a problem and structures a method for analyzing them, is a substitute for or analogue of the manager's own problem-solving, and is more efficient and more effective in many instances, (eg. linear programming solutions for distribution problems); it is very easy for quantitative specialists to argue therefore that the style of thinking implied by the model is a "best" one towards which a manager should aim. Though the manager may counter this by pointing to the very real limitations of OR techniques in certain circumstances, he is still likely to agree that his job requires some distinct methods of problem-solving and that anything else is unsuitable and even undesirable.

In recent years, the term "cognitive style" has appeared with increasing frequency in management literature, to the extent that it now constitutes a definite if small left-wing fringe in management science circles and is part of the conventional wisdom in more behavioral areas. The concept of cognitive "style" runs directly counter to much of the technical tradition mentioned above. It argues that there is no single right way of thinking, but that, as with personality in general, there are a range of strategies, habits, and abilities that all have value in particular circumstances. Competent individuals learn to build on their strengths and gravitate to positions where there is some fit between their cognitive style and the demands of their job - i.e. their style is such that they are comfortable as well as capable in processing the information and reaching the decisions involved in their work.

It is easy to outline the implications of cognitive style for decision-making, much less easy to develop reliable classifications of style. The whole field of cognitive theory is marked by a set of competing taxonomies which try to capture some very elusive processes in a simple conceptual scheme. This paper presents an experiment which uses a particular paradigm of cognitive style, but the aim is to establish a perspective rather than to justify that model. The experiment focuses on the process of problem-solving rather than on performance in obtaining correct solutions. One of the reasons we may overlook the degree and impact of differences in thinking styles is that we generally do emphasize answers rather than the processes leading to them. In academic tests, particularly those measuring IQ, each problem has only one answer, but in complex management functions in marketing and corporate planning, this is clearly not so; in the IQ test, the problem and the unique answer implicitly constrain process, but in more open ended problems, such as trying to forecast shifts in taste in men's fashions, the particular approach and direction of the manager may well determine what answers can be arrived at. The problems dealt with by the subjects in this experiment were designed to be a cognitive Rorschach - a set of very open-ended questions with no visibly correct answer; this allowed the subject to respond in any

way he wished and thus highlighted his idiosyncratic strategies and approach.

The experiment is part of a larger study of cognitive style. It involves 20 subjects whose performance on a set of tests given to 150 MBA students indicated a very distinct cognitive style. This sample is not representative, either of students or decision-makers. (The statement that psychology is 'the study of sophomores' is fair criticism.) The students do, however, intend to become business managers and have substantial work experience. In addition, the overall results of the tests they took correspond fairly closely with those of 100 middle-level managers. It would be very foolish indeed to claim that any of the experiments in the main study from which this one is taken can be generalized directly to decision-making, but the subjects are fairly similar to competent managers in skills, training, and aspiration. More interestingly, they view themselves as very much alike; from their responses to a detailed questionnaire on their general approaches to work and study, it was impossible to pick out those of one cognitive style from the other. As the discussion of the experiment will show, they are entirely different in their problem-solving behavior in terms of the type of problems they enjoy, their performance, the flow and structure of their arguments, and even their use of language. Hopefully, the discussion will establish the main points of this paper: that, regardless of the specific labels we attach, the concept of cognitive style is a useful framework for examining one's own and other people's approaches to problems, and that it provides some broad insight into decision-making behavior.

The paper does not describe in detail either the main model of style or the experiments which developed or applied it; these are outlined elsewhere and are tangential to the more general aims of this paper. If the arguments in the following pages are convincing, the paradigm of cognitive style they are based upon will obviously gain credibility. The experiment here, however, largely points to important phenomena that need explaining; the hope is to alert researchers, managers, and students to those phenomena and to convince them that cognitive style is an important component of the complex

management behavior that they all, from differing viewpoints, try to understand and assist.

II. Styles of Problem-Solving

The model of cognitive style underlying this experiment is described in detail elsewhere. (Keen 1973¹) The full model is two-dimensional, classifying individuals in terms of the strategies, implicit or explicit, that they use in:

- 1) information-gathering: screening and cataloguing new information from their perceptual environment
- 2) information-evaluation: assessing information and reaching a choice of solution in problem-solving activity.

The second of these two dimensions is the one which is relevant to this study. The paradigm of cognitive classifies problem-solving strategies along a spectrum ranging from Systematic to Intuitive. The differences in the two extremes relate mainly to planning. Some individuals are very methodological (which is in no way the same as methodical); their response to a problem is to explicitly define how they will approach it. Their main effort goes to laying out the constraints of the problem, selecting and then implementing a strategy. Their analysis is basically sequential, zeroing in on a solution through steps of increasing refinement; they try to set up their definition of the problem so as not to have to repeat any step in the problem-solving sequence. This Systematic mode of response is thus marked by several distinctive features:

- 1) a conscious awareness of where any substep fits within the overall plan
- 2) an ordered sequence of search and analysis
- 3) the justification of a solution largely in terms of method.

In many ways, the Systematic thinker's plan amounts to a program, in the computer meaning of the word. Before the program is run, all the rules for action have been

specified so that the rest of the problem-solving process is mainly computational or analytic; in a sense, the methodology guarantees the solution. This is not to say that the program contains rigorously deterministic rules. Simon, Newell, and Shaw showed in their early work on computer simulation of human thought, that many of them are heuristic - rules of thumb that do not guarantee a correct answer, but which provide a high probability at relatively low cost of effort.² Feigenbaum and Feldman summarize heuristics as offering "solutions that are good enough most of the time"³.

Not surprisingly, the Systematic approach to problem-solving seems to be common among engineers and production managers. They can - even should - make plans, since they can anticipate the general features of their problems and thus refine their strategy over time. The specific scheduling problems encountered by a plant manager may range over a variety of levels of complexity, urgency, and tradeoffs, but he can generally articulate before he starts on a particular problem a methodology for handling it. He can refine his plans as he learns; a common characteristic of engineers or production personnel is their ability to use checklists or standard procedures in crisis situations; their set of heuristics has been built up from many similar situations and generalized to the extent that it becomes a program that can be put into immediate and effective action.

Part of the difficulty in discussing Intuitive style is that unlike Systematic thinking it lacks conscious definition and visible structure. Its most obvious feature is a reliance on un verbalized responses; if the subject is not aware of how to articulate these, the researcher will be even less likely to do so. However, Intuitive problem-solving does have an underlying set of characteristics that are as consistent and purposeful as the Systematic's conscious plans. The main principle governing the Intuitive's sequence of thought is a continuous global sense of the whole problem. Once the Systematic thinker has defined the problem and his methodology for dealing with it, he can largely leave the original problem-statement behind. He can also break the process up into a series of discrete substeps - his plan provides the frame-

work for fitting them together into a coherent sequence. The Intuitive by contrast continually relates a step in his analysis to the overall problem, 'implicitly asking "does it fit together? does it make sense?" as he proceeds. This allows him to work with much more ambiguity in the problem. For instance, a manager who is asked to forecast consumer preferences over the next two years for men's shirt styles has a problem that is hard to fit into any plan. The Intuitive's response may well be initially to scan over a wide range of ideas and information, developing a sense of the issues and testing out some concepts well before he even defines the problem as such. He might, for example, review his own buying habits and his wife's influence on them, scan Sears Roebuck catalogues for the last two years and read through an industry report on the subject of men's fashions. The search is not random, but it is hardly planned. He may draw some tentative conclusions from each area of this initial analysis and the process of fitting them together or resolving some contradictions among them may then lead him to define the real "problem" which he might feel is to identify the lagged relationships between shifts in style in women's fashions and men's. He may, at that point, be able to articulate a systematic plan, perhaps in the form of instructions to a staff analyst. It is important to note that when he began his analysis he had no direct reference point for determining the relevance of each step. The Systematic can assess the value (and purpose) of reading the Sears catalogues by reviewing his methodology; the Intuitive's rationale is much more one of "let's see what I can get out of this". His reference point has to be his sensitization to the overall implications of the problem and an alertness to the meaning of what he has just done at each stage in the process. It is in this sense that he mainly relies on "feel" and cues where the Systematic uses method and plan.⁴

In this example of forecasting shirt fashions, the manager evaluates a wide range of information, whose relevance cannot be anticipated. He thus cannot afford to review it exhaustively and must be ready to discard lines of exploration that are un-

promising very quickly. Largely for this reason, the Intuitive does not verbalize his problem-solving to anywhere near the same extent that the Systematic thinker does. Essentially, verbalization involves the use of very limited channel capacity. Broadbent and others have shown that man seems to have a two-level memory structure.⁵ Short-term memory can hold a few items - the Magic Number Seven" of Miller's essay - for a fraction of a second.⁶ Memorization involves refreshing short-term memory several times, so that the stimulus does not fade out, while committing it to the apparently infinite long-term memory store. This process can be seen in everyday attempts to memorize a telephone number; to store the number 605-9361 a person will generally mutter it aloud or in his mind until it is learnt. Information in short-term memory is at the fringe of consciousness; it seems a plausible guess, though it is little more than that, to view the Intuitive as operating at this fringe, able to pause and bring information into more conscious awareness when he hits on some worthwhile line of exploration. It is in this way that his strategy with its potentially high fraction of false starts, redundancy and dead-ends can be successful. The Systematic's conscious awareness of what he is trying to do and of the direction of his analysis means that he will process only the data that is likely to be relevant - his plan in itself screens out noise and wasted effort. The Intuitive must operate with immensely more speed than the Systematic because he has no such mechanism for screening; the speed can only come from avoiding the substantial time lapses implicit in verbalization. A common phenomenon in his thinking is the "hunch", an unarticulated sense that some information or line of thought contains a vital cue. Quite often, that hunch comes a few seconds after the cue itself; he then tries to recapture it by backtracking and reconstructing his line of thought.

Cognitive style and learning are different facets of the same phenomenon, the development of the ability to handle problems in the very widest sense of the term. The Systematic's learning is in the direction of what Guilford terms "convergence" and the

Intuitive's towards "divergence".

"In convergent thinking the aim is to discover the one right answer to the problem set. It is highly directed, essentially logical thinking of the kind required in science and mathematics. It is also the kind required for the solution of most intelligence tests. In "divergent" thinking, on the other hand, the aim is to produce a large number of possible answers, none of which is necessarily more correct than the others though some may be original. Such thinking is marked by its variety and fertility rather than by its logical precision" (Zangwill)⁸

This comment seems a useful one in relating cognitive style and management occupations. The Systematic Thinker's drive and hence his learning is towards convergence. Very obviously, he is suited to and attracted to occupations that enable him to grow in this fashion. Most engineers are Systematic in style; to an extent, the engineer is the prototype of Systematic thinking. His learning is essentially in method and in formalization of problems and he refines his techniques over a period of time. There are many management positions, often filled by individuals with an engineering background, that both need and encourage this process. Production, distribution and administrative functions are clearly of this type. The Intuitive's learning is aimed towards divergence; in a role such as plant manager, the demands of the task and his own growth are in conflict - it is not so much a question of whether or not he is competent in the job, but that it does not "fit" his style, his process of problem-solving and assimilating of experience. His divergent learning is much more one of self-confidence. He needs to internalize his experience to a degree that he will feel confident in going out on a limb, trusting the sense that he cannot articulate but which has shown itself to be effective in previous situations. Over a period of time he will not necessarily become more "divergent" in terms of being able to invent more and more solutions but he will develop a skill in generating a variety of useful solutions - if the context of his job makes that desirable. As in most such processes involving the assimilation of complex feedback, there is a chicken-and-egg aspect to this. The Intuitive needs the context of such a job to allow him to produce the answers which over time

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increase his sense of confidence in his ability to thus operate intuitively. Again, it is not necessarily a question of competence; in many management problems, the Systematic and Intuitive will end up with the same solution, arrived at by a different process. However, the fit between their style and the ongoing demands of the job may well be different. Most individuals have both Systematic and Intuitive capacity. It is only when a person develops a marked imbalance in skills together with a preference or instinct for a particular mode of problem-solving that he can be said to have a cognitive "style". To an extent, cognitive differentiation is the likely outcome of a specialized education and environment. This argument is supported by Altemeyer's research at Carnegie-Mellon; he found that while freshmen in liberal arts and the sciences could not be differentiated as a group in terms of cognitive skills, there were definite and marked differences by the time they were seniors.⁹ This implies that specialization in college studies leads to specialization in problem-solving behavior as a whole. Perhaps there is a process here in which a person builds on his strengths and thus further reinforces them, while at the same time his weaker skills atrophy. This may well be the underlying explanation as to how a cognitive style emerges in a particular individual; where his environment in his formative years leads him to develop a set of stable, effective and reliable responses he will tend to lean on them, and use them in most situations. Of course, this also implies that a cognitive style need not develop; the more general the person's education and environment, the less he is likely to show such a cognitive specialization. Piaget's concepts of assimilation-accommodation are very compatible with this suggestion.¹⁰

An analogy with cognitive style may be found in other dichotomies in psychology, such as extrovert/introvert. Extremes of introversion and extraversion obviously occur but most people fall into a middle, neutral range. It is not that they are of neither psychological type, but that they show both characteristics at different times and in different situations. It is useful to relate a person's "introversion" to his behavior

only when it is marked enough to be a consistent style of response. Similarly, the term cognitive style is intended to describe the case where an individual's response to information-processing and problem-solving is consistently in a particular mode. That fraction of the population that has a definite style will partly depend on definition; exactly as with extraversion and introversion, the choice of cutpoint between "neutral" and introvert is critical and inevitably to some degree arbitrary.¹¹ A rough estimate of the proportion of managers whose behavior is sufficiently differentiated to merit the term "style" can thus be at best a guess. Over the duration of the research here on cognitive style, the estimate that has emerged and that seems an acceptable one is that 60-70% of the various subjects tested do have a distinct style.

The term "switcher" seems applicable to people who do not manifest a definite style. These are individuals who are not cognitive specialists in any sense; they can adapt their response to particular problems; they do react more to the problem-stimulus itself instead of imposing their own mode onto the problem. The switcher's ability is more general; as with people of strong cognitive style, they have assets and weaknesses. They may well cover the middle-ground very effectively. They can deal with most problems they encounter. Obviously, however, there are extreme types of problem where they are less at ease or less capable than a strongly Systematic or strongly Intuitive person. It seems likely that even the switcher will veer towards one mode of style if his work experience increasingly focuses on one functional area or type of problem. Cognitive specialization thus seems both natural and desirable for specialized job functions. Cognitive style would seem slow to change since it is an integral part of personality. None the less, the general urge towards cognitive ease, learning and effective commerce with one's environment would require some adaptation. Once again, the anthropological analogy is a valid one; success leads to a reliance on and confidence in particular responses and a corresponding atrophy of others and at a certain point this process hardens into a stable structure.

Figure 1 below summarizes the main characteristics of each mode of cognitive style:

Figure 1. Characteristics of Each Mode of Cognitive Style

Systematic thinkers tend to:

- look for a method and make a plan for solving a problem
- be very conscious of their approach
- defend the quality of a solution largely in terms of the method
- define the specific constraints of the problem early in the process
- discard alternatives quickly
- move through a process of increasing refinement of analysis
- conduct an ordered search for additional information
- complete any discrete step in analysis that they set out on

Intuitive thinkers tend to:

- keep the over-all problem continuously in mind
- redefine the problem frequently as they proceed
- rely on un verbalized cues, even hunches
- defend a solution in terms of "fit"
- consider a number of alternatives and options simultaneously
- jump from one step in analysis or search to another and back again
- explore and abandon alternatives very quickly

III. Identifying and Measuring Cognitive Style

Psychometrics is a complex science in which subtleties of methodological and statistical technique are of central importance. Developing a system for measuring cognitive style has thus been both time-consuming and difficult. The scheme that has emerged from that process is fairly broad, in that it discriminates well among subjects of a strong cognitive style, but is not as reliable in classifying those who are less specialized in their problem-solving behavior. However, it seems fairly robust: used as the basis for a set of experiments exploring the implications of style, it pointed to relationships among subjects that were both consistent and consonant with the definitions of the model. In the context of the experiment discussed here, the exact details of the classification method are not really important: it provided a basis for dividing subjects into two groups, Intuitive and Systematic, and the aim of the experiment is to examine differences in problem-solving behavior between those groups - the differences themselves are the focal point of interest.

The basis for classifying subjects' cognitive style was to compare performance on two standard pencil-and-paper tests requiring an Intuitive mode of problem-solving with two others which demand a Systematic response. The absolute level of performance is not relevant; the concept of cognitive style refers to relative performance. For example, a subject scoring 15 out of 20 on the Systematic and 13 out of 20 on the Intuitive pair of tests does not have as pronounced a style as one who scores 10 and 4 respectively, even though he obviously has more overall cognitive ability. The mechanics of classifying style are shown in the following examples:

Figure 2.

Subject	1 score on tests Systematic capacity	2 requiring Intuitive capacity	3 Total of all tests	4 % of total accounted for by Systematic	Cognitive Style
A	15	5	20	75	SYS
B	12	4	16	75	SYS
C	20	18	38	51	-
D	14	11	25	56	-
E	9	16	25	36	INT
F	2	8	10	20	INT

Subject A is classified as Systematic; of his total score of 20 points, 15 are accounted for by the two Systematic tests. Similarly, subject E is Intuitive with only 35% of his total score being obtained on the Systematic tests. Subject D is not regarded as Systematic even though he scores more highly on Systematic than on Intuitive capacity; the difference is not marked enough to justify labelling him as Systematic. In choosing a cutpoint between Systematic, Neutral, and Intuitive, a very conservative position was taken and subjects classified as Systematic only when their performance was markedly better on one mode of capacity than the other.

The four tests used in this scheme are all short (5 to 8 minutes) and part of ETS's huge inventory; sample questions from the tests are given in Appendix A.

The tests were administered to 5 samples of MBA students and to 100 middle-level managers over a three year period. The results were similar for all the samples. Approximately 70% of the subjects showed a definite cognitive style (40% Systematics, 30% Intuitive). There are some very real methodological issues only partially resolved in these experiments (particularly, the use of homogenous groups of MBA students, the development of a method for equating scores on each of the four very dissimilar tests, and the factoring out of motivational influences, visual vs. verbal skill, etc).

None the less, as a broad indicator of cognitive style, the use of the four tests seems very adequate. Moreover, subsequent experiments applying the classifications generated consistent and plausible results. Of particular interest in those experiments was a marked association between cognitive style and the Thinking-Feeling dichotomy (TF) measured in the Myers-Briggs Psychological Type Indicator.¹³ There was no association whatsoever between performance on the tests and the TF scale, that is, there is no apparent relation between personality and cognitive ability. However, an imbalance or bias in cognitive functioning seems to also include a similar bias in personality.

The Myers-Briggs Indicator measures psychological type as defined by Jung. Myers defines Thinking in terms of reaching judgements through a logical process relying on an "impersonal finding". Thinking stresses "realism" analysis, logic, critical faculty. Feeling, by contrast, takes its reference point for judgement from internal values and emotive responses; it makes little appeal to external validation. It was predicted that the Thinking type would tend to be Systematic in style and that the Feeling type would be Intuitive. The Systematic thinker is very much concerned, in his focus on methodology, with external validation; he looks for a process of problem-solving that can be replicated or programmed and whose steps can be independently verified. The intuitive relies much more on his own "sense" of things, which is similar in nature to Jung's "Feeling". The Systematic subjects were almost all Thinking in type (88%, n=25) while the Intuitives were predominantly Feeling (55%, n=29). These results are striking given that in all Myers huge samples, 70% of business students and engineers are Thinkers. The MBA samples contained 75% Thinkers, so that the association between feeling and an Intuitive style seems stronger than the 55% figure may suggest. Myers' summary of the characteristics of the two psychological types meshes well with and fleshes out the description in figure 1 of the problem-solving behavior associated with each cognitive style. She suggests that the strength of the two types are:

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Thinking Type

- analysis
- organization
- weighing "the law and the evidence"
- finding flaws in advance
- holding consistently to a policy
- reforming what needs reforming
- standing from against opposition

Feeling Type

- persuasion
- concentration
- teaching
- forecasting how others will feel
- advertising
- selling
- appreciating other's thinking

It is worth stressing that Myers defines the TF dichotomy largely in terms of interpersonal behavior. An interesting implication of cognitive style, discussed later in this paper, is its impact on communication and mutual understanding. Myers also provides a detailed summary, backed by substantial testing in a variety of settings, of the academic and occupational interests of each type. These are shown in figure 4 below. The Myers-Briggs Indicator measures four scales of Type: the TF scale dominated the results of this experiment; however, a second scale, Sensing-Intuition (where the definition of Intuition is distinctly different from Intuitive in the model of cognitive style) showed some relation to style. In figure 4, the four categories roughly correspond to degree of style; ST subjects are very likely indeed to be Systematic, NT also likely but not quite to the same extent, and at the other extreme NF subjects are almost certain to be Intuitive in style.

Figure 4

Cognitive Style	Systematic		Intuitive	
people who prefer:	Sensing + Thinking (ST)	Intuition + Thinking (NT)	Sensing + Feeling (SF)	Intuition Feeling (NF)
focus their at-: tention on	Facts	Possibilities	Facts	Possibilities
and handle these: with	Impersonal analysis			Personal warmth

Figure 4 (continued)

Cognitive Style	Systematic		Intuitive	
thus they tend: to be	Practical matter-of-fact	Intellectually ingenious	Sociable friendly	Enthusiastic insightful
and find their: scope in	Production Accounting Business Economics Law	Research Science Invention Securities analysis Management	Sales Service Customer relations Welfare work	Research Teaching Preaching Writing Counselling Psychology

In an additional experiment, using 82 MBA subjects, some similar relations were found between cognitive style and occupational preference as measured by the popular (and reliable) Strong Vocational Interest Blank (SVIB)¹⁴. Systematic subjects tended to score highly on occupations which had administrative or business connotations. (and the Intuitives displayed more compatibility with open-ended professional or artistic positions. The SVIB measures the extent to which the subject's interests are similar to those of individuals who have been in a particular occupation for at least three years and who report that they are satisfied with their job. Thus, though Intuitives score significantly more highly on the occupational scales for Artist, Music performer, and Librarian, this cannot be interpreted as an aptitude for or active interest in those fields. The differences between the Systematic and Intuitive subjects are statistically significant and conceptually meaningful, but obviously, one must assess them cautiously. The widest differences between the two modes of cognitive style were as shown below:

Figure 5

Systematics score higher on:

- Purchasing agent
- Production
- Army officer

Intuitives score higher on:

- Psychologist
- Librarian
- CPA owner
- Advertising

Figure 5 (continued)

Systematics scored higher on:

- Personnel Director
- Public Administrator
- Sales manager
- Chamber of Commerce Executive

Intuitives scored higher on:

- Lawyer
- Author/Journalist
- Music performer
- Social Science Teacher

The Systematic group's preferences are marked by their being largely administrative, business positions involving planning, control and supervision. The Intuitive's are more heterogenous and less structured. They involve much less feedback; all the occupations listed above for the Intuitive group lack the characteristic of clear criteria for action with clear feedback of results found in the Systematic group's preferred occupations. These overall characteristics provide at least circumstantial evidence in support of the theoretical formulation of the model. All the experiments cursorily summarized above suggest that the overall paradigm of cognitive style has conceptual validity, some operational soundness, and point to some interesting phenomena. As a package, they amount to an existence proof; the model makes sense and hangs together. However, the experiments provide limited insight into the complex processes of problem-solving. Hopefully, even in this brief summary, the claim that the model of cognitive style provides a meaningful organizing focus for examining differences in thinking has been established. The question that should always be asked of any theoretical paradigm of this type - "So what?" - is to be answered in the rest of this paper.

IV. The Cafeteria Experiment

A distinct limitation of the set of tests used in the scheme for classifying cognitive style is that it focuses on problem-solving capacity; an individual's style

is measured in terms of his differences in scores between tests requiring a Systematic and those requiring an Intuitive approach. The implicit argument is that an individual who scores highly on, say, the Intuitive tests and mediocrely on the Systematic ones is unable to adjust his responses, lacks ability to behave systematically; in this sense, his innate mode of response - his style - is Intuitive.

The "Cafeteria " experiment focuses on response rather than capacity. It explores how individuals "get into" problems and the direction and common themes of their problem-solving process. Twenty-five students were selected from the main sample of 107 who completed the original test battery. There were two criteria used in selecting these students:

- 1) they all were individuals whose style was clearly identifiable
- 2) they scored highly on at least one of the four pairs of tests used to classify style (eight tests measuring the four modes of style in the full paradigm)

The group was thus both distinctive in style and very capable - their style is based more on a real ability in a particular mode of problem-solving than on a disability along the other mode of style. Of the 25 students initially picked out, 20 agreed to take part in the experiment, which involved a one and a half hour session, held on an individual basis; the sessions were tape-recorded. The experiment centered around the problem "cafeteria". a set of problems designed or borrowed from other sources by this researcher. The subjects were presented with the menu of 16 questions from which they were asked to pick out any 5 to answer, using whatever criteria for choice they wished (hence the term "cafeteria") They were invited to talk aloud during the eight minutes assigned to each problem. Otherwise they answered the questions in writing. Most subjects answered at least one question orally, though there were several who preferred to work entirely in silence.

The problems in the cafeteria were intended to provide subjects with ample scope for mapping themselves onto the problem. The tests in the main cognitive battery

are all brief, with a right answer and no real opportunity for wide-ranging strategies. The problems in the cafeteria by contrast tend to be open-ended with, in many cases, no definite answer. Several were almost a problem-solving Rorschach; for example, one problem presented a result of a poll, showing the responses of three groups, teachers, parents and administrators. Subjects were asked which side of the unspecified issue they would support, on the basis of "public opinion" and what they felt the issue actually was. It was hoped that problems of this sort would highlight subjects' habits and strategies. Of the twenty students, one is excluded from this analysis simply because his style, though distinctive in terms of the Information-gathering dimension, was not marked enough on the Systematic-Intuitive scale to allow him to be confidently classified. The remaining 19 subjects divide fairly evenly:

11 Intuitives

8 Systematics

Figure 6 summarizes their performances on the original cognitive tests. The scores shown are the result of converting each subject's performance to a one-to-seven scale, where "1" indicates the subject was in the lowest 1/7th of the 107 subjects and a "7" shows he scored in the top 7th. Thus, the maximum score on each pair of tests is 14 and the minimum is 2. The reasons for using this very conservative scoring are given in Keen 1973;¹⁵ essentially it ensures that large differences in performance are required before a subject can be classified as having a particular style. This runs the risk of failing to identify subjects who do have a definite cognitive style, but minimizes the likelihood of pointing to relationships that are coincidental. The method seems very desirable in testing a new paradigm; the burden of proof is on the researcher and evidence should be weighted against, not in favor of, the model.

Figure 6

Total Scores on Each Pair of Tests				
	Subject	SYS	INT	% of Total Accounted for by Systematic tests
Intuitives	A	6	14	30
	B	5	10	33
	C	5	9	36
	D	3	9	25
	E	3	11	21
	F	5	9	36
	G	6	10	37
	H	4	14	22
	I	9	14	39
	J	3	8	27
	K	4	6	40
Systematics	L	12	5	71
	M	12	2	86
	N	11	2	85
	P	11	6	65
	Q	9	2	82
	R	13	7	65
	S	14	5	74
	T	12	6	67

(Mean for the full sample of 107 on each pair of tests in approximately 7)

The small size of the sample is due solely to limitations of resources. Even this limited group required 30 hours of a research assistant's time, excluding experimental overhead. In retrospect, the insights provided from the experiment would seem to have justified a much larger sample. Moreover, the small size of the group, and particularly of the subgroups (Systematic vs. Intuitive etc.) makes formal testing of hypotheses difficult; there is simply no enough volume of evidence (cell counts etc.) for the mathematics of tests such as chi-square to work. Though the focus of the experiments is intendedly qualitative rather than quantitative, there is always the need to demonstrate that "interesting" results also pass the often limited but rigorous tests of statistical inference. It must also be stressed that this sample is a highly select one, drawn on a very specialized basis from an already specialized larger sample of MBA students. If the aim in this experiment was to identify cognitive styles, the sampling procedure would make standard statistical analysis illegitimate. However, that initial step was accomplished in the earlier analyses and the Cafeteria experiment deliberately look at subjects whose ability and behavior represent extremes of style.

The problem cafeteria is shown in Appendix B. It consists of 16 problems which range widely in type and complexity.

One of the aims of the experiment was to compare the choice of problems in each group. There were indeed some marked differences. The Intuitives showed a definite preference over the Systematics for problems requiring a focus on conceptualization and rapid explicit hypothesis-testing. The problems they chose more frequently and rated more enjoyable, were all largely deductive in type, requiring a rapid ranging over alternatives and ideas and not permitting any easy decomposition into steps and substeps. The problems favored by the Systematics, by contrast, tended to need a convergent approach.¹⁶

Figure 8 shows the problems selected by each subject; the two problems rated as most enjoyable are underlined.

Subject	Problems Selected by Each Subject															
	Problem Number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A		X		X				<u>X</u>	X		<u>X</u>					
B	X	X	X					<u>X</u>								<u>X</u>
C		<u>X</u>	X	X			X						X			
D	X						X			X						<u>X</u>
E		X					X		<u>X</u>	X						<u>X</u>
F	X	X		<u>X</u>	<u>X</u>								X			
G			X				X	X			<u>X</u>					<u>X</u>
H							X	X	<u>X</u>	X						<u>X</u>
I		X						<u>X</u>	X			X				<u>X</u>
J	X							X	X		<u>X</u>					<u>X</u>
K		<u>X</u>		X		X					X		<u>X</u>			
Total for Intuitives	4	6	4	4	1	1	5	2	6	5	6	1	2	0	6	2
No. choosing problem as most enjoyable	0	2	0	1	1	0	1	2	2	1	3	0	1	0	6	2
L	X						X	<u>X</u>	<u>X</u>							X
M		X						X	<u>X</u>							X
N	X						X	<u>X</u>			X			<u>X</u>		
P	X			X	X						<u>X</u>		<u>X</u>			
Q		X						<u>X</u>			X		X			<u>X</u>
R	<u>X</u>		X		<u>X</u>						X	X				
S	<u>X</u>							X			X		X			<u>X</u>
T		X			X			<u>X</u>	<u>X</u>						X	
Total for Systematics	5	3	1	1	3	0	2	2	5	2	5	1	3	1	3	3
Most enjoyable	2	0	0	0	1	0	0	0	5	2	1	0	1	1	0	3

The small expected and observed frequencies for each problem make it difficult to compare the choices of the Systematic and Intuitive groups statistically. There is a clearcut difference on problems 9 and 15 in Figure 8 that is worth pointing to independently. All the Intuitives who chose No. 15 rate it as most or second most enjoyable; none of the Systematics do so. The situation is the reverse for No. 9: (No. 15 involves decoding a ciphered message and No. 9 classifying words into lists)

	Problem 15		Problem 9	
	Sys	Int	Sys	Int
No. choosing problem	3	6	5	6
No. rating most enjoyable	0	6	5	2
Total No. of subjects in this group	8	11	8	11

Both these problems were ones where substantial insight could be obtained about the subjects' problem-solving processes; problem 15 was answered orally by 6 out of the 9 subjects who chose it and with problem 9 it was easy to identify the overall strategy used by each subject regardless of whether or not he responded orally or confined himself to a written answer.

The tape recorded sessions include 38 instances where the subject provides a totally oral reply to the problem. This amounts to over a third of the 100 answers (20 subjects x 5 problems). It was strongly hoped that there would be a reasonably high proportion of oral response; they are clearly likely to reveal more of the subjects problem-solving process than a written answer, which tends to focus on the final solution and the immediate steps leading to it. No effort was made to require oral replies. The "thinking aloud" approach is very popular in studies of problem-solving; Simon and Newell rely on it almost entirely.¹⁷ Gagné' and Smith, among others, suggest, however, that a subject's problem-solving process is very different when he is forced to talk aloud as he goes than when he is not.¹⁸ For this experiment,

it thus seemed essential to allow the subject to respond as he wished and not to force him into a procedure that was not natural for him. Not surprisingly, some problems were answered by most subjects orally and some mostly in writing; Problem 1 for example, which is mathematical, produced few oral replies while "opinion" problems such as 7 and 11 generated more oral than written answers. Similarly some subjects are distinctly the silent type and a few very verbal indeed.

There are some distinct and interesting problems in using verbal data. It is harder to compare between subjects, is less manipulable than numeric data and most importantly, there is just too much of it. A half-hour tape contains a bewilderingly large volume of data; the difficulty is to condense, interpret, and shape it. It is also easy, consciously or otherwise, to cheat; from the mass of data available, one may too often pick out highlights that are subtly unrepresentative. In dealing with taped protocols, one needs some ground rules. The ones chosen for this experiment, which reflect the underlying hypotheses are:

- 1) to focus on the first paragraphs of a subject's response as most indicative of his strategy and immediate response to the problem.
- 2) to avoid comparing apples and oranges; this means not comparing subject A's first sentence with B's final paragraph, but either quoting the whole of the two protocols or quoting both apples and then both oranges.

The predictions to be tested as to the differences in protocol between the Systematic and Intuitive group came directly from the characteristics of each mode of problem-solving given earlier in Figure 1. There is also a secondary hypothesis to be tested; it was expected that the Intuitive group would tend to respond to the problems orally rather than silently, and vice versa for the Systematic group. Intuitive individuals seem to use thinking aloud as a way of cueing themselves; their own verbal responses often serve to alert them to possible avenues of analysis and exploration. This whole aspect of the problem-solving behavior of the 20 subjects will be explored fully later in the argument.

Problem 15 has more oral replies, six in all, than any other problem; it provides a useful starting point for this reason. In addition, it is of interest because of the striking preference the Intuitives show for it. All 6 who selected it, rated it as most or second most enjoyable. The problem involves deciphering a message in a simple code. The message is shown below together with the solution:

VEY CO XTS XCMS BEF IDD KEEJ MSV XE AEMS XE XTS ICJ EB XTS NIFXQ
NOW IS THE TIME FOR ALL GOOD MEN TO COME TO THE AID OF THE PARTY

The actual cipher is indeed simple: the letter C is coded as an A, and the sequence thereafter is to skip two letters (D and E) and set the next one equal to B, skip two (G and H) and set the next equal to C etc. The message was chosen fairly carefully. It contains several possible cues. For example, the sequence "XE AEMS XE" is useful to the alert subject; there are very few such combinations of a two-letter word separated by another - the most obvious cases are "as....as", "to.....to" and "of....of". In addition, the frequencies of letters are different enough from the general average to make deciphering the message a little difficult. The most common letter in the decoded message is "O" not as subjects naturally expect "E". "E" is only the third most frequent letter in the sentence. The message chosen was a well-known phrase rather than some sentence such as "Today the weather bureau is closed due to a holiday" to give an edge to the subject who focuses on pattern.

In this problem - as in almost all of them - it was expected that Systematic subjects will focus on how to solve the problem, would choose a definite method, and follow it through. By contrast, the Intuitive will look for clues, try out a hypothesis and build up the message by fitting the jigsaw together.

Of the nine subjects choosing the problem, three - all Intuitives - successfully decoded the message: the table below shows, very approximately, how much progress each subject made:

Systematics:

- Subject L - no progress; unlikely to have solved the problem within a half-hour
- M - about halfway through solving it; several errors, but seems likely to reach the solution given extra time
- T - admitted to being stumped; no progress towards a solution

Intuitives:

- Subject B - little progress; quickly gave up (***)
- D - solved the problem in under a minute
- E - close to solution, ran out of time
- H - total failure, on the wrong track entirely (***)
- I - solved the problem in four minutes
- J - reached the solution almost exactly on the time limit

Summary	Sys	Int
no progress	2	2
some progress	1	1
correct solution	0	3

(The "***" next to B and H is as a reminder that these two subjects still rated problem 15 as one of the two most enjoyable.)

The Systematic and Intuitive groups differ on the way in which they start off the problem:

Subject L (Sys):

"What I'm going to do is list how frequently various letters occur. It might be a bit long. I'll try and spot the frequently occurring letters."

Subject M (Sys):

"I'm going to count the number of times each letter in the alphabet and discover which ones generally speaking, are probably valid because they'll be the ones that are used the most."

(The quotations are verbatim, with syntactic flaws left undisturbed.)

Subject D (Int):

"If it's a simple substitution, one for one, we should be able to break it, but if it's not, it's going to be very difficult. Do you know an old fellow by the name of ETAOIN SHRDLU? Those are the letters in the English

Subject D (Int) continued:

"language by frequency of usage. So I'm just going to make a map and see what we come up with. "Now is the time for all good men to come to the" - that should be "aid", yup, "of the party".

(This is the complete transcript for this subject; it is followed by the research assistant's quiet query: "would you mind telling me how you did that?")

Subject H (Int):

"I'm just skimming through it to see what patterns there were. Obviously the X is rather peculiar. I'm starting off first by looking at simple transpositions like going one letter back or one letter forward or writing it backward."

Subject I (Int):

"One of the things you're supposed to do is look to see which letters are used because the six most common twelve - are ETAOIN SHRDLU, so for a long code I guess you can do it that way. If there are a lot of S's and there are, OK, clearly in eight minutes you've got to make a lot of guesses."

Subject J (Int):

"I'm going to write down all the letters of the alphabet. If it makes sense, maybe I'm going to shift all the letters back and see what happens. Move every letter one forward."

Subject M (quoted earlier) is the most Systematic of all the 20 subjects; his score on the two Systematic test was 12 and only 2 on the Intuitive ones, the lowest possible score. His approach to problem 15 is consciously programmatic, and though he does not get the answer, it appears probable that he would in the end, given enough time. His protocol is fairly lengthy. It is noteworthy that he, like Subject L who is also Systematic, comments on the fact that there is an alternative approach which he labels the "shot-gun" method:

"I'm going to count the number of each letter in the alphabet and discover which ones generally speaking are probably valid, because they'll be the ones which are used the most. "E" is either an "O" or an "E", probably an "O". Now there's another way, there are two ways to approach this problem. One is the long way, which I am doing, which I will not get done in 8 minutes. However, in the long run, if I had more than 8 minutes I be-

"lieve would pay off. The other way is more of a shotgun approach and that's to look at the words and say this could be what, fill it in and try moving all over the paper filling in. For instance, I could say 'VEY' is 'the' - 'the' is probably the most common word in the language, making 'V' a 'T' and so on and start substituting and figure out that way. I don't like the shotgun at all. I think it's less efficient in this case. Sometimes in a situation you really have no other choice. And since I'm not really concerned about finishing - though I wouldn't mind staying afterwards to finish it because my curiosity - I'd like to know what the heck it is.

Now let's see, we have 'E's, 'S's and 'X's, so they are probably A,E I or O -- U is usually down the list. If we take a look we'll look for a 'THE' usually ...OK, let's take a shot at this one; we'll make all 'C's I's, 'O's will be N's, 'X's will be T's. I don't like that though. In other words, I'm looking at the second two words as being 'in the', but that doesn't work out too well. But that might: 'E's are probably O's. I think all 'E's are O's. I've just got a gut feel here. I'll make the 'S's E's. OK, 'XTS' three times -- I'll assume they're all 'the's; going on that all the 'S's are E's, got those in, all the 'T's become H's. Any other 'T's? All the 'X's become T's and that's pretty good.

'XE' becomes 'to'. OK, Something 'in the time'. OK, now we have to come up with the other words. 'AEMS' looks like 'come'. One 'A', three 'M's. 'M's could be M, yes, M or N's. OK, so that makes, means A's or C's, there's only one, so we've got '-- in the time-- -- -- -- to come to the -- -- the --' OK, 'EB' could be 'on', could be 'or'. 'B' is R. Two 'B's. That doesn't help too much. 'In the time..... blank or the blank'. Would have taken a little time more maybe I would have got it. The key to this would have been the 'KEEJ', double O Something. 'Blank MEx to come to the' could it be? Can't think of it offhand. Once that would have fallen, I think. I would have had, let's see, the 'J' would have fallen. 'BEF', would 'F' have helped? Not particularly. 'In the time.....RO..' I'd just go through the alphabet."

Subject M made an early mistake in assigning 'in' to 'CO'. However, he is zeroing in on the answer in a fairly orderly sequence. The protocol for L, the other Systematic who answered orally, is similar to M's. He too comments on the time-consuming nature of his chosen method. Close to the time limit, he in fact admits that his 'methodical' approach will not work in the eight minutes: "I'm now trying to do it more intuitively than methodically. If I had more time I'd probably take the methodical approach to it." The protocol for subject M does match that expected for the Systematic. There is the formal statement at the start of how he plans to tackle the problem. He picks out a first substep, looking for a word with the three most common letters in it and then fills in all the T's, H's and E's. He then picks a second sub-

step, still within the initial plan, and uses the information available from setting 'AEMS' equal to 'come'. His third substep works through the possibilities of 'EB'. He recognizes, having been told that his time is up, that 'KEEJ' may be the key to getting the answer; he implies that he was leaving this to come up in its turn, in an orderly fashion within his program.

Perhaps it is a little close to special pleading to next pick out subject H's protocol to compare with M's. H failed badly in this problem, but he still felt that it was the most enjoyable of all. He is a very capable individual, scoring the maximum of 14 on the Intuitive scale. He protocol highlights the risk inherent in the Intuitive approach. He looks for cues and the ones he picks up are potentially very useful, but he gets into a wrong line of thinking and is quickly cut adrift:

"I'm just skimming through to see what patterns there were. Obviously the 'X' is rather peculiar. I'm starting off first by looking at simple transpositions like going one letter back or one letter forward or writing it backwards....I can't find anything there. I'm looking at it another way. The 'X's and number of 'E's and so on.... There are some obvious things that spring out like 'IDD' is obviously 'DID' -- or might be -- or 'AEMS' might be 'same'. But I'm not really -- that's a possible pattern. Some words you can sort of turn around to make sense, but other words you can't. It doesn't seem likely that 'X' is standing for another letter, because in some words it just wouldn't fit in at all if it was -- 'XCMS'. Could fit in smmething there. Well, what's the answer?"

Clearly subject H has no plan and no method; one might ascribe his failure to that fact. However, two other Intuitive subjects show the same overall characteristics as H in their protocols and solve the problem.

Subject J:

"I'm going to write down all the letters of the alphabet. If it makes sense, maybe I'm going to shift all the letters back and see what happens. Move every letter one forward. W, F, Z....T, C. I'm just trying to take every letter back, like starting with 'V' and moving back two, three, four. Then find a simple code...I think the letters are scrambled. I'll see what happens

"All right. If the whole alphabet were ^transposed, a 'V' would be equivalent to V plus 4 which would be Z... That doesn't do it. Try backwards. [^]Don't think this right. I'll try a longer one. See which letters are used most. 8E's, 7X's. If 'X' is a T... and 'E' is an O, 'TO', 'B' is an F. Not getting anywhere very fast. Say 'T' is an H and 'S' is an E. If 'X' is a T, '1,2,3, backwards. I don't see why they say this is a simple code.... Sure, once you know the answer it's very simple... 'Now is the time for all good men to come to the aid of the party.'"

Subject J's initial hypothesis is no better than H's. His reasoning is hard to follow in fact. He tries out several ideas at the same time. For example, while testing his notion of shifting the letters backwards or forwards he is also guessing that the letters are scrambled. Similarly, having correctly identified 'XTS' as 'the' by counting the main frequencies of letters he immediately switches back to checking on the shift; presumably his '1,2,3' refers to the shift of three letters E to H between 'S' in the cipher which equals E and 'T' which equals H. This at once gives him the full code. H does not have any formal plan. He is obviously alert to the implications of what he finds as he goes along. In his protocol -- and even more dramatically in D's, the full transcript of which was given earlier, there is the sudden almost unexplained jump to the solution. There seems to be a necessary incubation, the assimilation of a mass of unconnected concepts that fairly suddenly merge into a whole. It is this aspect of intuition that gives it the overtone of magic - of inexplicable 'hunch'

Figure 1 listed the characteristics of the two styles of problem-solving that constituted the hypotheses as to how the subjects would approach the problems here. The three protocols given here seem to show most of the features indicated: for the sake of completeness it would be useful to quote the other protocols for subjects who answered problem 15 orally, but they do not provide any new insights and are in total fairly lengthy. The table below summarizes all the protocols in relation to Figure 1.

Subject	Systematic		Intuitive			
	L	M	D	H	I	J
Systematic characteristics:						
1) look for a method, make a plan	Y	Y	Y-	N	N	N
2) conscious of approach	Y	Y	Y-	N	N	N
3) defend solution in terms of method	Y	-	-	-	N	-
4) define constraints early	N	Y	-	N	Y	N
5) move through increasing refinement	N	Y	N	N	N	N
6) complete each substep	Y	Y	-	N	N	N

Intuitive characteristics:						
1) keep the overall problem in mind	-	-	-	-	Y	-
2) redefine problem frequently	N	N	N-	N	N	-
3) rely on un verbalized cues	N	N	Y	N	Y	Y
4) defend solution in terms of fit	N-	N-	-	-	Y	-
5) several alternatives simultaneously	N	N	-	-	Y	Y
6) jump from one step to another	N	N	Y	Y	Y	Y
7) abandon alternatives quickly	N	N	-	Y	Y	Y

(Y= yes, N= no, -= no basis on which to decide)

The reader must judge from the protocols for subjects M, H and J whether or not the assessments above are reasonable; they attempt to err on the side of caution. They do support the predictions. The two Systematic subjects on the whole show 'Y' in the top half of the table, listing Systematic characteristics, and 'N' in the bottom half. The summary table below in no way suggests that the Yeses and Noes have equal weights, but is useful in examining the total picture implied by them:

Subject	L	M	D	H	I	J	Sys	Int
Systematic features:							(n=2)	(n=3)
Yes	4	5	0	0	1	0	9	1
No	2	0	1	5	5	5	2	16
Undetermined	0	1	5	1	0	1	1	7

Intuitive features:	L	M	D	H	I	J	Sys	Int
Yes	0	0	1	2	6	4	0	13
No	5	5	0	2	1	0	10	3
Undetermined	2	2	6	3	0	3	4	12

It is somewhat ironic that subject D's protocol does not provide enough information to classify its features; his response was so quick and contained so little insight into his method that classification is impossible in these terms, but the word Intuitive certainly seems necessary to describe the outcome of his one minute's thinking.

It does appear reasonable to conclude from the summary above that had the classifications of Figure 1 been used to score each subject's protocol they would have correctly assigned all the subjects except D to their cognitive style category; D would have been left unassigned. This one problem at least provides some very strong evidence in favor of both the specific assertions of this experiment and the more general overall arguments.

Problem 9 provides a useful comparison with 15 in that it is as distinctly preferred by the Systematics as the latter is by the Intuitives. Unfortunately, none of the five Systematics who chose the problem answered it orally, a fact that is interesting in itself. Four of the six Intuitives did reply orally. No subject completed the problem, which is not difficult but requires a careful, lengthy sorting of 50 words into 10 groups. There seem to be two obvious strategies for easing the cognitive strain on memory that is the main feature of the problem; the first is to find a category then go through locating and sorting all the words within the category, and the second is essentially the reverse of this, grouping words together going as completely through the list as possible. The first strategy is the more programmable and thus seems suited to the Systematic approach. Since none of the 12 subjects choosing the problem completed it, it is easy to identify their strategies from either the tape or from their rough working on the question sheet (all the subjects wrote over the list of words, the category and/or position within the category, e.g., next to the

word 'football' a subject would write '2c' meaning category 2 position c). Strategy 1 should result in fewer words being classified out of the total list of 50 than would strategy 2, since it involves putting the main effort into completely classifying all the words within a category. By contrast, strategy 2 involves going through the whole list with little pause to sort the words fully within the category. The table below shows the strategies used by each of the 6 Intuitive and 5 Systematic subjects (it ignores the lone Receptor who chose the problem):

Subject	Style	Strategy	Words Classified
A	Int	1	28
E	"	2	50
G	"	1	37
H	"	2	40
I	"	2	39
J	"	1	34
L	Sys	1	35
M	"	1	15
N	"	1	37
Q	"	1	18
T	"	?	32

(Subject T's strategy was not apparent from his written rough working.) The results for each of the two groups are:

	Sys (n=5)	Int (n=6)
Strategy 1	4	3
" 2	0	3
Unclassified	1	0

While it does appear that strategy 1, as predicted, is used by Systematic subjects, the differences between the two groups are of no significance (using the Fisher exact test). However, the differences in the number of words classified is significant (Mann-Whitney $U=5$, p . less than .05); in addition, the two strategies differ ($U=1$, p .=.008) with the three subjects using strategy 2 classifying more words than any of

the seven who used strategy 1. These results are not striking, though they support the hypotheses.

Since there are no oral transcripts from the Systematics, there is little value in analyzing the Intuitive's oral replies in detail. However, they contain an intriguing, if possibly coincidental feature; all four subjects began by saying that they did not understand what was involved in the problem and asked for more explicit instructions. It is clear that they also felt they should not have chosen the problem after all:

Subject G:

"I've got to do all these? What am I supposed to do? I don't really follow this. (Asks for instructions). Did I put down that this was easy? It looks horrid now."

Subject I:

"Looking at it very quickly, it does not look as easy as one thought it would."

Subject J:

"I'm not sure why I circled this. I don't even understand what I'm supposed to do."

J.A. Botkin used the cognitive style paradigm in an experiment on the use of computer systems as learning aids. One of his main conclusions was that Intuitives do not read instructions. Several of his subjects were quite explicit about that, commenting that they never bothered to do so.¹⁹ It does not seem farfetched to relate this to the Intuitive's preference for jumping into the problem and using self-correcting feedback to clarify what is involved.

Both questions 15 and 9 have a definite answer. There are a number of problems in the cafeteria where the solution is one of subjective opinion. This makes it difficult to evaluate the correctness or completeness of the answers given by subjects, but it also allows them great freedom of approach. A useful aspect of these problems

from an experimental viewpoint is that they are answered orally more than are any of the other ones.. Problems 2, 3, 7 and 11 are the four that fall most obviously into this group; they are answered by a substantial fraction of both the Systematic and Intuitive subjects:

Problem No.	Intuitive		Systematic	
	Oral	Written	Oral	Written
2 (poll)	3	3	2	1
3 (refute arguments)	3	1	0	1
7 (Germany and rise of Nazis)	2	3	1	1
11 (game theory)	4	2	1	4
	<hr/>		<hr/>	
	12	9	4	7

There is a clear imbalance between the two groups in terms of the total number of oral replies. However, there is sufficient data available here to compare them meaningfully. (The subject of the problem is given in parentheses, albeit in cryptically abbreviated form.)

The four problems are fairly varied; this is an advantage in testing the replies against the characteristics of the two cognitive styles shown earlier in Figure 1. The opening statement of the subject seems to give a clear immediate impression of his response and strategy. The Systematic students frequently begin by stating the problem as they see it; this is in line with the predictions in Figure 1 and especially interesting here in that the problems tend to be openended, sometimes ambiguous, so that there is a definite need, at some stage, to close the open constraints. The Systematics do this consciously at the start of their reply:

Subject M (Question 11):

"The problem for the twenty men seems to be that they should get together and act as a group because the group pressure of twenty people pitted against the group pressure of one person is eventually going to intimidate that one person."

Subject T (Question 2):

"The question seems to be looking at how far you're willing to go with your assumptions. I refuse to make any decisions that are not clear from the data."

The difference in flavor between these responses and the Intuitive group's are clearcut:

Subject F (Question 2):

"I kind of like this one. It's a policy question; that's why I picked it. It looked easy to me. It doesn't involve a lot of grunt work like I was doing in the first one (Question 1)."

Subject G (Question 3):

"We're supposed to be refuting the waiter here, because he says 'what difference does it make?' Theoretically, my arguments here I don't have to believe in and neither would the guy who's talking have to believe in them. He's just making arguments."

Subject J (Question 11):

"When I read this the first time it reminded me of the Olympics, you know -- the Arabs and Israelis. He obviously can't kill them all. He's only got six bullets and once he runs out of bullets he's dead."

Subject H (Question 11):

"This situation is similar to a terrorist action type of case such as a plane hijacking or the incident at the Olympic games in 1972."

On the whole, the oral transcripts largely confirm the findings of the more detailed analysis of Problem 15, given earlier. There is, however, an additional feature in the replies to these 'opinion' questions; the Systematic subjects all tend to choose logic over subjective feelings. For example, question 2 requires coming down on one side of an unknown issue on the basis of the outcome of a poll. The Systematics decide on the basis of the logical or mathematical implications of the poll data:

Subject M:

"To come up with some explanation that will make both groups happy you're going to have to weight their inputs which is the second solution (of four

subject M puts forward as possible approaches to the problem). This seems to be the only way that will be fairest to all. As a result, as there were 30 teachers, 30 administrators, 45 parents, reduce the 45 parents to 30 by dividing by two-thirds."

By contrast, the Intuitives are much more immediately concerned with their own 'gut' feelings:

Subject F (Question 2):

"I have a feeling that the way the problem's set up you should probably make the decision to be anti -- just because the superintendent has said he will support the public opinion I guess is the parents. That's the way I see it. But I would decide pro -- and I guess the reason I would do that is because -- I think I've decided what the issue is. I think it's voting for tax increases or you know public prayer, a sex education or something like that, that has been a policy issue. I guess I'm influenced by what actually has happened. I guess my prejudice is that I've disagreed with parents on those issues. I would always have sex education, I would always ban prayers in the schools. So I would guess that's why I decided it that way."

Similarly, on Question 3, which asks for refutation of an argument:

Subject R (Sys):

"Well, I would say that it's conclusively refuted. I don't think there's any logical inconsistency. That, er, the man's goal was presumably to have one or the other. Presumably, he's enquiring rhetorically why it doesn't taste like what he ordered. The waiter's argument presumes that it doesn't matter if he can't taste the difference; it ignores that he wanted a specific taste."

Subject C (Int):

"The question was 'what difference does it make?'. so I asked myself does it matter to this individual who has to live, to the customer, does it matter whether it's beef broth or not. From the waiter's point of view, it doesn't matter to him because he made a sale on this and from the customer's view they were buying something and wanted something for their money and they might have an allergy, or dietary

"reason or just because of their personal taste in food that it mattered to them. So I saw it as a difference in point of view."

It is worth pointing out that the differences in response here are very similar to those between the Thinking and the Feelings types on the Myers-Briggs type indicator.²⁰

The illustration of these and other differences could be extended here by more quotations; these would largely only reinforce the ones given earlier. There is a remarkable unity within the two groups; regardless of the specific problem, the Intuitives respond consistently in their distinctive style and so too do the Systematics. This is, perhaps, the key outcome of the experiments. Of some 50 responses analyzed in detail, there are only three instances where a subject seems to switch style - to reply on one specific problem in a way that is different from the rest of his answers and that appears to reflect an adjustment to the problem-stimulus itself. It needs to be stressed that this small sample of students contains only extreme cases; each of them was identified as having a strong cognitive style and therefore it is not too surprising that their style does dominate their problem-solving behavior. There is no supposition here that all individuals will show the same characteristics as these ones. However, the experiment clearly suggests that cognitive specialization of the sort found in these subjects has a powerful influence on their overall processes of problem-solving.

A final feature of the two groups of subjects, already touched on, is the strong tendency of the Intuitive students to respond orally. There is a chicken-and-egg problem involved in determining whether this is because they also choose 'opinion' problems which are best answered aloud. Regardless, there is a clear difference between the two groups. Over half the Intuitives' replies were oral, compared with 20% of the Systematics:

	Oral	Written
Intuitive	28	27
Systematic	8	32

(An oral reply is defined as one where the subject works aloud as he goes; most subjects provide some explanation after they have finished of their approach to the problem - this is of use in discussing their behavior, but is not counted as an oral reply.) Botkin, in his experiments, found that the Intuitive subjects seemed to like to talk aloud as they went along.^a They would ask questions, either of themselves or of the experimenter, and frequently then jump off at a tangent without waiting for a reply. This researcher found, as did Botkin, that the Intuitives were also likely to leave sentences uncompleted. Both sets of transcriptions for Intuitive subjects in the two experiments are full of '.....' indicating a broken off sentence.²² While there is no real way here to formally test the hypothesis, it appears that the Intuitive style makes much use of 'thinking aloud' to guide, cue and stimulate progress. This need to think aloud has an intriguing implication; the essentially rambling verbalization is very useful, even vital, to the Intuitive himself. It is disturbing waffle to a Systematic colleague.

The academic and work backgrounds, together with the Myers-Briggs type classifications (Thinking vs. Feeling) for each of the subjects are shown in Figure 9 below. All three columns in the table are suggestive. It is especially apparent that the Systematic subjects both majored in engineering or related applied sciences and stayed with engineering in their later work experience. By contrast, the engineering majors in the Intuitive group tended to shift to other types of work. With such a small sample, and with the preponderance of the students in the full sample being engineering and economic majors, it is hard to sort out the implications of this. As the very least, it is clear that the Systematic group tend to come from an engineering background and to be sufficiently happy with that culture or mode of operation to continue on with it. The Intuitive engineering majors (5 if subjects C and D are included under the loose categorization) do not seem to remain so happy in that area. Their work experience is much more variegated than that of the Systematics, with teaching

Figure 9

Subject	Undergraduate major	Work experience	Myers-Briggs (Thinking/Feeling)
A	Economics	Military Intelligence	T
B	Engineering	Teaching Math and Economics	F
C	Information and control systems	Information systems design	F
D	Production management	Teaching USN	F
E	Chemical Engineering	Technical sales	T
F	Mechanical engineering	Technical writer	T
G	French literature	Law trainee	T
H	Law	Sales, marketing staff	T
I	Philosophy, U.S. studies	Market research teaching math	T
J	Economics	Sales representative	F
K	No data available	No data available	T
L	Engineering	Construction engineering	T
M	Glass sciences	Engineering	T
N	Mechanical engineering	Computer hardware design	T
P	Civil engineering	Construction engineering	T
Q	Nautical science	Project manager, construction	T
R	Electrical engineering	Computer programming	T
S	Engineering	U.S. Coastguard	T
T	No data available	No data available	T

and sales positions being the most frequent occupations.

The Myers-Briggs results correspond overall with the findings for the larger sample. In particular, none of the 8 Systematic subjects are of the Feeling type, while 4 of the Intuitives are.

Summary

This experiment had two functions. The first was to provide a backward glance at the accuracy of the method used to classify cognitive style in the main sample. The second was more independent and qualitative, aimed at exploring the more general habits and strategies of each cognitive style in problem-solving. Both aims seem to have been reasonably met. The subjects selected as being Intuitive show consistent characteristics and so do the Systematic ones. Moreover, these characteristics mesh with the predictions made as to problem-solving behavior. They both flesh out the findings of the other experiments and add a richer texture through the focus on oral replies and on process rather than solutions. The more important aspects of the experiment to be pointed to concern the subjects' responses as a unified whole. First, it is apparent that the two groups differ meaningfully in their very use of language. The transcripts of oral replies show distinctive features within each group. The Systematics all tend to be deliberative, sequential in thought and consciously organized. The Intuitives tend far more to think aloud, to look for an organizing idea or approach to shift from one topic to another, and to base answers on their own feelings rather than on external validity such as logic. In concluding this analysis, the writer has some slight regret that all the oral transcripts cannot be quoted directly - they constitute a morass of data, which none the less, has a flavor that is in itself powerful evidence in support of the arguments of the study. It does seem worth ending with two final quotations, of a Systematic and of an Intuitive subject's response to the same question. They are fairly representative of the transcripts as a whole and

do, it is felt here, display vividly the differences inherent in the two styles. If the reader can accept that they are, in fact, representative, it should be clear which is the Systematic and which the Intuitive subject and also that cognitive style has a definite and distinctive impact on the whole problem-solving process.

The question involved in the transcripts is Number 11, the game theory situation of twenty men locked in a room with a threatening assailant.

A. Subject N

"The problem for the twenty men seems to be that they should get together and act as a group because the group pressure of twenty people pitted against the group pressure of one person is going to eventually sort of intimidate that one person. The thing that I would suggest they do is get together back in the corner and strategize about the assailant, discover the particular reasons and circumstances under which they were brought in and try to find out just what his plans are. Now they should while they're doing this keep track of him, so that if he gets really nervous about this kind of conversation, they can break it off. Then one person should act as a spokesman and this person will kind of know who he is in this kind of situation and tell the assailant that the group of twenty don't really, er, want to do, try to make sure the assailant looks at them as people he, the assailant, has to deal with and so that the assailant doesn't look at them as threatening individuals. It's very difficult to shoot a person that you think of as a person, but perhaps, relatively easy to shoot a person that you think of as an obstruction or someone who's trying to make life difficult for you. The twenty men should all stay on one side of the assailant so that he doesn't get overly nervous and should walk up to him as a group and discuss with him the reasons why he feels that he wants to shoot some of them and try to calm him down and talk with him about what are his problems what are his reasons for being upset in this situation. Now if they can get him to talk about himself and his own difficulties perhaps they can relieve some of the anxiety and tension, the disturbed feelings that he has. Perhaps, he will forget the idea, break down, feel a release of tension and drop the gun, if they're successful in this regard. In any event, when the twenty of them are together it seems they certainly can get to him physically if they have to that it's going to be very difficult in fact for him to kill all twenty, that the maximum he'll be able to do is kill one or two of them as that person grabs at his gun, so that under these circumstances somebody could rush him, grab him and take the gun away. Now perhaps, this sort of grouping around him is going to make him feel nervous, make him feel that these people are a threat to him. If he shows any signs like that at all then nineteen of them should go back into the corner of the room and just one man should go out and talk with him and try to appear very innocuous and unafraid of him, but at the same time not a threat to him, and this one person should do the negotiating with him and discuss with him his alternatives, point out to him that it's very difficult for him to get any benefit from the killing of six people. The main gist of the effort has to be in finding out what bothers the assailant

"and why he is driven to wanting to kill people in the first place. It would seem that there must be some sort of a disturbance either of a mental kind in terms of his family background and home life situation or a physical disturbance, brain tumor or something of this nature to make him essentially go off his rocker. Alternatively the assailant could be some sort of a criminal who's sort of looking for hostages or could be in a penitentiary situation. If the assailant is insane, he should be dealt with as an insane person and I'm not really familiar with the psychiatric techniques which are used to subdue or calm people who are in this situation but that was what I was suggesting in the first part of this tape. If he's a criminal however, really a sane person who's either trying to make an escape or who's caught in jail, he really should be someone who can be appealed to on a rational basis. It should be possible to show him on a rational basis killing won't work."

B. Subject J

"when I read this the first time it reminded me of the Olympics. You know, the Arabs and Israelis. He obviously can't kill all of them. He's only got six bullets and once he runs out of bullets, he's dead. So actually, he can really only kill five of them, because as soon as he uses the sixth bullet he's had it. So...gee, there's a one out of four chance, five out of twenty that if I was there I'd be killed. However, if we all stormed him, he'd probably get off two shots at the most, so instead of waiting -- also if you storm him there's less of a chance that he can kill both of you. He could miss or he could just hit you in the arm or something. There's no furniture. They're all back in the corner, 70 feet. That's how many yards? Twenty yards. You can go about 20 yards in about 3 seconds...I guarantee he couldn't get off more than 2 or 3 shots. He'd just be firing into the crowd, and firing into the crowd...there's a good chance he'd hit someone in the leg or the stomach. Of course, I sure as hell wouldn't want to be the guy up front...Hmmm. Everybody can talk without his hearing. The hardest thing would be to convince everyone to do it, because if you don't get everybody -- well I guess you don't need everybody. If you get ten guys. Of course, those 10 wouldn't want to do it unless everybody else would...If they could break the light somehow and wait until dark, then you'd have even a better chance. But I guess the chances of breaking a light are pretty slim. You could take a shoe off and throw it at it or something, I don't know. I guess the best way would just be to sort of spread out and kind of come in and just start -- well I don't know I wonder if you could talk to him, psych him out The circumstances are really important. I mean, you don't know why he's in there. If he's, like, a suicidal person, then I don't think he'd....you know. But if he's the kind of person that robbed a bank or something and he just got trapped in there with all these people. Then it might pay to say 'now listen, you don't want to die and neither do we, but if you start shooting the most you can kill is two or three. Then, we're going to jump on you, torture you' or something. I guess I'd try to reason with him first. If he wouldn't reason, you know, if I could see thatI guess first of all I'd talk with the group, figure out who was where, who wanted to sit there and take a chance and get a feel for the group. And then I think maybe come up with two or

"three people who'd want to be spokesmen and maybe the rest of the group would be sort of out of it. And just have the two or three people sort of talk to the guy, you know, see what happens. If you can talk him out of it, good. If you can't, I say storm him with as many people as you can because your chances of survival are far better that way than waiting for him to shoot five people. I'd try that, (the light switch is irrelevant). Well, I was thinking you'd don't know what the light situation is, if there are any windows. I mean, if there are no windows you can just wait until it's dark, anything to increase your chances. You might just, I might even try to take my shoes off and have everybody take their shoes off -- have everybody take their clothes off and throw them at him, anything just divert his attention....Maybe have everybody just whistling, try to drive the guy batty. He knows as soon as those six are gone....It's not the kind of problem, it's easy for me to Monday morning quarterback but I'm sure if I was in the situation I'd be scared stiff."

V. Conclusion - The Implications of Cognitive Style

With cognitive style, as with most aspects of personality, the injunction "Know thyself" is a useful one. However, most managers - if the experiences with the student samples are indicative - have a definite sense of how they themselves operate; because of this the injunction needs to be extended to "Know thyself and know others". Sometimes trivial incidents can reflect important general events; one such recurrent incident underlay many of the early ideas behind this study. These were the sometimes amusing instances of two immeasurably competent individuals dismissing the other as on the one side 'sloppy, doesn't know what he's talking about' and 'slow, pedantic nitpicker'. The important point was not the frustration with the other, but the choice of objection. It was easy to observe the cause of the irritations and later to directly relate them to cognitive style. For example, the combination of a very Systematic CPA and an Intuitive organizational theorist working together on teaching materials led to patterns of behavior in each that match the checklists of characteristics of each style given earlier in this study. The patterns generate no friction where each individual is working by himself; it is the conjunction that creates the mutual annoyance. Much of this seems to lie in the mere process of articulation of an argument or case. The CPA simply rejected the mode by which the other, Intuitive, individual

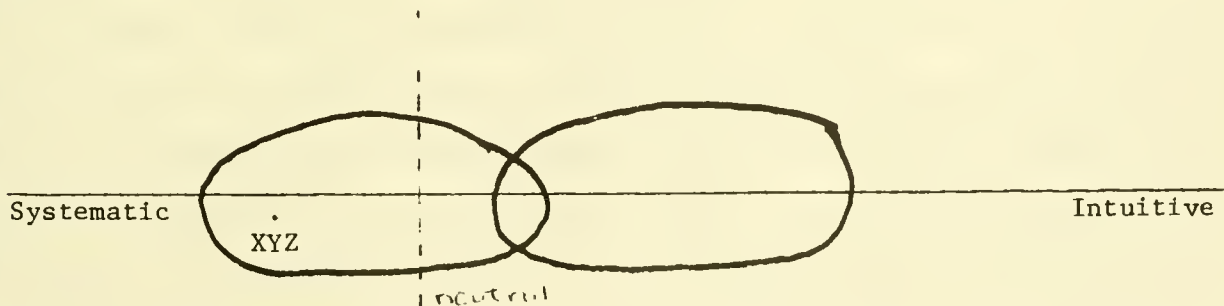
reached a conclusion; when he attempted to evaluate that conclusion he had almost to go back to the beginning and recast the line of argument. What was 'evidence' and 'proof' to the Intuitive, was not so to the Systematic and vice-versa -- perhaps more importantly, what was self-evident to the one was not so to the other, which led to the dismissal of each other as stupid. A more costly mismatch in style can be illustrated in relation to entrepreneurial partnerships. A fairly common pattern in new businesses is for an individual with an 'idea' to start up a company and later find that he needs a partner; often, the founder is Intuitive with a concept of what the market needs and with a streak of originality that enabled him to identify an opportunity or a new product. Once the business is underway he may feel the strain of running day-to-day operations, particularly in the areas of finance and accounting. He thus looks for a partner with the skills he lacks; he brings into the company a comptroller who will tend to be precise where the founder was unorganized, will 'rationalize' operations etc.etc. If, as it is quite probable, the comptroller is a strong Systematic, one would predict that the combination of the two types, initially promising, will end in divorce. They see the world very differently, their distinctive modes of response and problem-solving will irritate in situations of time-pressure and crisis, and they have little basis for sharing their individual insights. Quite obviously, cognitive style is not the sole explanation in such a situation, but it does appear to indicate why very capable individuals of équable temperament and cooperative natures can find astonishing difficulty in working with each other. It is not enough to label the problems as a 'conflict of personalities'.

In turning attention from incompatibility to compatibility, it is worth pointing to an aspect of every manager's experience; in day-to-day activity, colleague relationships develop which are highly-valued by the manager, but which often are not backed with personal friendship or social contacts. When the colleague leaves the company or is transferred, the manager will feel regret but make no effort to keep up the relationship. None the less, while it exists it is a strong one in the sense that

the two will value the other's opinion, work closely together and maintain an openness to the other that allows them to argue together, share insights and seek out each other's opinions. The literature on the subject of organization communication tends to explain such relationships in social or interpersonal terms; these are obviously relevant, but it seems very plausible that compatibility of thinking style is also a factor of importance. Herman Witkin, whose model of field-independence is the best known of all cognitive style paradigms, has found that in teacher-student contacts, individuals recognize very quickly if they have the same style and will be much more likely to develop a good relationship if they do.²³ The argument made here parallels that of Witkin.

In the example given at the start of this section, the CPA and organizational theorist were well aware of how they themselves operated, but either they did not understand how the other did so or, even with understanding, they disdained his mode of thinking. This study is essentially concerned with cognitive specialization; individuals who do not have a marked style are reasonably adaptive and can shift their mode of response to some degree to fit either a new task or interaction with a different individual. The CPA in the example has an unusual and rigorous specialized set of abilities and so too does the OB individual (OB: Organizational Behavior (ist), to use a convenient abbreviation). If one diagrams their abilities in the form of an 'operating space' the result is analogous to a Venn diagram:

Figure 10



The area of intersection between the two circles is very small. Each of the two individuals can operate with problems or task-roles that are specialized in demands.

For instance, given a problem where the information is well-defined and requires precise evaluation and where there exists a coherent and articulable plan for dealing with it, the CPA's operating space covers that type of problem (point XYZ in the diagram). The OB type's does not. Quite obviously, the CPA can provide the other here with insights and aids he would otherwise lack. The central issue for the two is how they can bridge the cognitive gap between them. Perhaps there is a degree of specialization of style where dialogue becomes impossible. None the less, it seems likely that the two can find some ways of building a 'meeting of minds'. Firstly, they are more likely at least to listen to each other if they can recognize that their own style is only one of several valid ways of thinking and not the sole 'logical one'.

There is, perhaps, a more contingent factor to be taken into account here, the task-context itself. The idea of an operating space is useful; if the CPA and the OB had been able to recognize the class of problem they were dealing with they might have saved much effort - more accurately, if they had recognized the class of the subproblem, the effort might have been saved; the distinction is important since most problems that require working together over a period of time involve a sequence of varying classes of subproblem. The problem in Exhibit 1, XYZ is one where the Intuitive mode, even if it does get a solution, is likely to be inefficient. The CPA has justification for irritation where the OB tries to intuitively solve a problem that requires only a few minutes of careful formalization to be easily dealt with. Similarly, of course, the OB is understandably annoyed at the waste of time and energy used up in trying to lay out a plan for a problem which demands initially at least a wider set of horizons and an exploration of possible directions of analysis. Where the two are sensitive to the problem itself, there can be a rich modulation of effort. In particular, the Systematic can begin at the relevant point to close the problem, to take the insights of the Intuitive and start to make a plan. At that point, the Intuitive fades into the background and perhaps later uses his special mode of respon-

se to test out and validate the Systematic's plan by ranging over its implications and trying out scenarios. This provides a complementarity in problem-solving that can exploit the powerful though narrow specializations of both thinkers.

The major irritant of the strong Intuitive for the Systematic appears to be his impulsiveness. The Intuitive will often jump in and try something and not complete what he does. In a roomful of Intuitives this provides no strain. For the methodological Systematic there is immense annoyance in following consciously, as he needs to do in his problem-solving mode, the tergiversations and random ramblings of the Intuitive. It is not recommended that the Intuitive curb his innate response, only that he be careful in not jumping in with his comment too early, but wait until it fits more directly into the Systematic's sequence. In addition, he can often accomplish what he wants by asking questions, by presenting his scenario, at the relevant stage, to the Systematic and asking how it 'fits' the latter's plan. This has the merit of also making sure that the plan fits the problem and possible conditions.

All these recommendations are of necessity somewhat relative and do not amount to well-defined rules. Problem-solving is a process (though we may forget that in focussing on 'answers') and one cannot provide neat rules for such a process, any more than checklists on how to make friends and influence people have value other than as broad guidelines. The recommendations given here are, however, strongly relevant to managers. The more a successful manager specializes in a functional area such as production or marketing, the more he becomes likely to lean on his style and experience. This makes him increasingly insensitive to both differences in problems, other ways of dealing with problems or the value to him of thinking styles that he finds uncomfortable to work with. Compartmentalization and departmentalization in organizations develop through specialization of tasks; they are compounded by specialization of style in the managers who occupy particular roles. This can be very damaging indeed when a manager is transferred or promoted if he takes with him

the same response to information and the same mode of arriving at decisions, without recognizing that the class of problem he now must deal with has changed. The first two recommendations provided here seem most helpful for such a manager. If he is aware of his own operating space, he will be better able to assess his new reality and how to react to it. He will also be able to pick assistants and advisers who can complement his mode of style in the ways most likely to fit his new environment.

The recommendations given for the individual manager apply with few changes to the context of information systems and decision aids; the manager should:

- 1) know his own style
- 2) amplify his own style through the use of information systems and decision aids
- 3) be aware of the impact of his own style on his use of such aids and on the design of them

Many of the conclusions to be drawn concerning how managers use informational aids follow directly from the preceding discussion. In particular, the interactions between the designer of computer models of MIS and the client-manager are often a dramatic clash between strong, distinctive styles. The discussion of the interaction of the individual manager with others of different cognitive styles could well have been extended to include the question of the Management of Expertise and their cognitive style. Staff experts are almost, by definition, very specialized, both in terms of their area of expertise and their cognitive style. How to make use of their very nongeneral skills is at times a painful problem to the general manager, as the ongoing debate about the use of management science in organizations shows.

About the time that all the experiments in this study had been completed an interesting proposal, "A program for research on management information systems", appeared in a paper by Mason and Mitroff in Management Science (January 1973). This paper does not use any concepts of cognitive style, but none the less, argues in similar directions to this study, including, coincidentally, the suggestion that the Myers-Briggs Indicator be used to classify psychological type in relation to information systems.

Mason and Mitroff provide a compact definition of an information system. It 'consists of at least one PERSON of a certain PSYCHOLOGICAL TYPE who faces a PROBLEM within some ORGANIZATIONAL CONTEXT for which he needs EVIDENCE to arrive at a solution (i.e., to select some course of action) and that the evidence is made available through some mode of PRESENTATION.'²⁴ Mason and Mitroff suggest, though without providing any experimental data, that management information systems tend to be designed by Thinking-Sensation types (these categories are those of the Myers-Briggs Indicator). The whole process of implementing information systems, especially those that are computer-based, requires the formalization and methodological focus on plans that is the main characteristic of the Systematic thinker. As Mason and Mitroff point out, 'the designers of MIS have tended to project (or mistake) their dominant psychological type (Thinking-Sensation) onto that of their clients.' This, restated in terms of cognitive style, is the central issue here, too. If the designer regards information as external, fixed and to be processed in the Systematic mode, rather than as 'evidence', then the resulting MIS will tend to be unhelpful to the Intuitive. There is substantial evidence that it is the Systematic feature of both information systems and management science techniques that has made their implementation less easy than anticipated in the early roseate flush of what Heany has called the Operation Researcher's march under the banner of 'Have technique- will travel!'²⁵

The whole topic of cognitive style and computer-based decision aids is discussed in detail in other papers by this author and his colleagues.²⁶ It is, perhaps, the most direct application of the cognitive style concept. The Management Scientist tends to be a Systematic par excellence, whose especial skill is the provision of techniques, the formalization of problem-solving methodologies and the building of explicit models. The failure to recognize his own cognitive style seems to be a frequent and expensive limitation among even highly competent quantitative analysts.

The final area of management practice where cognitive style is of substantial relevance has to an extent been partly covered in the preceding sections. It concerns

the design of small group or project teams to work together on a complex, multi-phase task; examples of such tasks are commonplace - capital investment evaluation, a computer or aerospace project, etc. There is a natural tendency for organizations to assign responsibility and leadership roles that are intended to hold for the whole length of the project task. In teams that work well together, however, roles tend to be more fluid, with each individual's expertise being tacitly accepted and adjustments made at various stages of the ongoing project to highlight a particular person's contributions. The recommendations to be made here draw very strongly on the concepts of differentiation and integration developed by Lawrence and Lorsch.²⁷

Extremes of cognitive style are likely to be found in specialized, differentiated task-roles.²⁸ As was suggested in relation to the management scientist's skills, such cognitive differentiation is potentially of immense value - given the integrative mechanisms essential to provide coordination and cooperation. In terms of cognitive style, which is a feature, but not the full picture of the differentiations of function, goals and time horizons Lawrence and Lorsch found in their field research, the integration process is partly one of translation. A hypothesis to be tested in a later research effort is that integrators will not generally have a pronounced cognitive style, but will be 'switchers' who can adjust their problem-solving process to the demands of the situation; the situation includes both the problem itself and the style of others with whom the switcher is to interact.

In a complex project the task will, at some stages, be best suited to a Systematic and at others to an Intuitive response. The most fruitful results seem likely to come from groups that include both a mixture of cognitive specialists and the necessary translators. The recommendations can be made specific through the example of a large-scale EDP project. The decision to 'put', say, capital asset accounting on the computer may presage several years of effort involving some dozen personnel. The first stage, of systems design, really requires, and often does not get, an open-ended approach to the global features of the problem. This involves an almost aesthetic

sense of shaping the system, creating a lucid abstraction out of the various inputs, necessary outputs, routings, and constraints of the organizational activity which constitute the environment of the computer system. This first stage clearly requires the varying, uncommitted hypotheses-testing of the Intuitive style, but in the second stage of the project, these characteristics are a liability; the detailed laying out, even at a general level, of the computer specifications requires a Systematic mode. The third stage, the detailed development of the computer programs requires even stronger Systematic skills, particularly in the area of program 'debugging'. Once the programs have been written and tested out, however, the Intuitive style again has useful virtues. The system as a whole, not as a set of individual programs, needs to be checked against the data of day-to-day operations, using the hypothetical scenarios the Intuitive naturally employs.²⁹

A systems analyst or programmer will be involved in all these stages to some extent. Moreover, the stages overlap; the Intuitive designer cannot think through the approach to master file up-dating without at least some attention to file structure and size. However, it is apparent that the stages and sub-tasks require essentially different styles. The skill that leads to a strong overall sense of the system design is ill-fitted to precisely focusing without preconceptions on a small subroutine in a program. It can be unequivocally said that Systematics usually design very poor systems and that Intuitives will need substantial time before they debug their programs. But, and the example can be extended to marketing, finance, accounting etc., there tends to be an assumption that specialization is functional not cognitive. While that has to be true to an extent, it can be misleading; the computer 'specialist' will have distinctive skills, but it is rare to the point of probable nonexistence for him to have substantial flair for all the stages of a computer effort. None the less, a common feature in organizations' EDP departments is the 'promotion' of an experienced, highly competent systems programmer to systems designer. Usually his Systematic skills are not transferable; he will impose on the design process a

planning that often ignores the unique features of the situation, features that tend to become pitfalls.

In successful computer projects - and these are more frequent than general managers may suggest - the individuals involved generally recognize this aspect of their own specialization. Here the project 'head' will be the formal leader and spokesman, but task leadership will shift over time in relation to the demands of the situation. The example is a special case, drawn largely from the author's main area of experience. Its implications, however, are general. In the design of work teams it may often be desirable to deliberately make use of specializations of style. It is also essential to provide for modulation of leadership and of responsibility. In the scenario above, the whole balance and product of the effort will be altered if, say the Intuitive as 'Chief Senior Systems Analyst' maintains task leadership throughout the project.

In some situations a particular project obviously will not need either a high level of specialization or specific styles. For example a project team working to bring a new plant on stream can well forego (perhaps should at all costs do so) the inclusion of an Intuitive style among its cognitive repertoire. Here the argument comes full circle. The effectiveness of problem-solving in organizations, at an individual or project level at least, will depend on the fit between task-role and cognitive style.

Specific areas where cognitive style is relevant to managers and administrators have been described here. Rather than focus narrowly on particular aspects of problem-solving and decision-making, the final recommendations are more broad in scope. The model of cognitive style is intended as a paradigm, in Thomas Kuhn's sense of the term in the context of scientific practice.³⁰ As such, it competes with many other paradigms of the decision process. It is a synthetic model and no doubt is incomplete, even inadequate. However, its intended value is specifically as a paradigm which, when adopted, gives a new focus for looking at existing prob-

lem areas, points to new problems and methodologies for research and as a whole, provides an organizing framework. For the practising manager, this framework may amount to a relatively simple conceptual scheme which allows him to understand his own and others' behavior and to be able to predict the events and outcomes of the decision process more easily. For the academic, it is hoped that the main concern here is convincing, to shift attention in the study of decision-making to the relativistic, contingent features of actual human information-processing. There are several other models of cognitive style that have substantial theoretical and experimental support. The main aim of this study is to establish a perspective; cognitive style exists and is relevant to our understanding of how we make decisions. That understanding, at a descriptive level, is the essential first step towards prescriptions for management practice.

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APPENDIX A: Sample Questions from the Cognitive Style

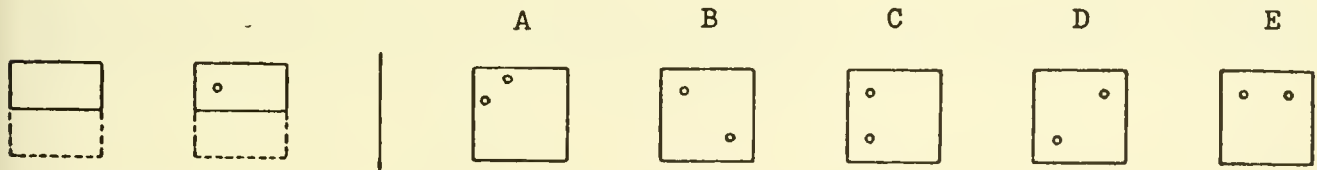
Test Battery

Under the conditions by which ETS makes tests available, no quotations may be given from the body of the tests, only from the Examples the subjects are shown prior to the test itself. These examples tend to be fairly simple; however, illustrate the format of the tests.

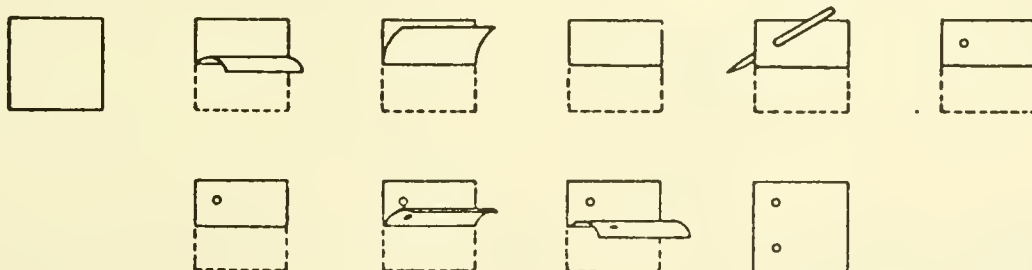
PAPER FOLDING TEST

In this test you are to imagine the folding and unfolding of pieces of paper. In each problem in the test there are some figures drawn at the left of a vertical line and there are others drawn at the right of the line. The figures at the left represent a square piece of paper being folded, and the last of these figures has one or two small circles drawn on it to show where the paper has been punched. Each hole is punched through all the thicknesses of paper at that point. One of the five figures at the right of the vertical line shows where the holes will be when the paper is completely unfolded. You are to decide which one of these figures is correct and draw an X through that figure.

Now try the sample problem below. (In this problem only one hole was punched in the folded paper.)



The correct answer to the sample problem above is C and so it should have been marked with an X. The figures below show how the paper was folded and why C is the correct answer.



2. Intuitive

VERBAL PUZZLES

Items 1 to 18 consist of word pairs. Think of a third word which is in one way or another related to the two words in each item. You are given the first letter of a suitable answer word. Fill in the blank with the remaining letters of the answer word. In some of the items you may select a word that has two different meanings and is related to one word by one meaning and to the other word by another meaning. Possible answers are given below to two sample pairs of words.

- | | | |
|----------|--------|--------------|
| a. piano | lock | K <u>EY</u> |
| b. drop | autumn | F <u>ALL</u> |

Items 19 to 24 consist of sentences each of which contain two blank spaces. Your task is to fill the two blank spaces in each sentence with the same word. That is, one word used twice will give you a meaningful sentence. Here is an example:

- (a) My latest information is that the squadron will fly past in formation at six o'clock this evening.

Notice that, although both blanks are filled with the same letters in the same order, the meaning is different, and that in one blank in the sentence the letters are divided to form two words.

SCRAMELED WORDS

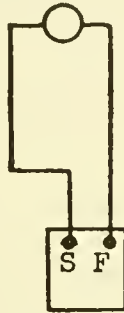
Each of the following groups of four letters would, if rearranged, spell a common English word.

eboy	e b <u>o</u> y
vyne	v y n <u>e</u>
toha	t <u>o</u> h a

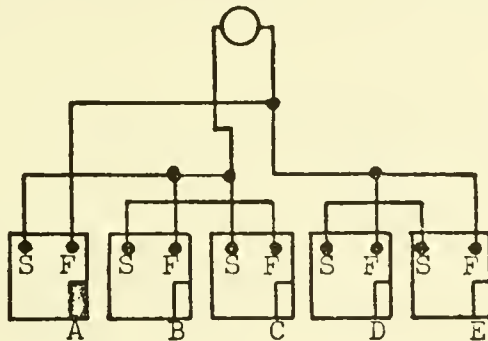
The first group of letters, eboy, when rearranged spells obey. To indicate this, the first letter of the unscrambled word, o, has been encircled in the column of spaced letters on the right. Similarly, the letters in vyne can be made to spell envy, and so the letter e has been circled. Tona is cata and so o is encircled.

CHOOSING A PATH

This is a test of your ability to choose a correct path from among several choices. In the picture below is a box with dots marked S and F. S is the starting point and F is the finish. You are to follow the line from S, through the circle at the top of the picture and back to F.



In the problems in this test there will be five such boxes. Only one box will have a line from the S, through the circle, and back to the F in the same box. Dots on the lines show the only places where connections can be made between lines. If lines meet or cross where there is no dot, there is no connection between the lines. Now try this example. Show which box has the line through the circle by blackening the space at the lower right of that box.

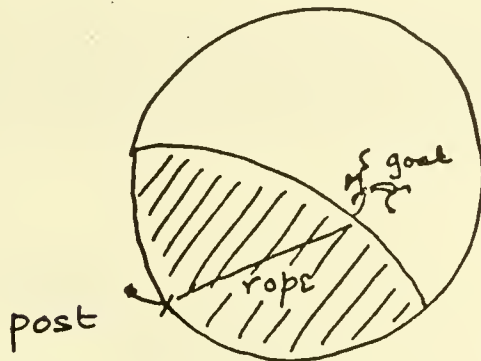


The first box is the one which has the line from S, through the circle, and back to F. The space lettered A has therefore been blackened.

Each diagram in the test has only one box which has a line through the circle and back to the F. Some lines are wrong because they lead to a dead end. Some lines are wrong because they come back to the box without going through the circle. Some lines are wrong because they lead to other boxes that do not have lines going through the circle.

Problem Cafeteria

1. A goat is tethered to the edge of a circular field by a fixed post. The field is 100 yards in diameter. Calculate the length of rope that will allow the goat to graze over exactly half the area of the field. (an explanation of the method of calculation is an acceptable answer; you need not do all the arithmetic.)



goat can graze over
the shaded area

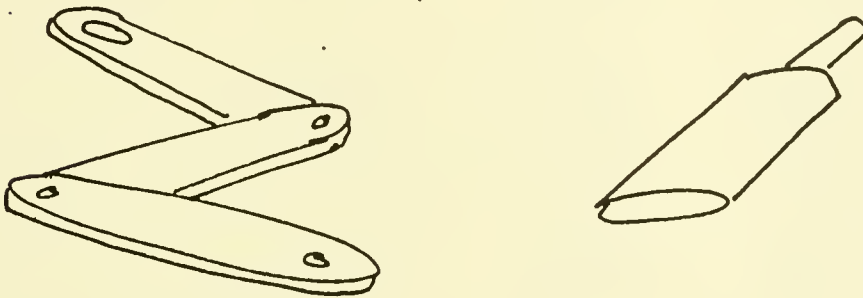
2. You are superintendent of schools in Transylvania, Ohio. You have to decide on a policy issue and have announced that you will support the public opinion on the matter. You took a poll of teachers, school administrators and parents, with the following results:

	Teachers	Administrators	Parents
Pro	25	20	10
Anti	5	10	20
Don't know	0	0	15

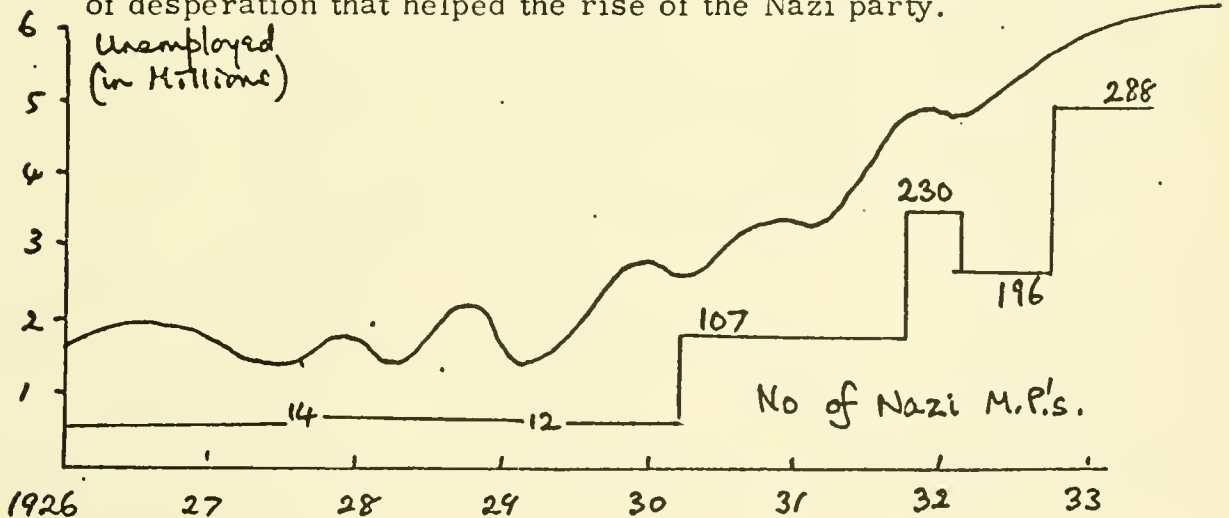
- a) What is your decision?
b) What would be your guess as to the nature of the policy issue involved?
3. Refute the arguments below (implicit or explicit)
- a) "Is this the beef broth or chicken broth, waiter?"
"Can't you tell by the taste?"
"No."
"Well then, what difference does it make?"
- b) There cannot be any real or basic mental differences between men and women, for both with men and women there are far wider differences in the particular group than between the

average man and the average woman.

4. To what would you ascribe the recent fashion for wide ties?
5. Consider the following numbers: 276,276 591,591 112,112. All are divisible by 13. Prove this is true for all numbers of this form.
6. List as many possible uses as you can for these two objects when they are used together. Provide a brief explanation of the method and purpose of use in each case.



7. The diagram below shows the level of unemployment in Germany between 1926 and 1934, together with the number of Nazi members of Parliament in those years. Discuss the hypothesis that the distress in Germany during the world slump created a mood of desperation that helped the rise of the Nazi party.



8. A flying saucer has landed in your back garden. Aliens emerge. They are blue, with six limbs, four feet high and encased in space suits. How would you communicate with them? (Note: you have no idea if they are friendly; your strategy should include the consideration of the snub-nosed rods in their "hands").
9. The words on the page below can be arranged in ten groups with the members of each group forming a scale. You are to label each word using a number for the group of which it is part and a letter showing its position within the group, "a" being the lowest, "b" the second lowest, etc. The classes do not necessarily contain the same number of members. An example is shown below for a small list of words:

Example	1e General	2b Algebra	1a Private
	2a Arithmetic	3b Afraid	1d Colonel
	3d Terror-stricken	2c Calculus	3a Bashful
	3c Frightened	1b Corporal	1c Major

(The classes are: 1- Army ranks; 2- Mathematics - level of complexity; 3- Intensity of emotion)

List for this question

football	arrest (verb)	order (verb)	steamboat	imprison
quarrel	train (noun)	possible	arraign	disagreement
command	sentence (verb)	overlook	request	demonstrable
hamlet	approve	force (verb)	anxious	marbles
automobile	excuse	praise	village	resentment
reluctant	electric car	displeasure	wagon	probable
battle	convict (verb)	war	city	willing
mudpies	doubtful	anger	golf	forgive
fury	conceivable	try (legally)	eager	town
metropolis	justify	feud	likely	airship

Write down the basis for each of the groups when you have completed the classifying.

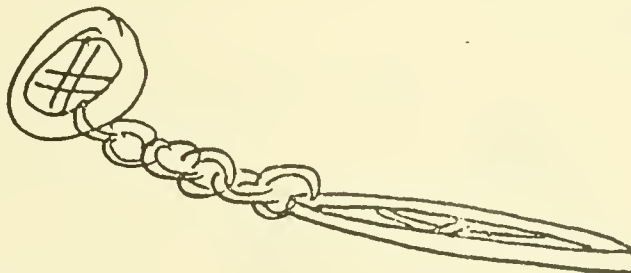
10. Fill out the square below so that it forms words reading across all the rows and down all the columns. You may use any English word that is not a proper noun (names of people, cities etc) and is in polite usage. In the example below, the square is half-completed - 'LOOK' and 'LAKE' across and 'OVAL' and 'KEEP' down. However, the square will be impossible to finish since there is no word 'OxKx' nor can a word be found for the first column 'LxLx' that will mesh with the fourth row 'xLxP'.

Example

L	O	O	K
	V		E
L	A	K	E
	L		P

11. Twenty men are held captive in a room by a single man with a gun. (the circumstances are too complex to relate here.) The twenty presume the gun is loaded and that it can hold six bullets. The assailant has told them he plans to kill them all. The room is empty of furniture and the lightswitch is next to the villain. The men can talk without his overhearing them. What are the options available to them? What would you recommend they do?
12. If there are very few famous men by the name of Smith do you think it's just a coincidence, seeing that the name is so famous? If not, how do you account for this.

13. Describe a bicycle, in terms that are absolutely unambiguous and precise. (To say it has 'two wheels and a chain' permits the following interpretation:)



14. Design a ceiling that will be cool in summer and warm in winter. No auxiliary aids, such as electricity, a heating system etc, are permitted.
15. The following message is in a simple code. Decipher it.

VEY CO XTS XCMS BEF IDD KEEJ MSV XE AEMS XE
XTS ICJ EB XTS NIFXQ

16. The diagram below shows the ships involved in the Battle of Trafalgar. Describe the British attack on the Franco-Spanish fleet. What was the French plan?



MAI 12 76

