An investigation of some relationships between learning and personality

Thesis

An investigation of some relationships between learning and personality

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Abstract

Title: An investigation of some relationships between learning and personality.

This study attempted to examine relationships between certain indices of learning style and efficiency and some aspects of personality. The methods adopted involved detailed study of a small sample of students (N = 14), learning a large and complex body of subject matter.

Four main indices of learning were studied.

1) Appreciation Span: the extent to which a learner planned ahead

2) Exploration: the extent to which a learner requested an outline of topics that he did not yet understand.

3) Errors: the extent to which a learner made mistakes when asked to explain topics that he had learned about.

4) Route taken: the extent to which a learner chose a wide range of topics to work on and extended his knowledge on a broad front, or confined his learning to a narrower 'in depth' study of one area at a time.

Hypotheses concerning appreciation span, exploration and errors focused on possible interrelationships between these variables, extraversion-introversion and associated characteristics. The results indicated no relationships between the distance ahead that students planned, the amount of exploration that they engaged in and extraversion-introversion. Possible explanations and implications of the results are discussed.

Hypotheses derived from previous work suggesting that extraverts have greater tolerance of ambiguity than introverts and thus make fewer errors when learning in unstructured, ambiguous situations were supported by the data.

A detailed theoretical discussion of attention deployment is presented and followed by an empirical examination of the extent to which the students studied developed their understanding on a broad or narrow front. Hypotheses concerning the relationships between this learning style characteristic and attention deployment, cognitive complexity and flexibility in problem-solving were supported by the data; indicating positive relationships between a 'breadth-first' learning style, wide (or diffuse) attention deployment, a high level of cognitive complexity and a flexible approach to problem-solving.

INTRODUCTION

This thesis contains six chapters.

Chapter 1 gives details of the equipment used and the general background to the experiments.

Chapter 6 provides a summary and discussion of the work conducted.

It may be useful for readers to begin by looking at Chapters 1 and 6 before chapters 2-5. Chapters 2-5 provide more extensive information on the work conducted and the results obtained.

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Appendices

CHAPTER I

BACKGROUND

Introduction

This thesis reports some investigations into the relationships between personality factors and learning activity.

Some time ago, when employed by an Industrial Training Board the author conducted a number of research projects. The aim of these projects was to develop a battery of selection tests that could be used to select suitable school-leavers for training as printing production workers. It quickly became apparent that these particular studies were destined to be no more nor less successful than a host of other studies of the same type. In other words a multiple correlation coefficient of approximately 0.5 could be anticipated. The reason for this lack of predictive power was that, like other studies of the same type, the tests used as predictors were exclusively tests of ability (eg mechanical comprehension, spatial ability, verbal ability) and a variety of other 'personality' factors were not being examined. The reasons for this lack of coverage were complex and included many sensitive and highly relevant political issues; however a distinct lack of useful information concerning the relationship of personality factors to learning and achievement was a contributory factor. The work reported in this thesis is one of the results of the interest in learning and personality initially generated by the situation just described.

Personality factors can help to explain performance on a training course in a variety of ways. It has been shown, for instance, that certain personality characteristics are related to performance on various types of criterion tests eg Gaudry and Spielberger (1971). This shows that personality may bias final test performance so that the investigator does not get a true picture of what the respondent has learned. It does not show that personality factors determine how much or what people actually learn. It merely shows how well they are able to demonstrate their understanding, under certain (often artificial) test conditions.

Personality does, of course, have an effect on how and what people learn. At a social level, personality factors may be related to study habits, relationships with teachers or machinery and thus, somewhat indirectly, to learning and achievement. A number of investigations have been conducted to examine such interrelationships, Entwhistle (1972). Personality may not only be related to the processes and organisation of learning at a general level as indicated above but also much more directly at the level of cognitive processes; where certain personality factors are associated with specific cognitive activity. Investigation of the relation-ships between cognitive activity and personality factors (as will be seen later these are not mutually exclusive categories) is the focus of interest for the studies reported in this thesis.

The decision to focus attention on the relationship between the cognitive processes involved in learning and personality characteristics raises two major problems. First, how can the learning process be examined and secondly, what personality factors should be examined. In practice solution to the first problem helps provide a frame of reference for the second, since by identifying the possible individual differences in learning that might be observed it is possible to suggest related personality characteristics that may be of importance. The difficulties involved in examining learning processes (as opposed to products) are substantial and will not be resolved easily.

The major difficulty is that such processes are 'internal', mental processes, and it is not normally possible to observe them.

To examine such processes a technique for exteriorising them must be used. Exteriorisation does not (and cannot) make unobservable processes observable. It merely gets people to do (and say) things which enable various inferences to be made about the possible nature/structure of unobservable processes. The challenge is to find methods of exteriorisation which enable worthwhile inferences to be made.

In this thesis reference is sometimes made to studying the learning process. To be more accurate it is an exteriorisation from which inferences can be made that is being studied. Whenever references are made to the study of learning processes this caveat should be taken as read.

An example of a previous technique used in attempts to exteriorise mental events is introspection, which relied on the verbal report of the participant for a description of what was taking place 'internally'. For a lengthy period introspective reports have not been regarded as reliable evidence in psychological experiments due to their unavoidably subjective nature; although quite recently some researchers studying the processes involved in learning and problem-solving have made extensive use of 'protocols', which are in fact, introspective reports of a subject's chain of thought; see, for example, Newell and Simon (1965) or De Groot (1965).

Many experiments in the main stream of behaviourist psychology, although not described as such by their originators, are also attempts at exteriorisation.

Indeed, any study of learning not solely concerned with efficiency (learning curves, error rates etc.), must be an attempt at exteriorisation.

Some examples will illustrate the point that, in fact, attempts at exteriorisation are part and parcel of the behaviourist paradigm.

When discussing conflict Hilgard and Marquis (1961) examine an experiment by Kaufman and Miller (1949). They note that Kaufman and Miller "established conflict", by giving rats 1, 3, 9, 27 or 81 runway trials reinforced with food and then 3 shock trials with a stronger shock on each succeeding trial. The results revealed a positive relationship between number of positively reinforced trials and the number of animals running all the way to the goal.

This is clearly an attempt to exteriorise or 'operationalise' conflict. Similarly an experiment by J S Brown (1948) attempted to exteriorise the 'motivation' of rats. He measured the strength of pull that rats would exert on a harness and showed that this was associated with training condition and distance from goal.

Osgood (1952) describes experiments where rats at the 'choice-point' in a 'Y' maze will make bobbing movements with their heads, first toward one alley - then the other. The 'intention movements' although not specifically described as such by the original investigators can be construed as exteriorisations of conflict.

Other techniques for examining cognitive processes have also been developed. A forerunner of much recent work is the work of Bruner, Goodnow and Austin (1956). The essence of their technique was to display limited information to the learner/problem-solver and issue other information when requested. By restricting access to information and observing participants patterns of requests it was thus possible for them to make inferences about some aspects of the concept formation processes used by their subjects. This general approach, ie making the supply of information contingent on subject behaviour is being used profitably to study reading eg Farnes and Thomas (1971). By restricting the reader's visual field and allowing him to select which part of the text is displayed in his visual field these experimenters can observe and record reading patterns. The procedure is mechanised and a record of the student's reading pattern is automatically taken. This recording throws light upon a sequence of hitherto private events and in a fairly direct way exteriorises a subject's reading progress. It acts as what Pask, Scott and Kallikourdis (1973) have called a 'cognitive reflector' and enables the observer to infer something about the internal events that are taking place.

With any such approach there is always a problem about what is 'really' taking place and what can be observed in the reflector. Nevertheless such techniques do help to reduce (though not eliminate) an observers uncertainty and can, as already indicated, be put to good use.

A distinction made by Kaplan (1964) is relevant to this issue. Kaplan distinguishes between 'logic-in-use' and 'reconstructed logic'.

> "Now the word 'logic' is one of those like 'physiology' and 'history', which is used both for a certain discipline and for its subject matter. We all have physiologies and histories, and some of us also think and write about these things. Similarly, scientists and philosophers use a logic - they have a cognitive style which is more or less logical - and some of them also formulate it explicitly. I call the former the logic-in-use, and the latter reconstructed logic. We can no more take them to be identical or even assume an exact correspondence between them, than we can in the case of the decline of Rome and Gibben's account of it, a patient's fever and his physician's explanation of it".

The distinction can be drawn more sharply, for current purposes as:

a) the logic that the subject (person being studied) is actually using, and

b) the logic that the experimenter (outside observer) comes to believe that **the subject is using.**

As Kaplan notes there is not necessarily an exact correspondence between the two. However this does not mean the reconstructed logic is not useful. If a particular piece of reconstructed logic can prove to have predictive and explanatory validity it can be a useful scientific tool and help one to systemalize and build up a useful and coherent picture of the phenomena being studied. Indeed much (if not all) scientific theory is developed in this way.

As the work quoted earlier has shown observational techniques grounded in reconstructed logic can be extremely useful; but it must not be assumed that the reconstructed logic and the logic in use are identical.

One contemporary attempt to develop exteriorisation techniques is the work of Pask and his colleagues, eg Pask and Scott (1973) and their development of a teaching system that they describe as CASTE (Course Assembly System and Tutorial Environment). The equipment used to examine learning activity for this thesis is an adaptation of the CASTE system. This adaptation was also developed by Pask et al and is entitled 'INTUITION'.* Using this equipment it is possible to observe and record certain aspects of an individual's learning activity and thus investigate relationships between these factors and personality characteristics.

The Learning Equipment (INTUITION)

The research reported in this thesis involved the use of techniques and equipment (INTUITION) that will be unfamiliar to most readers. The equipment used was developed not primarily as a teaching device but as an attempt to embody certain general theories of cognition. The equipment is, in fact, being continually remodelled and adapted; thus detail concerning the actual equipment is only of rather transient interest.

Bearing these points in mind there follows a description of the equipment and some underlying theory at a level of abstraction sufficiently non-technical for it to be grasped with ease.

This description does not do full justice to the equipment itself, nor indeed to the associated theories, but should help the reader to maintain clear sight of the issues that are of major relevance to the research reported here. Full details of the equipment and associated theoretical issues are reported in the literature. Pask and Scott (op cit), Pask (1973).

The Topic Map

One of the main features of the techniques embodied in CASTE and INTUITION is the use of a map of the subject matter that is displayed to students.

***Footnote. Individual TUITION.**

This map is an attempt to display some piece of knowledge in a way which is understandable to the learner and which indicates to him what subject matter "topics" are covered and how the topics are related to each other. An example of part of a map is given in Fig. 1.

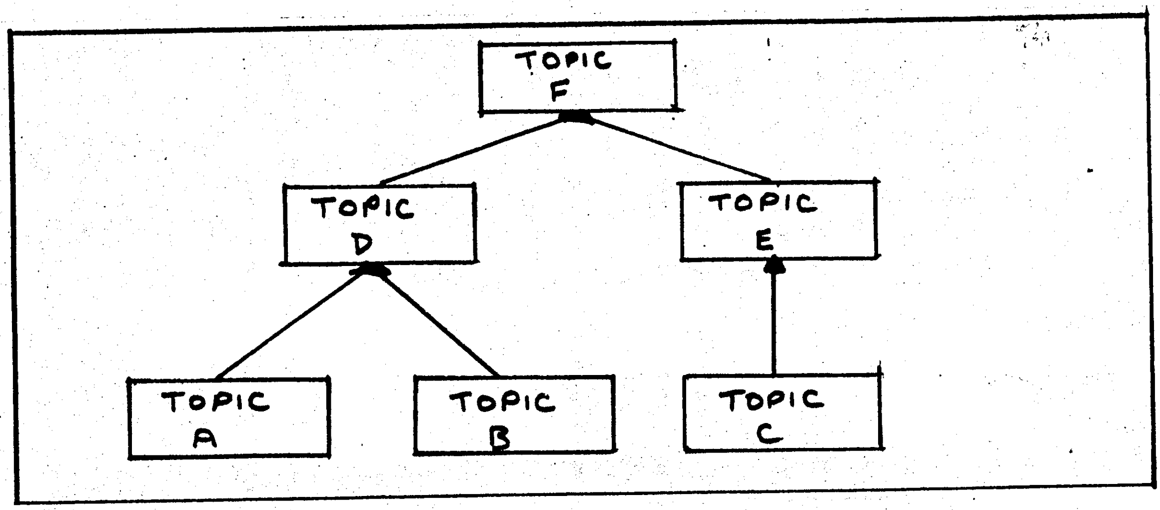

Fig. 1 (A mini topic map)

As Fig. 1 shows the subject matter to be displayed is broken up into six related topics. A typical map will show a collection of named topics and will show how the topics relate to one another, (the nature of the inter-relationships is discussed below). An example of part of a map concerned with probability theory is given in Fig. 2.

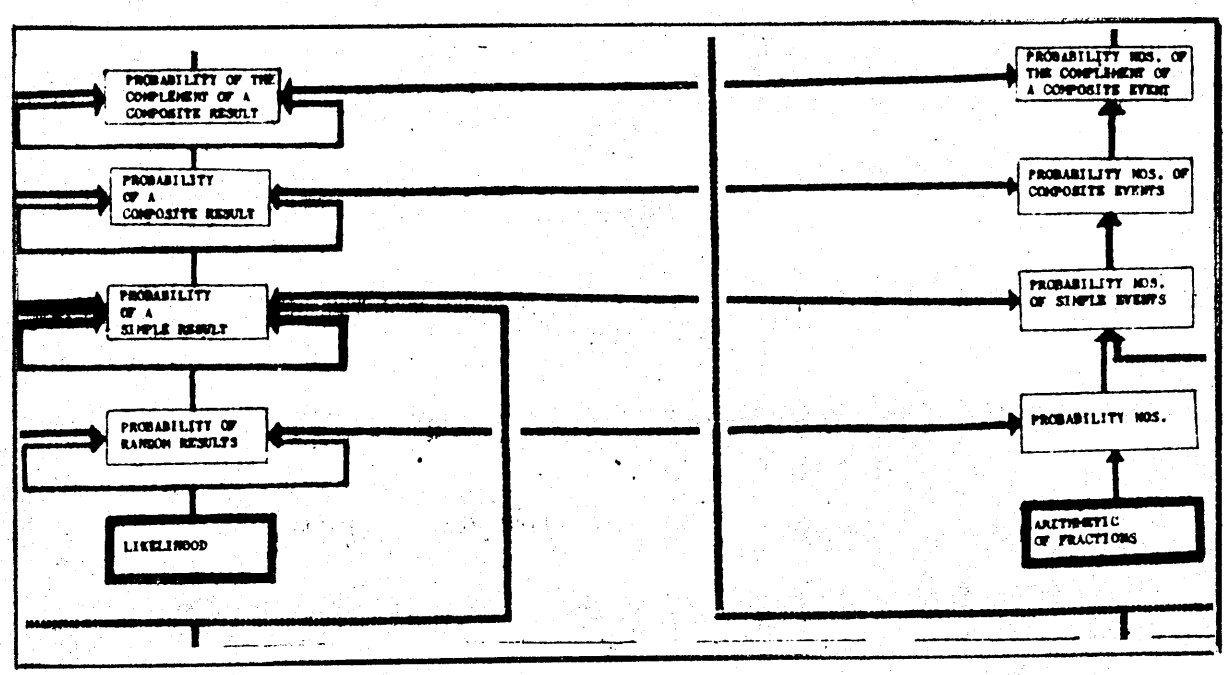

Fig. 2 (Part of a topic map)

Theoretically it is possible for any subject-matter to be displayed in this way with the help of a subject-matter expert. The specific topics chosen and the way they are inter-related represent the subject-matter expert's view of the subject-matter. Thus what is meant by 'topic' and the definition of a topic will depend on the subject-matter expert. Any map simply represents a thesis concerning the subject-matter; it is not necessarily the best nor the only description of that body of knowledge.

An example of a map, as seen by the student, (showing the topics that make up certain areas of probability theory) is shown in plate 1.

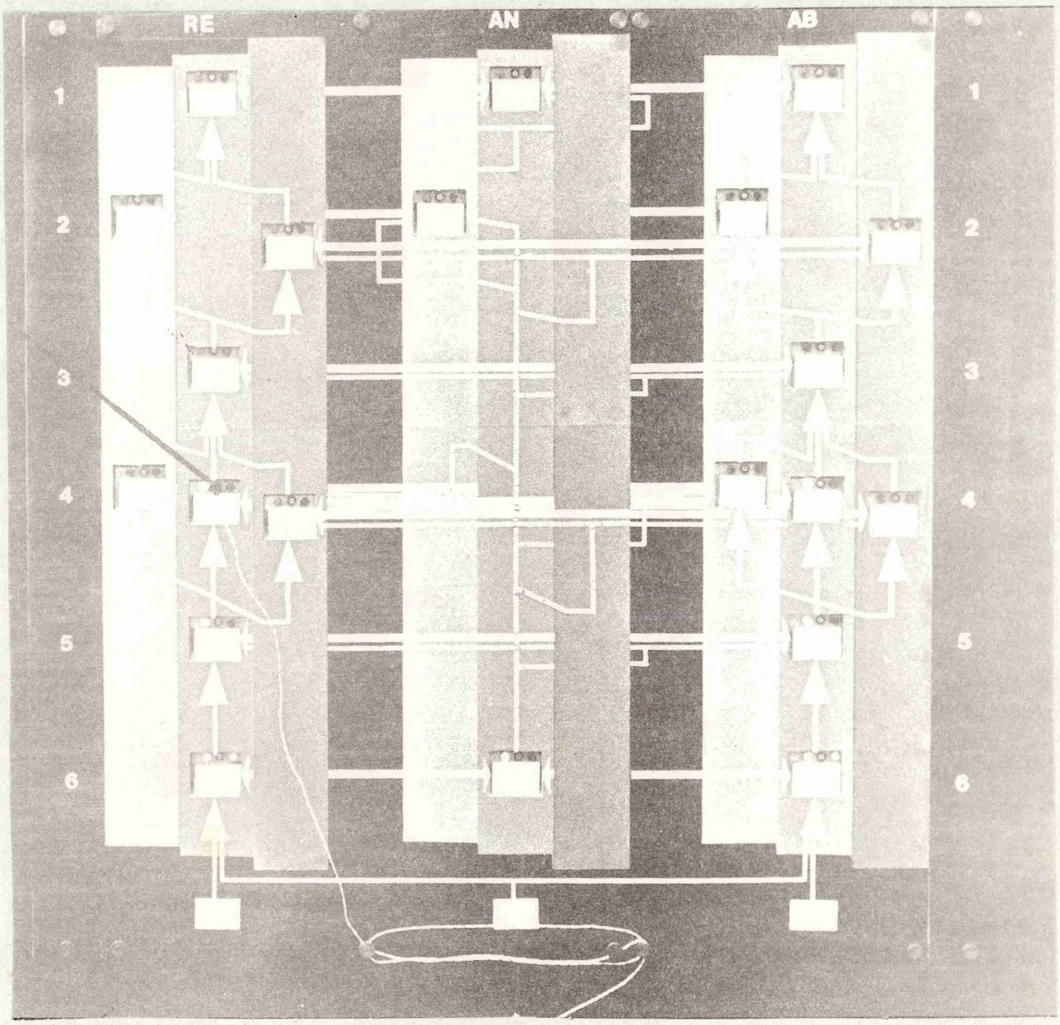

Plate 1 (A topic map, as seen by a student)

Plate 2 shows a map in situ with the rest of the equipment (the other elements of the system and how the student interacts with it will be explained in due course).

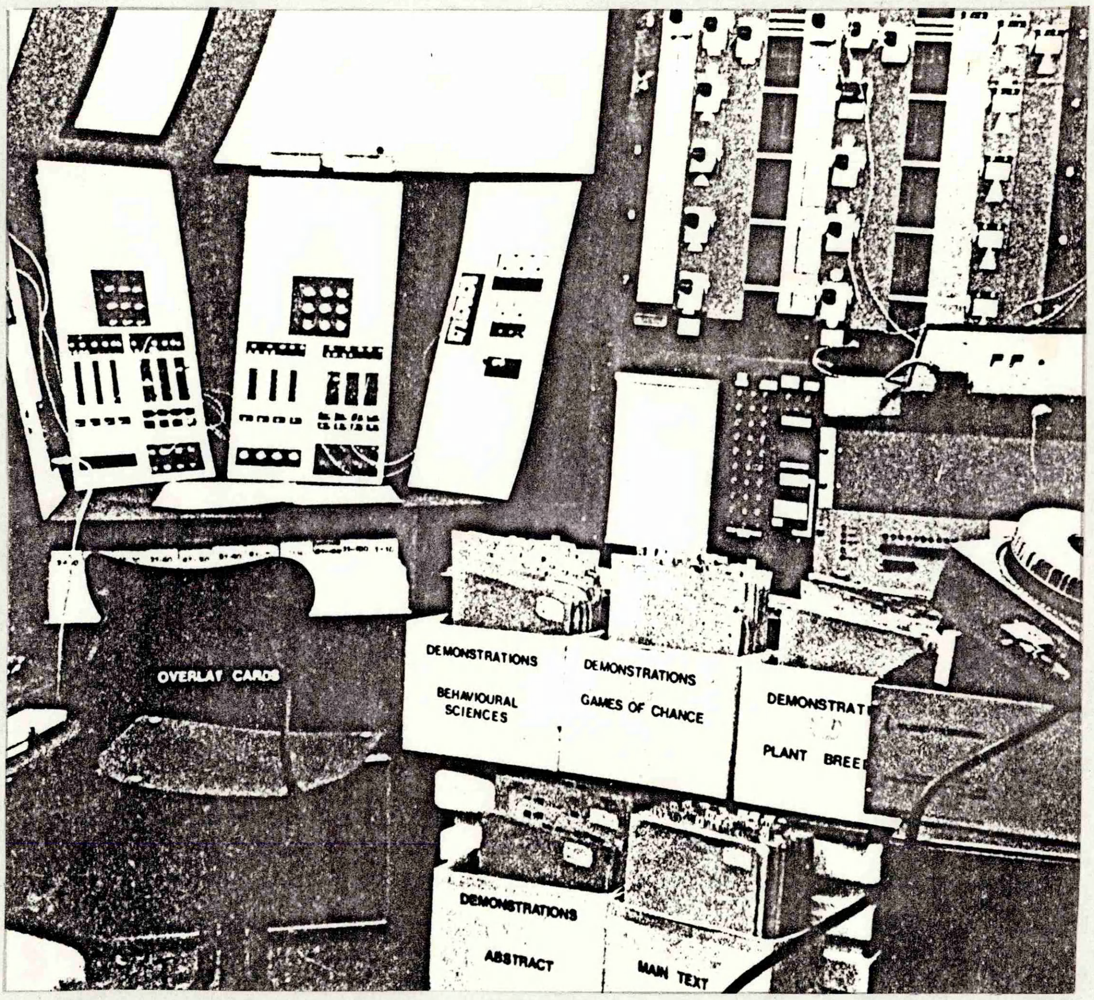

Plate 2 (The INTUITION equipment)

i) <u>The 'contents' of topics and relationships between topics</u>

For each topic that is displayed on the concept map there is also a full specification (not shown on the map) of what a student must be able to <u>say</u> and <u>do</u> in order to demonstrate his understanding of the topic. This specification, or 'task structure' is, in effect, a statement of the behavioural objectives for that topic.

In addition to the task structure, which describes the contents of each topic, there is also an'entailment structure' that indicates how the topics are related to each other.

ii) An Example

An example may help to clarify the points raised so far. Fig. 3 shows a very simple map for topics A, B and C.

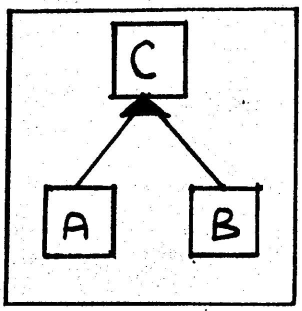

Fig. 3 (A conjunctive organisation)

Figure 3 shows that topics A and B are pre-requisites for topic C and both must be understood before a student can begin work on topic C (a conjunctive rule).

Figure 4 is a slightly more complex map.

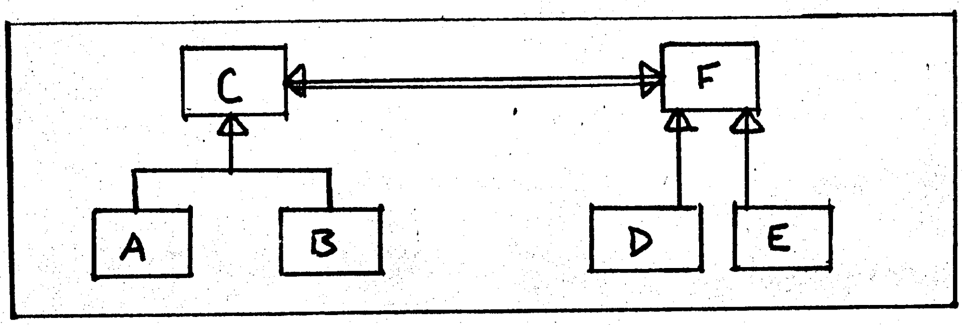

Fig. 4 (Conjunctive and Disjunctive Organisation)

Figure 4 shows that, as before, A and B are pre-requisites for C and must both be understood before a student is allowed to begin work on C. It also shows that when a student understands either topic D or topic E he can progress to topic F. Thus the vertical lines indicate an ordering of topics. The bi-directional lines between topics C and F show that these topics are analogous.

iii) Analogous relations

If the topic map in Figure 4 was concerned with 'probability theory' (as the one used for this research was) topic C could be entitled "Frequency of a simple result". Now the task structure (or behavioural objectives) for that topic would ensure that a student could deal with a certain aspect of probability; namely that he could actually compute the long-run stable frequency of a real simple result, eg 'throwing a six',or tossing a coin to land on 'heads'.

Topic F, on the other hand, could be entitled "Probability numbers of simple events". Whereas topic C is concerned with 'real' occurrences,topic F is concerned with mathematical or abstract models of real occurrences where symbols are manipulated and used to model the 'real world'; and an abstract probability number is the 'model' of the actual observed frequency. If the abstract model is an accurate model then there is an analogy between the topics - or they are analogous topics. This relation is represented by the bi-directional horizontal line in Fig. 4.

Analogy relations do not only occur between topics in probability theory, though they are particularly clear in this area. In Physics, for example, there is an analogical relationship between simple harmonic oscillators (spring , weight and friction combination oscillating under an applied vertical force, and electrical devices (such as a circuit with resistance, inductance and capacitance, activated by an electric generator).

People make extensive use of analogy relations in learning and problem solving and often an analogy is the only way to gain insight into a novel or new situation or concept. If the next situation can be seen as analogous to some other more familiar situation then the learner or problem-solver can develop his understanding as he tests the validity of the analogy. In a sense people try to understand the world around them by trying to detect similarity and stability and the detection of analogical similarity between seemingly disparate and unconnected phenomena may often be an important and time-saving step in the learning or problem-solving process. For example, if someone who is familiar with electrical devices perceives the analogy noted above between electrical devices and springs, weights etc...(ie harmonic oscillators) considerable learning time and effort can be saved; furthermore the development of a 'higher level' or more abstract,general concept of 'oscillation' can occur.

To summarize:

- A concept map is a succinct representation of a body of knowledge showing the topics involved and how they are related.
- The evidence that a topic has been adequately learned is specified by the task structure (behavioural objectives) (not shown on the map).
- The relationships between topics (precedence ordering and analogy) are shown by the entailment structure (knowledge objectives).

General Features of INTUITION

INTUITION is an adaptation of CASTE. Before describing INTUITION in any more detail an outline of the parent system (CASTE) will be given. CASTE is a computer-based system with the following major characteristics.

1 It supplies the student with a map of the subject matter that he is required to learn.

2 It exteriorises certain aspects of a student's learning activity, acting as 'cognitive reflector'.

3 It is adaptive. The system computes various indices relating to each student's progress and adjusts the teaching strategy to cope with student characteristics.

There is, of course, no necessity for a teaching system to be adaptive, see, for instance, the "telling" approach discussed by Lewis and Cook (1969). The important difference between CASTE and INTUITION concerns the extent to which the systems are adaptive. As already noted, with CASTE the material presented is changed to suit students' characteristics. The student, working on CASTE is not 'free learning', he interacts with the system and his learning and future interactions are guided and controlled.

INTUITION maintains some of the characteristics of CASTE, ie it provides the student with a map and signposts to enable him to choose a route through the subject matter and it acts as a cognitive reflector; however it does not, to the same extent, control the student's learning.

How the Student uses the Equipment

Theoretically the INTUITION equipment can be adapted to teach any subject matter that can be represented in topic network form but for the work described in this thesis the subject matter covered was probability theory. The topic map was divided into three modules.

Students work on one module at a time - progressing from 1 - 3 (each module takes from 3 to 5 hours to complete - further details of learning sessions etc. are given later).

The topics for probability theory are grouped into three main categories.

These are clearly visible as the vertical divisions on the map shown in plate 1. The three divisions are:

1 Topics concerned with activities (in the present case, experiments) carried out in the 'real world' (headed 'Re' on the display).

2 Topics concerned with constructing abstract models of the real world (headed 'Ab' on the display).

3 Topics concerned with the form of the analogy which relates real world activities to the abstract models (headed 'An' in the display).

Thus a student is presented with a body of subject matter clearly divided into three categories. One of these categories 'Re' is concerned with actual activities in the real world, such as throwing dice. Another category 'Ab' is concerned with the representation of these real activities in abstract terms, such as using a probability number derived from observed long-run stable-frequencies. The final category 'An' concerns the analogical relations that obtain between the two other categories; so that, for example a list of (real) simple results is related analogically via a theory of simple experiments to an (abstract) event set of simple events.

The full topic map for modules 1, 2 and 3 is shown at Appendix 1.

Plate 1 shows the topic map for module 1 as seen by the student. The lower-most topics are called primitives and any student taking the course must have prior understanding of these primitives. They are taught informally before the course begins. The 3 uppermost topics are the head topics. A student has completed the course when he understands the 3 head topics.

INTUITION does not compute the various indices of performance that CASTE does, nor does it react adaptively to a student's behaviour. A student working on INTUITION is essentially in a free-learning situation where he can display his own learning style characteristics. His eventual aim is to understand the head topics by beginning work on a topic near the bottom of the map and working his way through the topics.

A new student is presented with an introduction* to the equipment.

Having read the introduction the student is then given an opportunity to familiarise himself with the appearance of the equipment, to inspect the topic names and ask general questions. Also to reinforce the introduction already given in writing, the purpose and function of various items is explained verbally until it is apparent that the student understands the equipment, and is ready to begin.

The steps that a student follows when working on the equipment are listed below - then each one is explained in more detail.

Outline of procedure for student working on INTUITION
1 Explore topics (optional facility)
2 Select a topic to 'aim for'
3 Select a topic to 'work on'
4 Read text and carry out instructions
5 Take test(s) of understanding when necessary
Then, if test of understanding is passed, repeat 1-5 until the module is completed.

Table 1 (Outline procedure)

Explore the topics

A student can request a brief explanation of what is covered by any particular topic. He makes the request by interacting directly with the equipment - not via any experimenter/observer.

When a student requests information in this way (when he 'explores' a topic) he triggers a slide projector which displays an appropriate slide on a nearby screen. The slide gives a two or three line summary (often with an illustration) of the subject matter for the topic in question. The information supplied

*This is given to the student in writing (see appendix 2). For the sake of continuity the operation of the equipment is fully explained in this current section and the reader may ignore appendix 2.

always attempts to exhibit the central concept of the topic. An example of the information supplied during the explore transaction given in figure 5.

The complement of a composite event consists of those simple events that are not members of the composite event.

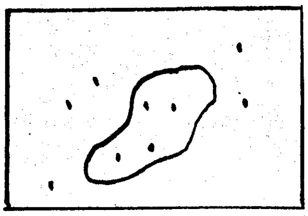

Figure 5 (Sample 'explore' slide)

<u>Select a topic to aim for</u>

Once he has explored as many topics as he wishes the student must select and identify (again, he does this by direct interaction with the equipment) a topic to 'aim' for. The student's aim topic must be a topic that he does not yet understand but hopes to understand eventually.

The problem of identifying a topic that is not yet completely understood by a learner, but is something that he wishes to understand, is not new and was discussed as long ago as Plato.

In the situation described here the learner is required to describe the topic that he wishes to aim at and satisfy the experimenter/observer that it is not merely a haphazard choice. Although he will clearly not be in a position to give a complete description of the aim topic the learner must minimally show that he understands how the aim topic is related to other topics on the entailment structure (eg'this topic is analogous to topic 'x' and before I can learn about it I must understand topic 'y').

The aim topic should be an explicit indication of the learner's future intentions and should indicate the most distant topic that he has given consideration to and has explicit intentions of working towards.

Some students tend to select aims only a small distance ahead whereas others aim at topics that are far ahead and that they will not be in a position to work on for some time.

It is made clear to the student that he is free to aim at any topics (that he does not already understand) as long as he is able to give a description of the topic relative to the other topics on the map. In other words he must demonstrate that his aim is not just a 'stab in the dark'. Furthermore, the student can change to a new aim whenever he wishes.

Select a topic to 'work on'

Eventually a student must begin work on a particular topic. When he has explored as much as he wishes and has chosen his aim, he must select and indicate a topic to work on (this again is done by direct interaction with the equipment).

The two basic rules that restrict which topic a student can aim for are that:

a) he must understand any topics that are prerequisites for his choice.

b) the topic chosen must either be his aim, or be subordinate to his aim (ie a student cannot work on a topic that is not 'en route' to his aim - he can, of course, as noted earlier, change his aim whenever he wishes.

Thus, to begin with he will only understand the primitives and his choice of topics will inevitably be limited to those at the bottom of the map.

Read text and carry out demonstrations

Once he has selected a legal* topic to work on the student is directed to the main explanatory text material. As well as being directed to the main text he is also given the opportunity to carry out practical demonstration exercises that will help him to understand the topic. These exercises are conducted with the aid of an electronic modelling facility - STATLAB - see plate 3.

* Footnote. The equipment will warn a student by ringing a buzzer if he selects an illegal topic.

(All of these operations are conducted without the interference of an experimenter/observer).

The student reads the text and conducts a variety of exercises, skipping or re-doing sections as he chooses until he feels ready to take the test of understanding.

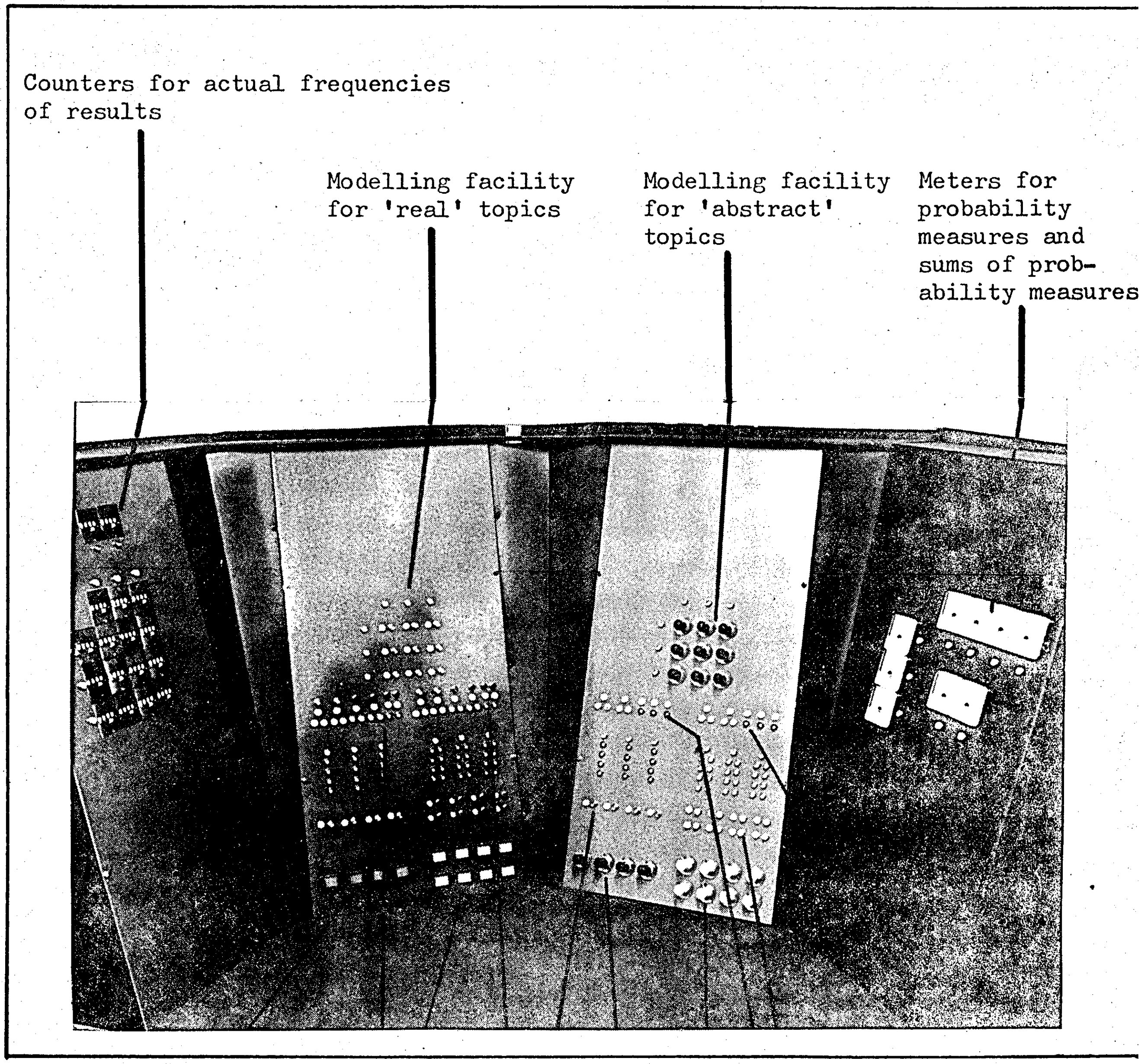

Plate 3 Modified STATLAB for classroom use.

It is worth noting at this point that the subject matter used for the experiments described here (probability theory) was organised into a fairly coherent **hierarchical** system and displayed to students as such. To do the same thing for other areas, eg social psychology, history, or any 'soft' discipline would be a difficult task. With the assistance of a 'subject matter expert' prepared to expound his thesis it should theoretically be feasible - although, of course, the subject matter expert may not find it possible (or sensible) to develop a simple **hierarchical** structure.

Take Test of Understanding

When he feels ready, the student opts to take a test of understanding. At this point the experimenter does become involved (although it is possible to conduct this stage without an experimenter). The experimenter refers to a pre-determined list of problems and a check-list to check students' solutions. The problems constitute a thorough test of whether or not the student has achieved the behavioural objectives (task structure) for the topic.

If he passes the test the student is ready to move on and select a new topic to work on (perhaps he will also explore some more topics and/or select a new aim).

The cycle (1-5) **see table 1, continues until the head topics for each module are understood.**

Number of topics worked on

Because of the correspondences and inter-relationships between topics it is not necessary for students to actually work on all of the topics displayed on the concept map, though they are free to do so if they wish. Students can build up their understanding in various ways and they do not all follow the same route through the topics nor do they all necessarily work on the same number of topics.

<u>Records Taken</u>

In the sessions reported in this thesis students worked on the equipment in a series of sessions of $1\frac{1}{2}$-2 hours. The number of students, frequency of sessions etc., will be discussed later. During each session an experimenter/observer recorded student activity and administered tests of understanding. Records taken included:

1) Topics explored
2) Topics aimed at
3) Topics worked on and the order in which they were worked on (ie the route taken through the material)
4) Errors made on tests of understanding.

Table 2 (Records taken)

All of these records are indices of learning. They can be divided into indices of learning <u>achievement</u> (errors) and indices of learning <u>style</u> (topics explored, topics aimed at and route taken).

<u>Summary of major features of INTUITION</u>

The features of INTUITION that are of major importance for this study are:

- the student is provided with a concept map of the subject matter area that he is going to learn about. This map presents a body of knowledge to him in a coherent way since it indicates the topics involved and how they inter-connect.
- the system can be used to specify, and devise tests for, both knowledge objectives (entailment structures) and behavioural objectives (task structures)
- the system helps to exteriorise strategies that students use to find their way through a knowledge structure
- although, to begin with the system (equipment) may be strange and disconcerting to a student it has the advantage of minimal experimenter involvement and all subjects interact with an unbiased machine.

Most importantly it is a system which enables a researcher to make inferences about the cognitive processes taking place, in particular the learning strategies used, and where reliable measures can be taken and related to scores on standard personality tests.

Thus INTUITION was used in this study as a means of 'observing' the learning process as an integral part of an attempt to study relationships between learning and personality.

Studies of learning

Before attempting to observe or conceptualise processes such as learning the investigator must take a decision about the sort of data that he wishes to study and the conceptual framework within which the data is to be examined. When learning takes place changes of various sorts take place and investigators can examine phenonena ranging from physiological studies of synaptic changes to shifts in attitude and conceptual structure. These changes can be studied and related to a variety of different models such as the stimulus response or artificial intelligence paradigms.

Much of the work concerned with the general area of learning does not seem to impinge directly on the activities, classified as learning, taking place every day in schools and colleges. This does not mean that such work is of no eventual value for everyday learning (programmed instruction for example) but does indicate the gap that often exists between psychological research and everyday learning. Researchers are often forced to trade-off 'realism' against 'scientific' rigour' and the mose objective, replicable and clearly defined an experiment becomes the less use its results are likely to be in any 'real life' problem situation. On the other hand the more closely an experimental situation corresponds to 'real life' the less likely it is that results can be unambiguously interpreted. The INTUITION equipment is a promising development since the student is placed in a situation where his activities can be recorded with a high degree of objectivity and can be recognised as immediately relevant to everyday learning.

The situation is, of course, not perfect and the system may suffer from faults that a more microscopic investigation of, for example, paired-associate learning would not - but the compensation for this is that the investigator can study a more complex and life-like situation.

Personality

A major area of interest for this study concerns the relationship between learning and personality. Before considering possible relationships between the indices of learning achievement (errors) and learning style (eg exploration) and personality factors a brief examination of what is meant by the term personality will be undertaken. Interest in personality as an area of study has a long history. An early attempt to identify personality 'types' was made by Hippocrates and used later by Galen, Kant and Wundt. This classification into melancholic, choleric, phlegmatic and sanguine has also influenced contemporary writers; see Eysenck(1964). However, only in the twentieth century have any systematic attempts to measure and study personality been made.

Early workers in the field displayed a variety of different approaches to the problem, for example Kretschmer (1925) and later Sheldon (1942), and an emphasis on constitutional types, Baldwin (1897) and later Mead(1934) and the concept of self. Contemporary psychology probably has almost as many personality theories as there are psychologists studying the matter. It is however possible to identify certain general approaches. Pervin (1970) isolates five different categories - two of which are particularly appropriate in the context of the current study. These are:

1) The Trait/typological approach
2) The cognitive approach

Trait Theories

The two most influential figures in this field are Eysenck and Cattell. Trait theorists attempt to summarise behaviour by developing a limited number of quantitatively varying dimensions which would be applicable to all persons.

Allport (1961) is critical of Trait theory by arguing that there is no such thing as a 'trait' that is invariant across persons, only personal dispositions which are unique characteristics of individuals. A more substantive and related consideration is that of whether or not factors (or traits) developed by factor - analytic procedures are invariant or replicable.

Peterson (1965) reported the results of a series of studies designed to examine factor invariance and concludes that the data do not offer impressive evidence for invariance. Other investigators Becker (1960) and Tyler (1965) have indicated that factors derived from Cattell's three media (L, Q and T data) do not match very well, even Hundleby, Pawlik and Cattell (1965) do not provide unequivocal evidence.

The demonstration of the existence of moderator variables eg Kogan and Wallach (1964) also poses great problems for the factor analyst since the technique is based on the assumption that there are, in effect, no moderator variables.

Eysenck also uses factor-analytic procedures supplemented by criterion analysis in an effort to determine the structure of personality and as Adcock (1965) has shown, the classifications of Eysenck and Cattell begin to look very similar when one examines the second order factors of Cattell and the factors proposed by Eysenck. It also seems that at this level of specificity (ie type as opposed to trait) the evidence for stability of factors is much better. For example, Peterson (op cit) did indicate invariance for factors labelled, Adjustment and Extraversion - Intraversion. Although the evidence linking personality types with the various physiological measures proposed by Eysenck's theory is not always in accord with theoretical implications eg Franks (1963), Spence and Spence (1964) the possible stability of his main personality types seems quite good by comparison with evidence for Cattell's scheme eg Orpen (1972), Eysenck (1972).

Cognitive Theories

Traditionally personality theorists have emphasised the motivational, emotive and biological characteristics of individuals and only in the last 15-20 years has a consideration of thought processes been important.

Cognitive theorists such as Kelly (1955); Bieri et al (1966); Schroeder, Driver and Struefort (1967); Witkin et al (1962) focus attention on the possible consistent individual differences in cognitive processes and structure that may exist. Most cognitive personality theorists have tended to conceptualise individual styles of thinking in the same way that trait theorists have conceptualised traits, eg Witkin and Moore (1974). Until work such as that mentioned above began, interest in individual differences in the cognitive area had centred on 'intelligence' or abilities, seen very much as differences with a positive and negative pole - not simply as differences.

A number of 'cognitive personality factors' have been identified and evidence for their invariance is often more impressive than that for conventional traits. A more thorough comparison of trait and cognitive personality theories is given in Chapter 6. For the moment it is sufficient to conclude that to gain a coherent picture of personality 'as a whole' both 'non-cognitive' and 'cognitive' factors should be included. Thus the view of personality taken in the rest of this thesis is that the conventional personality traits dealing with essentially non-cognitive elements of personality must be supplemented by an awareness of consistencies in cognitive style as personality traits. This position is particularly relevant for a consideration of possible relationships between personality and learning.

'Cognitive traits' refer to consistent modes of processing and storing information. Conventional traits refer to consistencies in response to the situations represented and transformed by our cognitive processes.

With personality seen in this way it is sometimes inappropriate to search for relationships between personality and learning. In one sense this is legitimate ie when examining relationships between conventional traits and learning. When cognitive personality traits are considered however, one is attempting to identify fundamental consistencies in cognitive style that are manifest in both the personality and learning areas ie cognitive personality traits and consistencies in learning could be manifestations of the same fundamental consistencies of cognitive style.

Previous work on learning and personality

This section is not intended as an exhaustive review of previous work on personality and learning. It is meant to give the 'flavour' of previous and current research and make it clear that the work reported in this thesis, by approaching the problem in a different way, complements much of the previous work done in the same general area.

A substantial amount of time and effort has been devoted to studies attempting to examine the relationships between learning and personality. Studies have examined the relationships of personality variables to both teaching conditions and academic achievement.

Goldberg (1972) reviews a large number of studies aimed at uncovering relationships between teaching conditions and personality factors and notes the lack of positive findings. He then goes on to describe an extensive study of his own and concludes that, "In summary then for each of these five criteria and each of these two major variations in experimental teaching conditions some 300-400 'a-priori' personality scales produced a few dozen significant inter-action effects. All these inter-actions could have arisen by chance alone and none of them were truly large in magnitude".

Most of the work concerning academic achievement has been conducted with the personality scales of Eysenck or Cattell.

In a series of studies by various investigators the relationship of Eysenck's personality factors to achievement was found to be rather complex. Furneaux (1957) and later Lynn (1959) found that successful students tended to be introverted. Callard and Goodfellow (1962) working with secondary school children found that high achievement was associated with low neuroticism. Savage (1966) found that successful primary school children were extraverted and not neurotic. Further large scale studies by Entwhistle and Cunningham (1968) [N - 3,000] and Eysenck and Cookson (1969) [N - 4,000] also produced apparently contradictory results.

However, closer inspection and subsequent research has revealed a pattern see Entwhistle (1972): Successful pupils in primary school tend to be more extraverted and less neurotic and successful students at university or college are more likely to be introverted and possibly neurotic. However, as Entwhistle (1972) points out, results are not entirely unequivocal.

Research with Cattell's factors is even less conclusive. Cattell, Sealy and Sweeney (1966) reported a number of studies where the correlations between attainment and personality factors were generally very low. Rushton (1966) also found low correlations, but did demonstrate that results for the second-order factors, Anxiety and Extraversion were comparable with those obtained by Savage (1966) for primary school children. Thus, at least the results obtained using the two different scales appear to be compatible.

As noted above it is possible to identify a general pattern for the results obtained using the Eysenck scale. Establishing such a pattern presents the new problem of 'explaining' the pattern. One explanation is that the change in personality profiles of successful students reflects differences in teaching methods and the learner's ability to cope; so that, for example, when a university student is largely expected to rely on his own resources an introverted disposition would pre-dispose the student to engage in good study habits, Eysenck (1972). Other points of view have been put forward and Anthony (1973) posits a 'non-causal' one based on the assumption that an individual's rate of development of general ability and extraversion is constant, relative to his peers.

There is, however, no widely accepted general explanation of the results described above. One reason for the lack of a comprehensive explanatory principle may lie in the orientation of the studies. Most of the studies are 'product' centred rather than 'process' centred. The products of learning (eg examination results) have been examined and attempts made to relate them to personality dimensions. Such an approach is understandable since the process of learning appears to involve a collection of private, internal cognitive events not available for examination by an observer. Furthermore if process differences do not cause product differences they are not of urgent pedagogical significance. However, such a product-oriented approach does not do a great deal to help clarify any possible dimensions of learning activity that may be related to personality factors. A process-oriented approach aimed at defining stable indices of learning and investigating the relationship of such indices to personality factors could act as a profitable complement to the product-oriented approach already widely used and is more likely to help produce an 'explanation' of the results obtained. It would be interesting to see how the factors of most interest (extraversion/introversion) can be related to learning processes. One of the few attempts to do this; Leith and Trown (1970) will be discussed fully in a later section.

Study of the existing work on learning and personality indicates that most authors seem to consider that in addition to conventional (orectic) personality dimensions the only other significant factor that may relate to academic performance is 'intelligence'. Cognitive factors always seem to be viewed from an 'evaluative' viewpoint and having 'more or less' general ability/verbal ability/intelligence is related to 'better or worse' attainment. Few studies give the impression that 'differences' in cognitive activity could be related to 'differences' in attainment. In other words differences in the way people learn bring about different - but not necessarily better or worse - learning outcomes.

An Eclectic Approach

The approach adopted for this study was an eclectic one and no single theoretical view of personality has been adopted. It was felt that an approach where useful tools or concepts were used freely without concern for theoretical dogma would be most appropriate.

This approach is not a particularly novel or unusual one since there is little unity in any of the areas of psychology. Attempts, like this one, to get to grips with a new area usually involve an initial period where there is a pragmatic search for dimensions of difference, which lead to useful results; and during which the investigator is prepared to cast his net very widely and use whatever methods and associated theory seem appropriate.

Thus, in this study extraversion-introversion, attention deployment and personal construct theory and various other concepts were used as and when they were seen to be useful. However care was taken that the use of various concepts and any theorizing was consistent with the basic theories or viewpoints from which they have been developed.

Plan of Study

Introduction

A dilemma that often confronts an experimenter is whether to collect a number of easily obtained measures from a large number of people, or whether to take measures that are more difficult or take longer to obtain, from a smaller number of people. This is a fairly crude statement of a very difficult problem for which there is no general answer. It is often pointed out that the use of large samples will ensure that a high level of confidence can be placed in any significant results obtained - eg McCall (1970). On the other hand it has also been noted that, if a large enough sample is taken it is possible to find statistically significant differences between almost anything, eg **Morrison and Henkel (1970).** Although there are, of course, techniques available for examining the magnitude of effects.

Small differences of relationships that are significant for a large sample size may prove to be of no value when considering individual instances; conversely data concerning a small sample may be unreliable and make little contribution to the understanding of general issues.

Many more 'pro' and 'con' statements can be put forward and serve to demonstrate that there is no general solution to the problem and each situation must be evaluated and a course of action pursued that is appropriate for that specific situation.

The study reported here was a rather detailed, 'nit-picking' inquiry. One of the aims of the study was to examine the possibility of making inferences about cognitive processes and of relating these to scores on standard psychological tests of personality. Because of the nature of the study which was in some ways a feasibility study and also because of the methods used for attempting to examine learning it was essential that the performance of each individual student was studied intensively and monitored very closely. Thus the study did not lend itself to data collection for large numbers of people.

In practice 14 learners were studied - the time and effort involved in data collection was extensive - probably more extensive than many large sample studies where it is possible to collect data from large groups all in one go. For this study something in excess of 12 man weeks was taken up purely on observing learners or administering tests. This figure does not include travelling time, preparation time, and so on. The total period of data collection for this study extended over 3 school terms and demanded the services of one experimenter/observer more or less full-time (the work was shared 50/50 between the writer and various other experimenters).

As already noted there are no universal advantages for the intensive study of small groups over less detailed study of larger groups but for this particular study, which is in practice a modest pioneering study, it was felt that the devotion of attention to individual students was the most appropriate way to proceed.

The intensive study of students only applies to their learning performance since this is the area where little is known about the nature of individual differences. Instruments used for measuring personality factors were with a few exceptions, standard psychological tests that can be administered fairly quickly (the longest must be administered on an individual basis and takes approximately one hour). Although it would have been possible to make a much more detailed and intensive study of personality factors this was not felt to be either necessary or justifiable bearing in mind the abundance of existing, easily administered tests and their reliability and validity. The potential usefulness of any findings was also felt to be enhanced if the personality measures were standard - thus only two measures were specially developed for this study.

General aims and overview of study

As already noted the investigations conducted were essentially opportunistic. The writer was given the opportunity to participate in studies using the INTUITION equipment and felt that the opportunity was worth taking and would provide a possible means of getting a better understandingof a number of areas of .interest. These areas of interest centred upon personality and learning. They included an interest in how cognitive processes can be exteriorised and studied and whether stable individual differences in learning strategies could be identified, measured and correlated with personality variables.

The general aims of the study reported here were:

1) To identify and assess the reliability of the possible indices of learning style that can be examined using the INTUITION equipment.

2) To generate hypotheses concerning the relationship between these indices and individual differences in personality.

3) To test the hypotheses generated at (2) above.

4) To examine relevant theoretical and methodological issues.

The INTUITION equipment has been fully described earlier. The equipment enables the experimenter to observe many characteristics of student behaviour:

1) Errors made.

2) Time taken on each node.

3) 'Aiming' behaviour.

4) 'Exploratory' behaviour.

5) Route taken through material.

It would perhaps have been possible to learn a good deal about the processes involved in learning by examining the relationship of these various parameters to each other and look for individual differences in the pattern of relationship between factors like errors, aiming activity and exploration. To do this on an 'ad-hoc' basis with five measures to examine would require larger numbers of students than are available for this study. The alternative procedure would be to engage in an investigation of the theoretical literature relevant to such measures and make 'a-priori' predictions. This would be a sensible approach if the principle aim of the study was to investigate learning behaviour alone. However, the purpose of this study was to investigate learning and 'personality' so that interest is not centred on learning as such. Thus no predictions concerning relationships between learning indices were made. The fact that no hypotheses were held concerning relationships between the various indices of learning style means that each could be considered separately and, in effect, treated as separate experimental data. In practice there may well be relationships between the various indices - and these were considered on an 'ad hoc' basis.

A series of separate 'sub-experiments'

In effect a number of separate experiments were conducted. The central aspects of the experiments were attempts to validate specific predictions concerning relationships between personality factors and indices of learning activity. However related issues such as the feasibility of studying 'internal' cognitive processes and the theoretical issues underlying the predicted interralationships have also been given extensive attention.

Four indices of learning activity have been examined:

- 'Aiming' activity
- Errors
- 'Exploratory' activity
- Route taken

The reliability and validity of these indices have been examined and attempts made to validate specific predictions. The investigations conducted are reported as follows.

Chapter 2 - Aiming, errors and personality.

Chapter 3 - Exploration and personality.

Chapters 4 and 5 - Route taken and personality.

The personality measures employed can be divided crudely into non-cognitive (eg the Eysenck personality inventory) and cognitive measures (eg cognitive complexity).

The work discussed in Chapters 2 and 3 examined non-cognitive personality factors, whereas the work described in Chapter 4 examined cognitive personality measures.

Chapter 6 provides a summary of work carried out, conclusions and a discussion.

Students worked on the equipment individually for sessions of $1\frac{1}{2}$-2 hours (ie a double or treble 40 minute period). The students were all 6th form pupils at the Grammar School and were all (unpaid) volunteers. The learning equipment was at the school from February-December 1974 (excluding holidays). During this time a total of 15 students worked on the equipment on an individual basis. (There were also some students working as groups, but they are not discussed in this thesis).

Students using the equipment normally attended on a regular basis, either once or twice a week for learning sessions*. Whenever a student worked on the equipment an experimenter/observer was present. This work was shared between the author (approximately 50% of the workload) and three others. As far as possible each student was assigned to a specific experimenter for the whole of his course. Table 3 shows the numbers of students completing the various modules of the course.

	Module 1	Student No	Module 2	Student No	Module 3	Student No
Number of students completing each module.	14	-1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -11 -12 -13 -14	10	-1 -2 -3 -4 -5 -6 -7 -8 -9 -10	2	-6 -7

Table 3 (Students completing the 3 modules)

* Footnote There were a number of missed sessions due to illness, school trips, the need to attend certain lessons etc....but frequency rarely fell below one session a week per student.

As table 3 shows all but one of the students completed module one. The student who did not complete module one appeared to find the equipment difficult to 'come to grips with' and was extremely nervous and withdrawn during the learning sessions. Her progress was extremely slow compared to the other learners.

One of the students who completed module one but not module two left school prematurely to take up full-time employment. The others who did not complete module two were still working on the equipment in December; at the end of December the equipment was no longer available for use at Henley Grammar School.

Only two students completed all three modules in the time available.

Tests Used

Personality tests

All of the students were given a battery of 'personality tests'. For the moment no explanation of test contents or administrative procedures will be given other than the title of the test, approximate time to administer and whether it is given in a group or individual setting. A thorough consideration of each test will take place at a later point when specific hypotheses concerning personality factors and learning behaviour are discussed. The tests used are listed below:

Group Tests

1) Eysenck Personality Inventory. Eysenck and Eysenck (1968) (20 minutes)
2) Cognitive complexity test. Bieri et. al. (1966) (40 minutes)
3) Tolerance of ambiguity test. Budner (1962) (15 minutes)
4) Test of self-consistency. Gergen and Morse (1966) (20 minutes)
5) **AH5 general ability test. Heim (1968). (40 minutes)**

Individual Tests

1) Attention deployment test. Mendelsohn and Griswold (1965) (30 minutes)
2) Industrial Relations (problem-solving) test. Developed specifically for this study. (50 minutes)
3) Information collection test. Developed specifically for this study. (40 minutes)

Two group testing sessions took place in June and November. Each student also attended an individual testing session where he was given the three individual tests. **All tests were administered by the writer.**

Summary

Main points in Chapter 1

- This study was an attempt to relate learning processes (not products) to personality factors.

- It made use of a sophisticated system to study students' learning activity. The system supplies the student with a topic map of the subject matter area and makes use of special techniques to exteriorise the learning strategies that students use to work through the material.

- The work conducted sought to complement work already done by studying the learning process and by making use of 'cognitive' and 'non-cognitive' personality factors.

- It was a study based on the intensive examination of the learning activity of a small number of students. This represents a considerable investment of time and effort in the data collection phase of the study (much more, in fact, than many studies of substantially larger samples).

- The study was conducted using a small group (N-15) of students from Henley-on-Thames Grammar School and data was collected over a period of one academic year.

- The major aims of the study were to identify and assess the reliability of possible learning style indices. To develop and test specific hypotheses relating these indices to personality characteristics. To study inter-relationships between the indices of learning activity on an 'ad-hoc' basis. To discuss relevant theoretical issues.

CHAPTER 2

TOLERANCE OF AMBIGUITY, EXTRAVERSION AND LEARNING ACTIVITY

Introduction

This chapter is concerned with relationships between personality factors and specific indices of learning activity. The indices of learning activity to be considered are:

i) "Appreciation span" - ie the distance between the topic that a student is working on and the topic he is aiming at.

ii) "Errors" - ie the errors made by students when attempting to demonstrate understanding.

These indices will be discussed more fully later and for the moment the general description of what they signify, given above, will be sufficient.

The behaviour of a student working on the INTUITION equipment can be considered on, at least, two levels. At the 'macro' level the way in which the student plans and organises his learning can be examined.

Measures relating to the topics chosen as aims, the topics explored and the route taken through the topics displayed are all macro variables and can be evaluated by recording how the student interacts with the topic-map, with no reference to what takes place when he actually attempts to come to understand specific topics.

By contrast, micro variables are concerned with what takes place when a student works on a particular topic and attempts to understand it. This distinction is, to some extent, an arbitrary one and also there are certainly levels other than the macro and micro categories mentioned here; nevertheless the distinction is useful.

The distinction helps to highlight the differences and similarities between the study reported here and other studies of the learning process. Most of the indices of learning to be examined here are macro variables and relate to the way in which a student plans and organises his learning of a complex body of knowledge made up of discrete, identifiable but interrelated topics.

Appreciation Span

The instructions given to students and the role of the aiming transaction in the learning procedure are dealt with in Chapter 1 and appendix (2).

Before a student is allowed to begin work on a new topic, as he progresses through the material, he is required to indicate his current aim.

The topic that a student chooses as his aim must be one that he does not yet understand. It is explained to the student that he is at liberty to choose an aim that is some distance away from his immediate goal, or alternatively his immediate goal and aim may be the same topic. For example when a student begins work on his first node the board could be as shown in Figure 1, Figure 2 or somewhere in between.

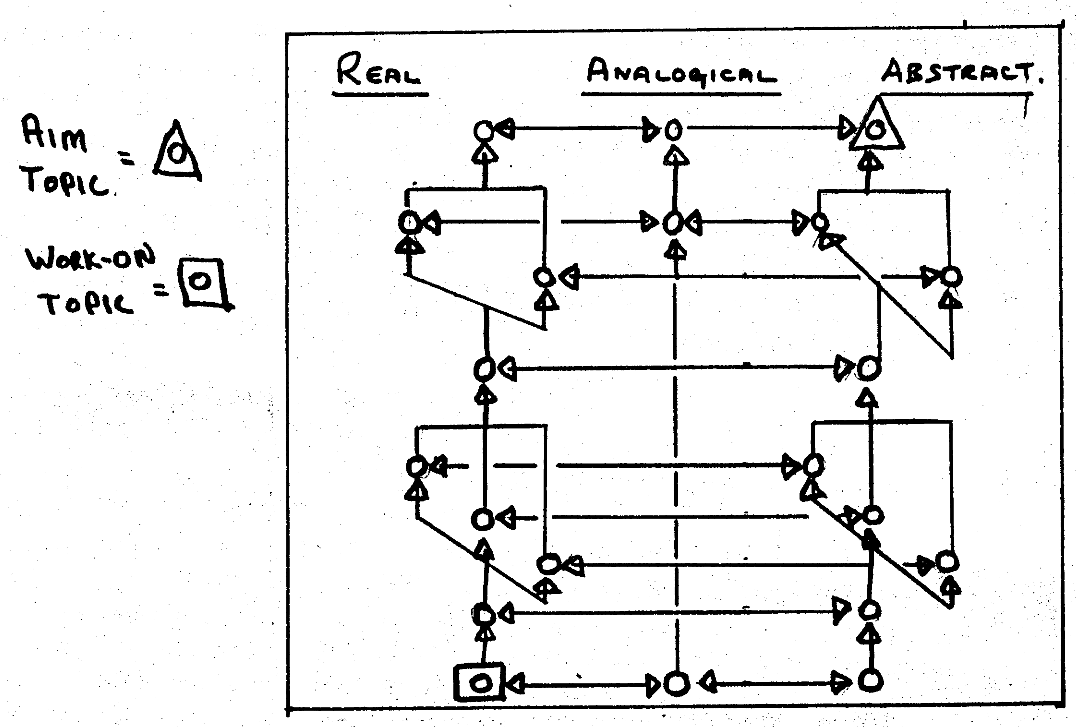

Figure 1. (Aim topic and 'work-on' topic far apart)

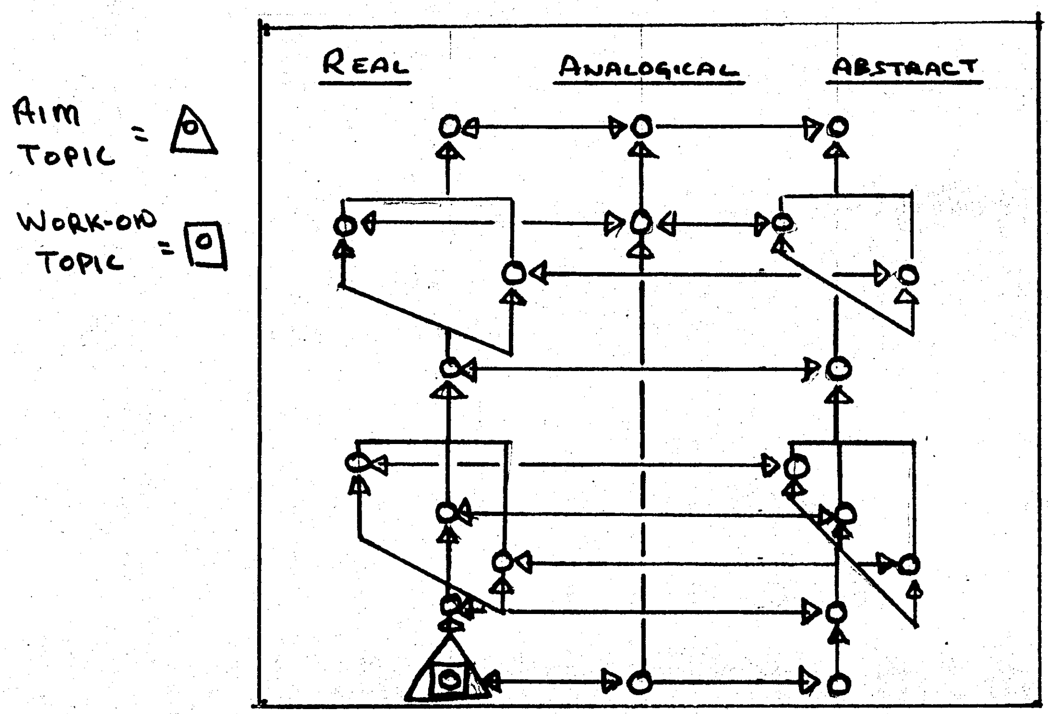

Figure 2 (Aim topic and 'work-on' topic are the same)

In figure 1 the student's 'aim' and 'work-on' topics are separated by the largest possible distance. Whereas in figure 2 the student is aiming at the very topic that he is currently working on. The 'distance' between the node that a student is working on and his aim has been termed the student's "appreciation span", Pask, Scott and Kallikourdis (1973), because it appears to represent the extent to which a student looks ahead and 'appreciates' topics ahead of those he is currently working on. (Whether this is so or not will be discussed later).

Pask, Scott and Kallikourdis do not go into the details of computing an index of appreciation span and the procedure described below was developed as a computational aid.

Computational Procedure for Appreciation Span

A value computed to express appreciation span should reflect the 'distance' between the topic currently being worked on and the topic being aimed at. To illustrate the procedure adopted module 1 of the three modules concerned with probability theory will be used as an example figure 3 shows module 1 using code numbers for topics.

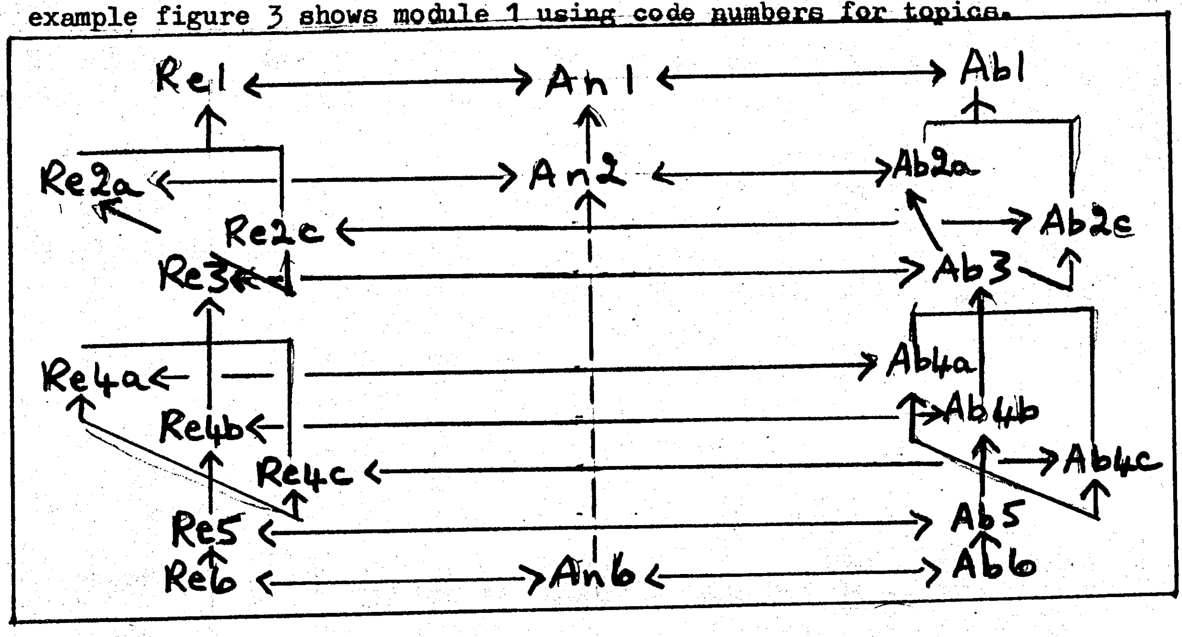

Figure 3 (Topic map for Module 1)

To compute a value for appreciation span the entailment structure for each module was divided up into a grid. The grid for module 1 is shown below in Figure 4 .

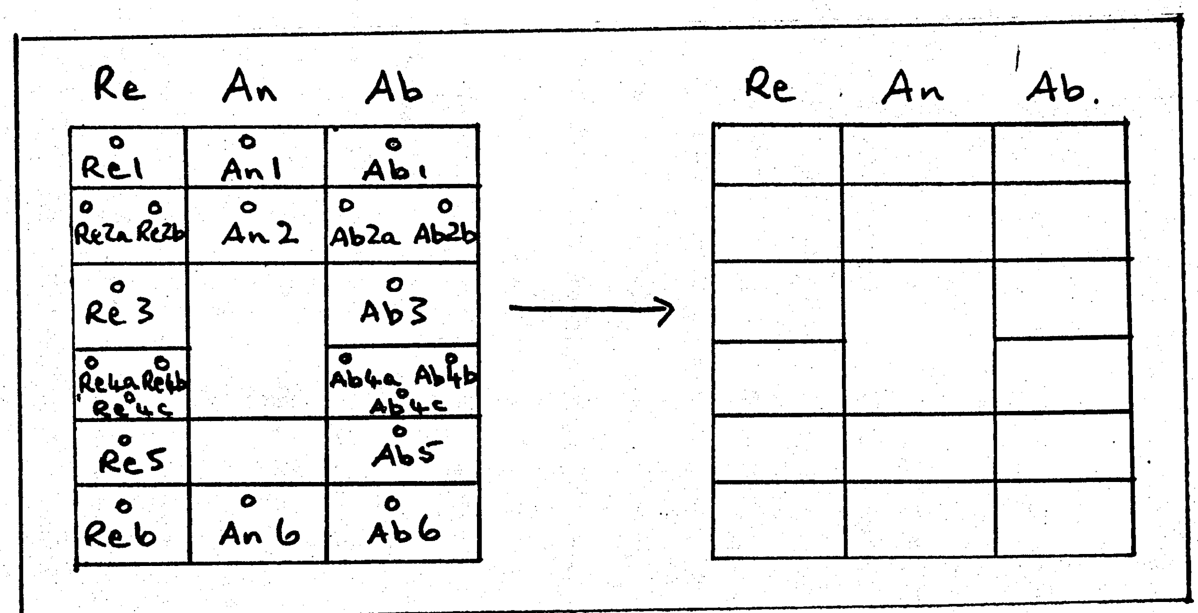

Figure 4. (Grid for computing appreciation span)

Using the grid, a value for appreciation span was computed by counting the minimum number of cells that a student must pass through to progress (legally) from his 'work-on' topic to his aim topic*.

Examples are given below:

Example 1

Aim topic = Re5

Topic being worked on = Re6

Topics already understood = None

This is shown on the grid as in Figure 5.

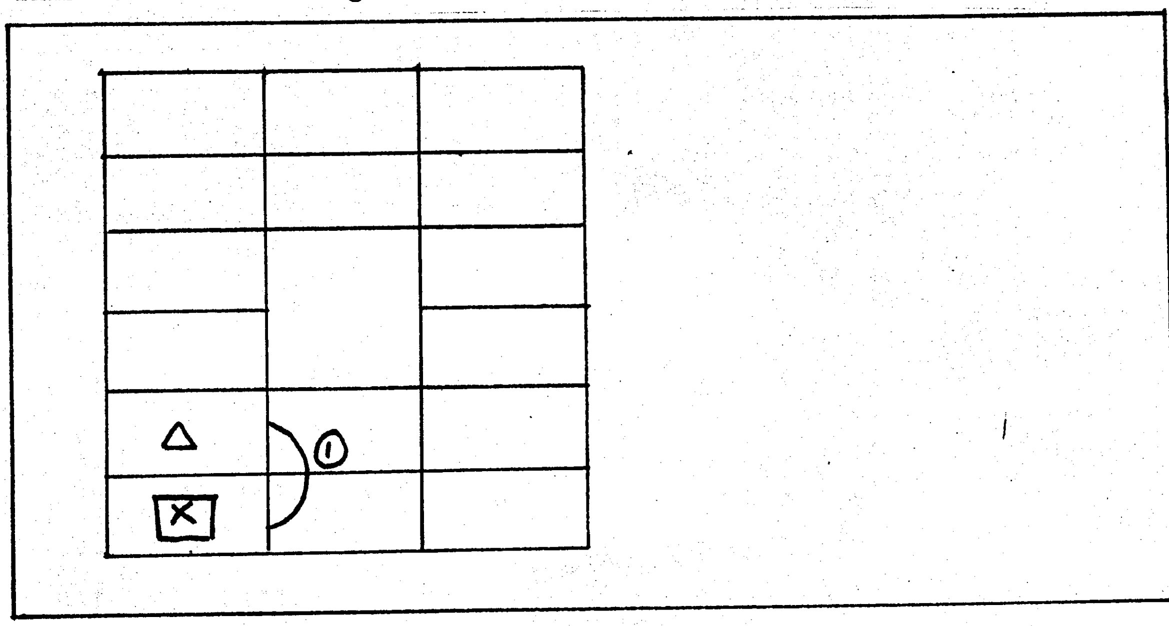

Figure 5 (Appreciation Span = 1)

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*Footnote: For computational purposes topics on the same vertical level and in the same semantic category were counted as one cell; eg Re4a, Re4b, Re4c. The cell was only classified as understood when all member nodes were understood. This seemed to provide a more realistic representation of how the students perceived the entailment structure. In practice (although absolute values are different) there is little difference between computing in this way and adopting an approach where each topic is considered separately, especially when mean scores for a whole module are computed (as they are for all statistical analysis reported in this thesis).

Example 2

Aim topic = Ab1

Topic being worked on = Re5

Topics already understood = Re6, An6, Ab6.

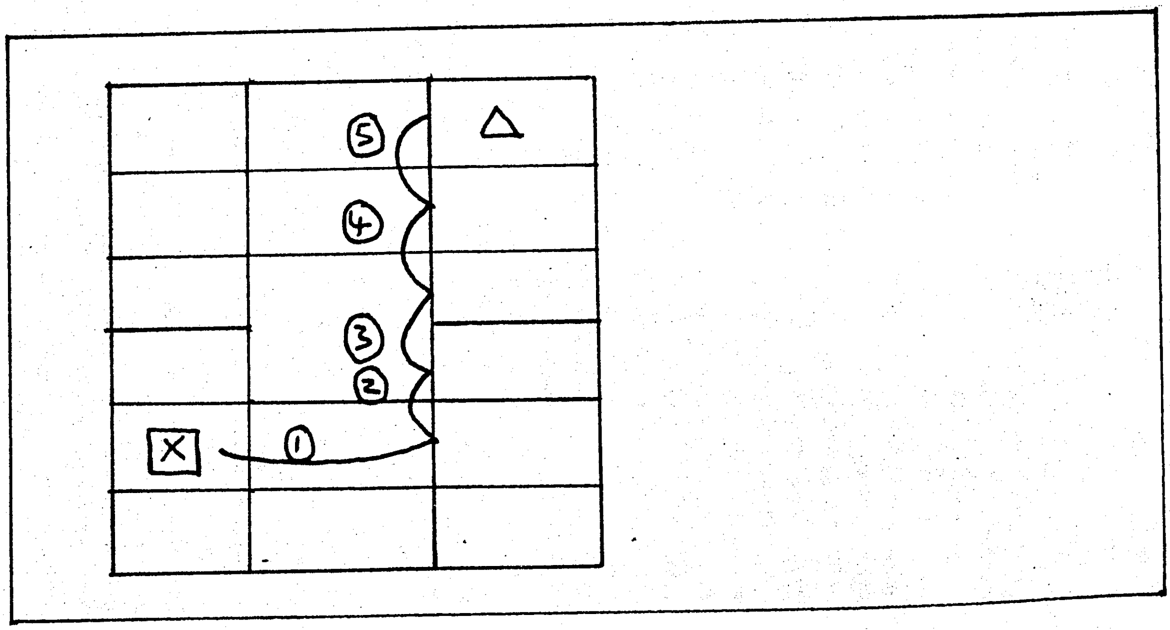

Figure 6 (Appreciation Span = 5)

In written introductory material (see appendix (2)) and in a separate verbal introduction the student is told how to use the aim plug. He is informed that he may aim for any topic on the board, as long as he does not already understand it, but that he should not aim for a topic that is meaningless to him. The aim topic should constitute an explicit indication of his future intentions.

Once a student begins work on the equipment he is given complete freedom to choose any aim that he wishes in the expectation that he will do so in accordance with instructions already given. From time to time when choosing a new aim students are reminded of the purpose of the aim transaction.

When learning new material, either by INTUITION or by some more conventional means such as a text book, learners frequently have opportunities to look ahead and plan their future activity by specifying (perhaps only to themselves), aims of one sort or another. It is a hypothesis worth considering that people differ in how much they choose to look ahead and plan their learning and that this difference represents a <u>general and consistent disposition on the part of individuals to plan ahead or not</u>. On the other hand it may be that planning of learning behaviour may vary greatly according to situational factors - such as subject matter, or it may be influenced strongly by momentary changes in mood or motivation, so that planning activity is fluctuating and inconsistent, not dependent on general traits or dispositions.

Reliability

The implication of this for the present study is that the reliability and consistency of aiming behaviour displayed by learners should be the first factor to be examined. It is likely that students will exhibit differences and similarities in aiming activity. Previous studies eg Pask and Scott (1972, 1973), Daniel and Dunn (1973) suggest that learners exhibit wide inter-individual differences together with highly stable intra-individual consistencies, such that people give a wide range of appreciation span values but each person fairly consistently chooses an aim far away from or near to his immediate goal throughout his learning. Previous results, however, have been obtained using the CASTE equipment and no data had been gathered relating to the INTUITION equipment used in this present study. Although there are many similarities between CASTE and INTUITION there are enough differences for students to behave very differently.

As already mentioned three modules of learning material were used in the present study. The reliability for appreciation span could be examined by correlating students values for this index across all three modules. (In practice most students only completed two modules and it only proved possible to correlate scores for two rather than all three modules). Secondly records may be inspected to check that within a module students consistently aim close to or far away from their immediate goal (an estimate of internal consistency).

These two procedures will supply evidence on the stablity and reliability of appreciation span as an index of learning behaviour, in this particular learning situation.

The record sheets at appendix (4) give a record of students progress through the learning material, showing topics worked-on and corresponding aims. Appendix (3) shows graphically the changes in appreciation span for each student. The ordinate represents the distance* between current node being worked-on and aim node. Thus the line plots each students' measured appreciation span as he progresses through the material. The crosses (X) indicate 'exploration' and will be referred to later at a more appropriate point. Inspection of these graphs and the recording sheets in appendix (4) reveal that students are consistent in the appreciation span that they exhibit. Some students, number 7 for example, seem to consistently set their aim some distance ahead - and slowly work towards it, having reached it they then specify a new aim, also some way ahead, and work towards that - and so on. Others such as number 3 or 5 settle down to aiming consistently at the immediate next node to be worked on. Others such as number 2 or 10 have a series of medium distance aims.

An average value for appreciation span may be calculated for each student on each module by dividing the sum of the student's appreciation span(ie compute a value for each node worked on - and sum) by the number of nodes worked on.

$$\text{Average Appreciation Span} = \frac{\text{App. Span at each node*}}{\text{Total nodes worked on}}$$

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* Calculated as shown earlier.

The reliability of this measure as an index of student learning activity may be assessed by examining student scores on modules 1 and 2.

The mean appreciation span for each student on Module 1 and 2 is shown below.

Student No	Appreciation Span (Module 1)	Appreciation Span (Module 2)
1	1.43	1.93
2	0.86	1.29
3	0.79	0.0
4	1.79	4.7
5	0.38	0.0
6	1.46	5.16
7	1.92	2.63
8	0.92	2.26
9	3.85	5.11
10	0.56	0.96
11	1.94	3.85 (almost complete)
12	1.11	-
13	0.0	-
14	2.14	-

Table 1 (mean values for appreciation span)

The product moment correlation coefficient for the students who completed both modules = 0.759 (N = 10)

$\therefore$ Spearman/Brown reliability coefficient for combined scores = 0.863

Thus, mean measured appreciation span is a consistent and reliable parameter and the combined scores for modules 1 and 2 will be reliable.

In order to combine scores for modules 1 and 2 standard z scores were computed for each module, added and divided by 2 to provide a combined score. These scores are shown in table 2.

Student No	Z Score
1	-0.1095
2	-0.5627
3	-0.9401
4	+0.8064
5	-1.1441
6	+0.7642
7	+0.3206
8	-0.2748
9	+1.9399
10	-0.7994

Table 2 (combined (Z) scores $\frac{\text{Mod 1} + \text{Mod 2}}{2}$

Thus the most reliable index of appreciation span is the combined standard scores for modules I and II (reliability = 0.863). To check for confirmation (or contra-indications) any statistics computed using the combined scores will also be computed using Module I scores only (N = 14).

Personality dimensions related to appreciation span

Having established that appreciation span has the property of reliability the next step is to consider what a high or low appreciation span might be an indication of.

The most immediately attractive point of view is that the greater a student's appreciation span, the further ahead he was looking, so that, for example, a student who consistently aimed at the node he was about to work on was not looking ahead at all. In other words a large appreciation span means that the student gave consideration to topics well in advance of his working region and understood how they related to other topics; whereas a student with a small appreciation span gave no consideration to topics ahead of his working region. Clearly the instructions given to students are designed to ensure that appreciation span does indicate this feature of student behaviour.

Discussions with students after they had completed the course and a close examination of student records revealed that appreciation span does appear to represent the extent to which students looked ahead..

More specifically, it indicates how far ahead they made specific plans concerning future activity.

When questioned at the end of the course students who had displayed a small appreciation span often claimed that as they worked through the course they did have some idea of what future topics were about but never entertained any specific plans concerning the order of working on future topics. Students with large appreciation spans, by contrast, often said that they had a clear idea of the eventual route that they would take and had an idea of the topics to be covered en route.

Possible reasons why Appreciation Span may not indicate planning

i) 'over-aiming'

There are two major errors that could have occurred and made appreciation span invalid as an indicator of how far ahead students made plans. Firstly, there is the possibility that a student could have aimed at a topic some distance from the topic being worked on, (ie displayed a high appreciation span) when he did not, in fact, have the required minimal understanding of his chosen aim, and thus it did not represent a realistic aim. Questioning and probing on the part of the experimenter/observer always ensured that at a very minimum each student could give evidence of how his aim node related to the node currently being worked on. It is possible that occasionally a student was unclear about the status of his aim in relation to other semantic categories on the entailment structure; but it is felt that as long as the student could relate his 'aim' to his 'work-on' node this was sufficient to prevent aims further ahead than a 'true-aim' being chosen. Thus 'over-aiming' is not seen as a significant source of error.

ii) 'Under-aiming'

Secondly, the reverse of the above may have happened and a student's true aim could have been further ahead than that indicated by his chosen aim node. Thus, although a student had a specific aim in mind (some distance ahead), for some reason he did not indicate that this was the case. Verbal reports have already been cited and indicate that students who displayed a small appreciation span did not entertain specific aims concerning future topics. More significant than these verbal reports is an examination of students' exploratory behaviour. Remember that students may 'explore' any topics on the map whenever they wish to, and receive a brief (2-3 line) outline of the topic.

If students were, in fact, entertaining 'real aims' some distance ahead of their 'stated aims' it would be expected that, at least occasionally, they would explore topics beyond their stated aims. If, however, exploratory behaviour normally took place within a region bounded by the stated aim node it is unlikely that a student's real-aim was further ahead than his stated aim. Figs 7 (a + b) show the alternative situations.

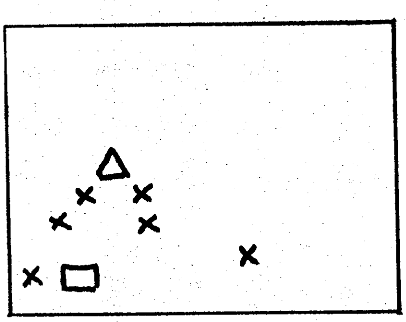

Fig 7 (a) (No exploration beyond aim)

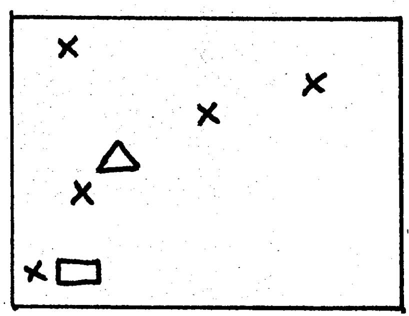

Fig 7 (b) (Some exploration beyond aim)

△ = Aim node

X = Explored node

□ = Work-on node

If the normal situation was that found in fig 7 (a) it is unlikely that 'real aim' was beyond stated-aim. On the other hand if students frequently explored beyond their aim node - as in fig 7 (b) it is possible that 'real aim' was beyond 'stated aim'.

Inspection of students' records shows clearly that students hardly ever explored topics beyond their stated aim except when exploring to select a new aim.

Thus the available evidence indicates that appreciation span is an index of the depth of specific forward planning that students engaged in.

This planning activity may be relatively situation-specific and although students show consistencies from one module to another, if the subject-matter or mode of presentation were changed the planning activity could also change. So that for one particular subject matter student 'X' may plan ahead rather extensively and student 'Y' may not plan ahead at all - but for another subject matter student 'Y' may plan ahead and student 'X' may not. Alternatively, the planning behaviour engaged in may be influenced by general dispositions and although situational changes have some effect student 'X' will consistently engage in more extensive forward planning than student 'Y'.

Which of these alternatives is the case is a question of some importance to the study reported here. In an attempt to resolve this problem, relationships between student behaviour on INTUITION and theoretically relevant personality characteristics will be examined.

The approach adopted will be to identify specific personality characteristics theoretically related to looking ahead and forward planning and examine the relationship of these characteristics to observed appreciation span.

Personality Dimensions related to looking ahead and Planning

Extraversion/Introversion

Eysenck has developed a theory concerning the structure of personality and the evidence in support of his theoretical viewpoint has been mentioned earlier. One of his major dimensions of personality is Extraversion/Introversion. Other writers, eg Cattell, identify similar dimensions. Eysenk discusses extraversion at both the physiological and behavioural level and has made strenuous, though not entirely successful, efforts to identify and interrelate individual differences at these levels of analysis. His theory is one of the more widely discussed conceptualisations of personality and as the discussion in an earlier section demonstrated has been much used by investigators studying relationships between learning and personality. It was also noted earlier that the majority of existing studies were product-centred. To identify a relationship between a variable, such as appreciation span and extraversion or introversion would be a significant step forward and could contribute to understanding the existing pattern of correlations between extraversion and academic achievement.

Eysenck(1967) describes extraverts and introverts and says that a typical extravert is 'impulsive, takes chances and acts on the spur of the moment', whereas an introvert 'tends to plan ahead , looks before he leaps, distrusts the impulse of the moment and likes a well ordered life'.

These statements suggest that a relationship between appreciation span (as an index of planning ahead) and extraversion can be expected. Eysenk asserts that introverts plan ahead whereas extraverts do not, thus it would be anticipated that extraverts would, in general, exhibit smaller values for appreciation span, than introverts.

A study not mentioned earlier but of particular interest here is one conducted by Shadbolt and Leith (1967), reported in Leith and Trown (1970). Shadbolt and Leith investigated the hypothesis that, "......teaching materials constructed so as to induce errors and to arouse ambiguity and uncertainty would favour extraverts , while carefully structured, clearly defined sequences of teaching material would give better results with introverts......". Their data supported the hypothesis.

Leith and Trown (1970) gave students 'structured' or 'unstructured' learning material. The structured material was a rules first condition; students were supplied with rules to "explain or cover the logic of practice examples". With the unstructured material students gradually developed an understanding of the rules. Degree of extraversion was related to the sort of material that students performed better with; extraverts being better with unstructured material. Leith and Trown (1970) discuss both of the studies mentioned above and suggest that extraversion/introversion is related to tolerance of ambiguity and structure, with introverts preferring unambiguous, well structured learning situations.

Tolerance of Ambiguity

The comments of Leith and Trown introduce the idea that tolerance of ambiguity, extraversion and learning preferences are interrelated. Their suggestion that introverts prefer unambiguous situations is in accordance with Eysenk's description of introverts as preferring 'a well ordered life' and seems to fit in well with their experimental data; however, extraversion/introversion can certainly not be considered as a 'pure' test of tolerance of ambiguity and a test developed by Budner (1962) can be used to examine this personality dimension more directly.

Strategic uncertainty

When a person is working on the INTUITION equipment, or is in any other situation where he is given a choice of route to take, he is faced with an element of strategic uncertainty, Pask and Scott (1973). This uncertainty is manifest every time he has to choose a new node to work on.

One possible way to reduce uncertainty is to look ahead early on in the exercise and plan a route. As with any planning, the activity of selecting an aim can reduce the range of possible immediate choices and thus reduce strategic uncertainty. By specifying an aim some distance away from his current position a person can reduce some of the uncertainty concerning future work.

When learners begin work on the INTUITION equipment they are faced with a totally new learning environment and the prospect of working through a large number of strange and unfamiliar topics.

From the student's eye view this may appear to be a highly unstructured and ambiguous situation. Students who are unhappy with ambiguous, uncertain, non-directive situations may well wish to make attempts to impose direction and structure and to reduce uncertainty. Budner (1962) has suggested that individuals who are intolerant of ambiguity may react in different ways to reduce it, and has devised a scale to measure general intolerance of ambiguity. Intolerance of ambiguity is defined by Budner as 'the tendency to perceive (ie interpret) ambiguous situations as sources of threat'. He suggests that the important features of ambiguity are novelty, complexity and insolubility.

Learners who obtain a high score on Budner's scale (ie who are intolerant of ambiguity) should, when confronted with a learning environment such as INTUITION, characterised by novelty and complexity, perceive it as threatening. Reaction to this threat would be dependent on opportunities available for reducing or avoiding ambiguity. As already noted Students may attempt to reduce ambiguity and uncertainty by planning ahead. This implies that students with low tolerance of ambiguity will tend to plan ahead more extensively than students who are tolerant of ambiguous situations.

Problematic uncertainty

Pask and Scott also discuss another kind of uncertainty known as 'problematic uncertainty'. This refers to the extent to which a student is uncertain - not about the order in which he will work through a set of topics, but about the topics themselves and the subject-matter that they are concerned with. Problematic uncertainty may be reduced in many ways. In a sense, learning can be seen as a reduction of problematic uncertainty and any student must (by definition) be uncertain about topics that he does not fully understand. Thus one way to reduce problematic uncertainty is to learn about the topic in question. However, there are many topics that people do not understand - but this does not make them feel uncertain. For example most people are uncertain about the origin of the universe - but this uncertainty only becomes apparent when they give some consideration to the incomplete knowledge that they do possess concerning the origin of the universe. Thus, for most people the uncertainty that exists about certain topics, although statistically legitimate is psychologically meaningless since the uncertainty becomes apparent only when consideration is given to the topics not understood. Thus students may avoid or simply fail to notice problematic uncertainty by not considering topics, ie they do not perceive or interpret the source of threat.

Because problematic uncertainty can be resolved in different ways, it is often difficult to say whether particular activity will result in an increase or decrease in uncertainty. For example, when a student 'explores' a node he may be searching for information to reduce his uncertainty, alternatively he may be extending his uncertainty by considering a previously ignored topic. More generally, people can come to recognise, by "having a go" at something, that they are more ignorant than they thought...

Similarly, when a student reduces his "strategic" uncertainty by planning ahead he may bring to his attention previously ignored topics and increase his problematic uncertainty.

Because of these difficulties it is not possible to derive hypotheses involving consideration of uncertainty in general. Attention must be confined to strategic uncertainty.

It is hypothesised that students who are intolerant of ambiguity will display higher values for appreciation span than students who are more tolerant of ambiguity. This will be done in order to reduce strategic uncertainty.

Hypotheses concerning Appreciation Span

Although reasons have been given for questioning the validity of appreciation span, it is probable that this measure is both a reliable learning style index and a valid measure of the extent to which a student plans ahead. Data obtained have already been used to examine the consistency and reliability of appreciation span, and experimental hypotheses predicting relationships between appreciation span introversion and intolerance of ambiguity are given below:

The following hypotheses were tested:

Hypotheses 1

Low scorers (ie introverts) on the extraversion - introversion scale of the EP1 tend to exhibit higher values for appreciation span than high scorers (ie extraverts).

Hypothesis 2

High scorers (ie intolerant of ambiguity) on the Tolerance of Ambiguity scale tend to exhibit higher values for appreciation of span than low scorers (ie people who are more tolerant of ambiguity).

Both of these hypotheses represent predictions that students with certain personality characteristics will plan further ahead than students who do not have, or exhibit less of, the relevant personality characteristics.

Before considering these hyptheses in further detail, some discussion of errors made by students will take place.

Errors

The sequence of events involved when a student works on INTUITION has already been described (Ch 1) and it was noted that before any topic can be classified as understood the student must pass a test of his understanding of the content of the topic. In the learning sessions described in this thesis the test of understanding was administered by the appropriate experimenter/observer with the aid of 'command sheets' and 'check sheets'. The command sheets list a series of commands that require the student to carry out practical exercises using the modelling facility (STATLAB). The check lists describe the STATLAB configurations constituting a correct and complete carrying out of the command. Typical command and check list sheets are shown in appendix (5).

If a student failed to carry out any of the commands correctly an error was recorded on the record sheet. When a student failed he had the option of returning to the tutorial material for revision or attempting the test again immediately.

The complete set of record sheets are shown at appendix (4). Errors were recorded on a binary basis. If a student made no errors at all when demonstrating his understanding an error score of '0' was recorded for the relevant topic. If on the other hand a student made one or more errors an error score of '1' was recorded for the topic. This method for recording errors was as sensitive as conditions allowed. Once a student had made an error on a topic the experimenter/observer would offer advice on what he should do (eg go back to a specific part of the text) or he would try to help the student with a verbal explanation. To allow the student to continue completely unaided and merely record subsequent errors would probably have been better from a measurement point of view but would probably have resulted in a number of frustrated and annoyed students dropping out of the experiments.

Thus, an error was recorded each time a student failed to give a completely satisfactory response. A brief note of the exact nature of the error was also made. The proportion of errors made by students on modules 1 and 2 is shown below:

Student No	Module 1 $\frac{\text{No. errors}}{\text{No. topics}}$	Module 2 $\frac{\text{No. errors}}{\text{No. topics}}$
1	0.0	0.0
2	0.1	0.0
3	0.12	0.04
4	0.19	0.0
5	0.0	0.0
6	0.0	0.0
7	0.15	0.0
8	0.08	0.0
9	0.0	0.1
10	0.125	0.15
11	0.06	-
12	0.0	-
13	0.25	-
14	0.0	-

Table 3 (Errors)

There is a clear decrease in errors from module 1 to module 2 and this probably represents students' adaptation to the equipment. Predictions (to be made later in this chapter) concerning personality correlates of errors are mostly concerned with the effect that a novel, unstructured and ambiguous learning environment will have on students of different personalities. Any relationships will be much more likely to be visible when the students first interact with the material, ie during module 1 rather than module 2.

It would be inappropriate to attempt to combine scores for 1 and 2 in any way and any subsequent computation will treat data for the two modules separately.

Personality Dimensions related to Errors

Discussion of personality correlates of learning has, so far, concentrated on a 'macro' index of learning - appreciation span.

In a study quoted earlier Leith and Trown found that Extraverts performed better than Introverts on unstructured material and hypothesised that this was due to differences in tolerance of ambiguity. The predictions made earlier concerning appreciation span assume that students will take action and attempt to reduce or avoid ambiguity whenever possible. Such predictions were not directly derived from Leith and Trown's work, which is more directly relevant to activity at the 'micro' level.

Leith and Trown suggest that learning performance and degree of structure in the learning situation are related to tolerance of ambiguity (and hence extraversion), the essence of their findings being the relationships between personality characteristics and errors (extraverts make less errors on unstructured complex material). At the 'micro' level the teaching material associated with INTUITION has some of the characteristics of ambiguous situations described earlier, ie novelty, complexity and insolubility.

When students begin work on a particular topic they are not supplied with specific instructions telling them what to do but are simply given access to main text and demonstration materials. They must decide for themselves how best to make use of this material and decide, for example, how much, if any, of the demonstration material to use. The main text does, in fact, supply a specific statement of the essential rules to be learned, but invariably the student will have to conduct considerable further investigation, problem solving and 'discovery-learning' before grasping the rules well enough to pass the test of understanding. Thus the learning involved is not simply a case of internalizing clearly stated rules by rote, or similar methods; the student is forced to develop his understanding by an open-ended, discovery -based approach. Thus, when working on any specific topic students are in an unstructured ambiguous learning situation.

In practice the ambiguity in the situation may be less threatening than it might be because of the lack of time pressure on the students, since ambiguity is probably much more threatening and difficult to cope with when it has to be dealt with quickly.

The previous work quoted has already shown that extraverts are likely to learn more successfully than introverts in ambiguous situations and the suggestion has been raised that this is due to higher tolerance for ambiguity on the part of extraverts. On that basis the following predictions could be made.

1) High scorers (ie extraverts) on the EPI will make less errors than low scorers.

2) Low scorers (ie tolerant of ambiguity) on the Budner tolerance of ambiguity test will make less errors than high scorers.

When working on INTUITION students decide for themselves when to attempt tests of understanding. It might be expected that extraverts would behave impulsively and tend to opt to take this test of understanding at too early a stage, before they fully understand the topic. Such a tendency would be reflected in the comparative error rates of extraverts and introverts. Extraverts would make more errors than introverts.

This prediction contrasts with the one made earlier stating that extraverts and people who were tolerant of ambiguity would make less errors than introverts. Also consistent with this alternative point of view is the expectation that introverts would behave cautiously and thus tend to make less errors.

Because of these conflicting expectations it is not sensible to put forward an unambiguous hypothesis concerning the direction of relationship between extraversion and errors. The null hypothesis that there is no relationship will be examined and any correlation found will be discussed in the context of other relevant results. This amounts to testing the validity of the null hypothesis that there is no relationship between extraversion and errors.

A specific hypothesis concerning the relationship between tolerance of ambiguity and errors can be made.

Hypotheses concerning errors

Thus two hypotheses will be considered.

Hypothesis 3

This is the null hypothesis that there is no relationship between degree of extraversion/introversion and errors.

Hypothesis 4

Low scorers (ie tolerant of ambiguity) on the Budner tolerance of ambiguity test will make less errors than high scorers.

In addition a positive relationship between extraversion and tolerance of ambiguity is expected.

Ability

The individual difference dimension most frequently used to account for or 'explain' differences in learning is that of general intelligence. Any alternative dimension must compete with 'g' as an explanatory concept and the most useful additional dimensions will be ones that are unrelated to 'g' and thus offer additional explanatory or predictive power. Bearing this in mind the AH5 test of general ability was included in the battery of tests given to students taking part in the experiments described in this thesis. Results from this test could be used to estimate the degree of overlap between ability and the various other factors considered.

Analysis of Results

Hypothesis 1

This concerns the relationship between extraversion/introversion and appreciation span. Relevant data is given below (see p39-42 for details of how appreciation span scores are derived).

Student No	Module 1 (mean score)	Module $(\frac{1+2}{2})$ (z)Score	EP 1 Score
1	1.43	-0.1095	19
2	0.86	-0.5627	17
3	0.79	-0.9401	19
4	1.79	+0.8064	12
5	0.38	-1.1441	12
6	1.46	+0.7642	15
7	1.92	+0.3206	7
8	0.92	-0.2748	20
9	3.85	+1.9399	18
10	0.56	-0.7994	11
11	1.94	-	12
12	1.11	-	13
13	0.0	-	5
14	2.14	-	22

Table 4 (Appreciation Span and Extraversion/Introversion)

The hypothesis states that extraversion will be negatively related to appreciation span, ie extraverts will show smaller appreciation spans than introverts.

(Mod 1 + 2) pearson product moment r = +0.005 (N = 10)

(Mod 1 only) pearson product moment r = +0.33 (N = 14)

Thus the data do not support the hypothesis.

Hypothesis 2

This concerns the relationship between appreciation span and tolerance of ambiguity. Relevant data is given below.

Student No	Module 1 (mean score)	Module $(\frac{1+2}{2})$ (Z) score	Tolerance Ambiguity score
1	1.43	-0.1095	38
2	0.86	-0.5627	56
3	0.79	-0.9401	40
4	1.79	+0.8064	47
5	0.38	-1.1441	37
6	1.46	+0.7642	49
7	1.92	+0.3206	42
8	0.92	-0.2748	43
9	3.85	+1.9399	52
10	0.56	-0.7994	52
11	1.94	-	51
12	1.11	-	44
13	0.0	-	51
14	2.14	-	34

Table 5 (Appreciation Span and Tolerance of Ambiguity)

The hypothesis states that intolerance of ambiguity will be positively related to appreciation span (ie a positive correlation between the sets of soores).

(Module 1 + 2) pearson $r = +0.36$ $(N = 10)$

(Module 1) pearson $r = +0.05$ $(N = 14)$

It was felt that (although there are high positive correlations for appreciation span scores on modules one and two) students may take some time to arrive at a stable level of appreciation span and hence the relationship between tolerance of ambiguity and appreciation span would be more visible on later modules. With this possibility in mind data for Module Two only was also examined.

Pearson (product-moment) $r = 0.40$. $(N = 10)$

Thus the data relevant to hypothesis 2 shows differences in the predicted direction but not at an acceptable level of statistical significance (ie $p < .05$).

Hypothesis 3

This concerns the relationship between tolerance of ambiguity and errors.

The hypothesis states that low scorers on the tolerance of ambiguity scale will make less errors than high scorers.

The relevant data is shown below:

Student No	Tolerance of Ambiguity score	Error Score ie $\frac{\text{No errors}}{\text{No topics}}$	
		Module 1	Module 2
1	38	0.0	0.0
2	56	0.21	0.0
3	40	0.14	0.04
4	47	0.14	0.0
5	37	0.0	0.0
6	49	0.0	0.0
7	42	0.15	0.0
8	43	0.08	0.0
9	52	0.0	0.1
10	52	0.125	0.15
11	51	0.06	-
12	44	0.0	-
13	51	0.25	-
14	34	0.0	-

Table 6 (Tolerance of Ambiguity and Errors)

Module One

Pearson (product-moment) $r = \underline{\underline{+0.46}}$ $(N = 14)$

$(p < .05)$ one-tail test

Module Two

Pearson (product-moment) $r = \underline{\underline{+0.43}}$ $(N = 10)$

$(p < .1)$ one-tail test

Thus, the data for module 1 supports the hypothesis and the data for module 2 shows a trend in the predicted direction but does not reach an acceptable level of statistical significance.

Extraversion and Errors

The relationship between extraversion-introversion and errors was also examined.

The relevant data is shown below:

Student No	EP1 Score	Errors Score ie $\frac{\text{No errors}}{\text{No topics}}$	
		Module 1	Module 2
1	19	0.0	0.0
2	17	0.21	0.0
3	19	0.14	0.04
4	12	0.14	0.0
5	12	0.0	0.0
6	15	0.0	0.0
7	7	0.15	0.0
8	20	0.08	0.0
9	18	0.0	0.1
10	11	0.125	0.15
11	12	0.06	-
12	13	0.0	-
13	5	0.25	-
14	22	0.0	-

Table 7 (Extraversion/Introversion and Errors)

Module One

Pearson (product-moment) r = -0.49 (N = 14)

(p < 0.1) 2-tailed test.

Module Two

Pearson (product-moment) r = +0.05 (N = 10)

Relationship between EP1 and Tolerance of Ambiguity

It was noted earlier that a positive correlation between extraversion and tolerance of ambiguity was expected, ie a negative correlation between the two sets of scores. Analysis of the appropriate data reveals a positive correlation.

Pearson (product-moment)r = -0.35 (N = 14)

It has been noted, eg Eysenck and Eysenck (1963), Farley (1970) that extraversion has two components; sociability and impulsiveness. Thus it could be argued that it would be the impulsiveness component of extraversion that would relate to planning ahead and the observed lack of relationship found here is due to the contaminating influence of the inventory items concerned with sociability.

According to this point of view a relationship between EP1 scores and appreciation span should be apparent if only those items in the EP1 that relate to impulsiveness are considered. Using the source quoted above to identify the relevant items an impulsiveness score was computed. The following correlations were obtained.

	Appreciation Span	
	Module 1	Module $\frac{1+2}{2}$
EP1 (impulsiveness score)	+0.02	- 0.02

	Errors	
	Module 1	Module 2
EP1 (impulsiveness score)	-0.48	+0.2

Table 8 (Impulsiveness, Appreciation Span and Errors)

Ability

Relationships between the AH5 test and other measures were also examined. Student scores on the AH5 are given below followed by a correlation matrix.

Student No	AH5 score	Student No	AH5 score
1	38	8	32
2	40	9	21
3	46	10	38
4	48	11	45
5	44	12	41
6	48	13	34
7	37	14	42

Table 9 (AH5 scores)

	Appreciation Span		Errors	EP1	Tolerance of Ambiguity
	Module 1	Module 2			
AH5	-0.38	-0.44	+0.001	-0.06	-0.235

Table 10 (Correlations of AH5 with other measures)

Discussion of Results

APPRECIATION SPAN

Two predictions concerning personality correlates of appreciation span were made. These predictions concerned the relationships between appreciation span, extraversion and tolerance of ambiguity.

1) Extraversion

According to theory introverts should plan ahead more than extraverts. The technique used to measure appreciation span when people work on the INTUITION equipment represents an attempt to 'exteriorise' individual differences in planning ahead, and the available evidence has indicated that appreciation span is an indicator of the degree to which individuals generate specific future aims and plans of action. Thus a relationship between extraversion-introversion and size of appreciation span was predicted. Such a relationship is not apparent in the data for this study.

The hypothesis tested was that the distance ahead that a student planned(ie mean value of appreciation span) would be related to extraversion-introversion. This hypothesis was not supported by the data; it is however possible that ah alternative hypothesis, that the intensity rather than distance of forward planning is related to extraversion-introversion, could be valid - though the data collected here provides no opportunity to test this.

It cannot be assumed that people with a small appreciation span are not planning ahead at all, merely that they are not planning a long distance ahead. Indeed it is quite possible that people with a small appreciation span are planning ahead very cautiously and thoroughly - but over a short distance. Thus the data obtained here can be used to illuminate and develop Eysenck's description of typical extraverts and introverts.

The results show that introverts do not plan a greater distance ahead than extraverts. If then, as Eysenck claims, introverts do plan ahead more than extraverts they must do so more cautiously and thoroughly over a short distance - rather than actually planning further ahead.

The lack of support for the original hypothesis should, however, still provide a note of caution for workers studying personality and learning. Numerous investigations, cited earlier, have indicated relationships between extraversion and attainment. This study shows how difficult it may be to explain those relationships. It demonstrated that introverts and extraverts do not behave as might initially be expected when a widely accepted description of their behaviour is used to generate predictions and that existing descriptions are perhaps a little too general and lack specificity.

Situational Factors

There is a continuing and incomplete debate concerning the relative importance of person versus situation variables in psychology. The debate goes back at least as far as the work of Hartshorne and May (1928) who demonstrated the situation specificity of honesty. More recently authors have been suggesting an interactionist approach where both sets of variables are considered, eg Mischel (1973), Bowers (1974), Argyle (1975). This debate is discussed further in Chapter 6. It may be that in the current experiment situationally dependent factors have outweighed the effect of the stable personality disposition in question. One of the potentially strongest situational variables in any learning situation is 'difficulty' and there is some ad-hoc evidence to suggest that the difficulty level of the material may have exerted moderating influence on appreciation span.

Ad-hoc analysis reveals a negative correlation between Appreciation Span and errors.

Pearson (product-moment) $r = -0.38$ ($N = 14$)
($p < .2$) 2-tailed

This is not a strong relationship but is in accordance with the possibility that students who experience difficulty with the material will tend to operate with a small appreciation span.

The analysis of students' errors (to be discussed fully in the next section) showed that introverts made <u>more</u> mistakes than extraverts. Thus there could be competing, contradictory influences on students' appreciation span scores. On the one hand students with appropriate characteristics (ie introverts) may, as predicted, be stimulated to plan further ahead but these same students make more mistakes and this may tend to encourage them to limit their appreciation span.

To summarize, there is then no evidence that an individual's degree of extraversion (as measured by the EP1) bears any relationship to the index of learning studied (appreciation span). This lack of relationship could occur because the effect of underlying personality factors is masked by situational variables. Ad-hoc analysis has suggested that when students experience difficulty with complex learning material this may tend to limit the extent to which they plan ahead. It appears, however that introverts do not necessarily plan <u>further</u> ahead than extraverts and any significant differences in planning may be related to the intensity or thoroughness of planning rather than distance.

2) Tolerance of Ambiguity

It was hypothesised that students who were intolerant of ambiguity would exhibit high values for appreciation span.

The results obtained offer little support for the hypothesis. It was suggested that it may take some time for a relationship between tolerance of ambiguity and appreciation span to become apparent and the results do show an apparent change from module one to module two, but this seems due to the different group of students used when results for modules one and two are examined, rather than the increased influence of tolerance of ambiguity. Even when examined in the most favourable way (ie module 2 only) the results do not reveal a relationship of acceptable ($P < .05$) statistical significance. There are a variety of factors that may account for this.

One possibility is that the measures used lack validity or reliability. The reliability and validity of appreciation span has already been discussed and appears to be satisfactory. Evidence concerning the reliability and validity of Budner's scale is reported by Robinson and Shaver (1970). Significant correlations with other tolerance of ambiguity scales and validity studies involving inter-judge agreement on ratings of respondents intolerance of ambiguity support the validity of the scale. Budner (1962) reported a series of reliability coefficients for 16 different samples (total N = 932). The mean reliability coefficient = (0.49).Reliability coefficients were computed using Cronbach's alpha formula (Guilford 1954) which often produces slightly lower coefficients than the more normal split-half or test-retest technique. A 17th sample (N = 15) produced a test-retest correlation coefficient of 0.85.

Thus, the reliability of the test may be a little low but is by no means unacceptable.

It is important to notice that the hypothesised relation between tolerance of ambiguity and appreciation span requires the student to actively and consciously attempt to reduce ambiguity by planning ahead. The control of ambiguity may not be a particularly strong spur to behaviour, indeed Budner makes a remark to this effect based on patterns of inter-correlations that he obtained. Thus students may not make particularly strong efforts to <u>control</u> the degree of ambiguity in a learning situation and its influence may be difficult to detect. However, this is not to say that intolerance of ambiguity is unimportant in the learning situation. The relationship between errors and intolerance of ambiguity (to be discussed in the next section) is evidence of this. The potential influence of situational factors on appreciation span was raised in the preceding section dealing with extraversion-introversion and their significance is no less when considering appreciation span and tolerance of ambiguity. However, perhaps most important of all is the possibility that tolerance of ambiguity may be related to an aspect of planning behaviour not revealed by measuring appreciation span.

Appreciation span is an index of the distance of forward planning engaged in and it was hypothesised that to reduce ambiguity students would plan further and further ahead. The results have shown that this does not seem to happen to any significant extent. It may be that reduction in abmiguity is related not to <u>depth</u> of planning (as hypothesised) but to <u>intensity</u> of planning. This would mean that to reduce ambiguity a student would not necessarily plan further ahead - but that any planning he did conduct would be very efficient and conducted with great thoroughness to eliminate uncertainty.

On this basis the hypothesis would be that students who are intolerant of ambiguity will reduce ambiguity by planning ahead more intensely or carefully. The data collected in the current study are not appropriate for testing this hypothesis and to do so would require a separate study and the development of a technique for measuring intensity of planning.

To summarise, tolerance of ambiguity is not strongly related to the distance ahead of forward planning that learners engage in. There may be a weak relationship that could be identified by using a fairly large sample and long learning times but the possibility may not warrant further study. It may be worth investigating the relationship of tolerance of ambiguity and intensity of planning but this will require investment in the development of new measuring techniques. Further discussion of the results takes place in Chapter 6.

ERRORS

Two hypotheses concerning errors were investigated. One was the null hypothesis that there would be no relationship between extraversion/introversion and errors.

It was also hypothesised, mainly on the basis of previous work reported by Leith and Trown (op. cit.) that people who were tolerant of ambiguity would make less errors than people who were not.

1) Extraversion

The results for Module 1 indicate that degree of extraversion is negatively related to errors made so that extraverts made less errors than introverts. The results for Module 2 do not indicate any relationship - but these results must be viewed with caution since only 3 out of 10 students made any errors at all on Module 2.

The results are most closely in accordance with the hypothesis that when students are in a novel, ambiguous and uncertain learning situation introverts will be more inhibited and perform less effectively than extraverts. As time passes the effect of novelty and uncertainty would be expected to decrease and differences between students become less apparent. The decrease in errors from Module 1 to Module 2 supports this suggestion. The alternative hypothesis raised earlier that extraverts will behave impulsively and opt to take the test of understanding at too early a stage is not supported by the data. In fact the results concerning the impulsiveness scores on the EP1. parallel the results obtained for scores on the scale as a whole, indicating that students who are impulsive ie extraverts, (according to the EP1) made <u>fewer</u> errors. A closer examination of the conditions under which errors were made also helps to explain the data.

A distinction can be made between,

a) informative errors, and

b) punitive errors which act as penalty points.

Students will have realised, fairly quickly, that as far as work on INTUITION was concerned making errors was informative, rather than punitive. Thus the anticipated caution that introverts would normally be expected to display (in comparison with extravert's impulsiveness) may not have been so noticeable because of the non-punitive, possibly sometimes even positively valued nature of error making.

<u>Differences in test performance</u>

There is a potential explanation of the observed relationship that should be considered. This is that the differences in errors are due to differences in performance in the test situation, rather than in the learning attainment. It could be that extraverts and people who are tolerant of ambiguity did not actually learn the material more effectively, but that when they were placed in the (possibly stressful) test situation they were able to display their understanding more effectively.

On balance this explanation seems less likely than the alternative that error rates were caused by differing learning performance. As already noted, the test situation was kept fairly informal and as far as possible a non 'test-like' atmosphere was created, reducing stress to a minimum. Students were told that there was no 'penalty' involved in failure and that the test was given as much for the positive purpose of helping them as for any other reasons.

2) Tolerance of Ambiguity

It was hypothesised that students who were intolerant of ambiguity would make more errors than students who were tolerant of ambiguity. The results provided some support for the hypothesis.

The pattern of relationships between the three measures used is of some importance when considering and interpreting the results obtained. Two possible extreme patterns underlying the observed correlations are shown in Fig (8).

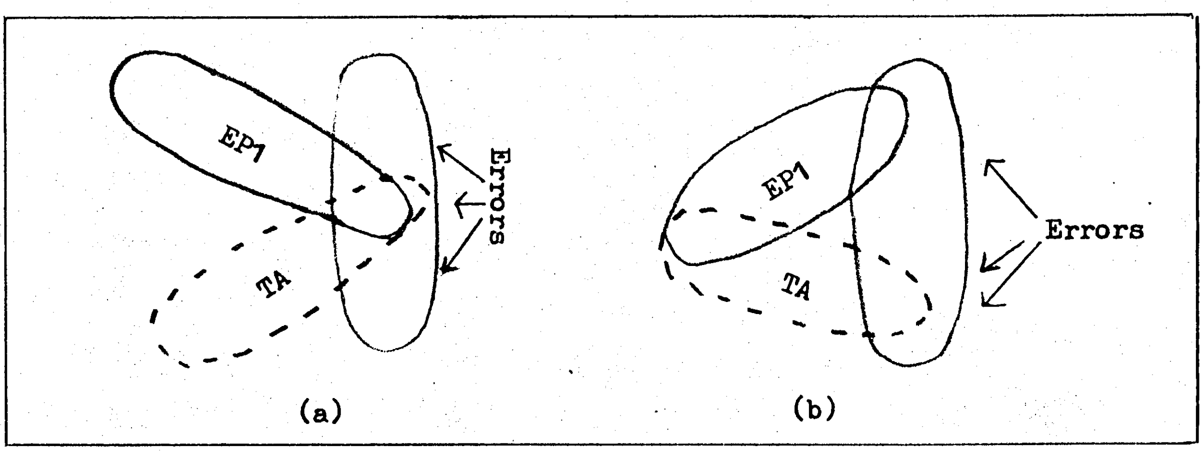

Figure 8 (Venn diagrams showing possible patterns of relationship).

The observed correlation coefficients could have been obtained under either circumstances. The difference between the two situations is considerable; in 8(a) introversion and intolerance of ambiguity relate to errors 'for the same reason'; whereas in 8(b) they are independently related to errors. The actual state of affairs could be in accordance with extreme (a), (b) or lie anywhere in between.

It is conjectured that the pattern of relationships is likely to be in accordance with, or at least closer to, Fig 8 (a) than Fig 8 (b), since this pattern is in agreement with the earlier discussion of the relationship between introversion, tolerance of ambiguity, and degree of structure in a given learning situation; ie introverts are less tolerant of ambiguity than extraverts and in an unstructured, ambiguous situation will tend to experience learning difficulties. and make less errors.

This conjecture is made tentatively since, as shown, the observed correlation coefficients could have been obtained with a very different pattern of relationships. The tentative nature of the interpretation of the results should not detract from the demonstration that both extraversion-introversion and tolerance of ambiguity are related to errors.

The results obtained show that intolerance of ambiguity may be related to errors made, particularly in the early stages of learning when situational effects are likely to have their strongest influence. This discussion of results concerning both extraversion and tolerance of ambiguity represents the sort of interactionist approach advocated by eg Bowers (1974) or Argyle (1975) where person, situation and interaction variables are taken into account in an attempt to provide a clear picture of what is taking place. Further discussion of this approach takes place in Chapter 6 when cognitive and non-cognitive personality factors are compared.

Ability

The relationships between the results for the test of ability and the indices of learning seem somewhat counter-intuitive.

Firstly, some relationship between errors made and ability would normally have been expected (in fact r = +0.001). The most likely explanation here is that the ability range of the students was, in practice, quite narrow since they were all from the sixth form of a highly selective grammar school. Differences in general ability revealed by the AH5 test were probably not sufficiently large nor of sufficient relevance to influence performance on the learning exercise studied. This feature of the results points to the value of conducting studies like the one described, where factors of importance in the learning situation, not related to ability, are examined and provide useful results that increase our understanding of the learning process.

The small but consistent relationship between AH5 and appreciation span is somewhat puzzling if it is a 'true' relationship. It indicates that people of lower ability tend to plan ahead further than people of higher ability.

The correlation coefficients are not statistically significant and the most likely explanation is that the results occurred by chance. On the other hand if the relationship is a true one it may show that students of higher ability tend to cope with a difficult and complex learning situation more 'intelligently' by limiting the distance ahead that they plan. From the point of view of the experimenter/observer to plan ahead only a fairly short distance certainly appeared to be the 'intelligent' thing to do.

Summary

This study has shown that extraversion-introversion and tolerance of ambiguity are related to errors made by students, when they are working on novel, unstructured material. These findings, if confirmed in wider contexts, are both interesting and important. The structured-unstructured dimension is at the heart of many ways of conceptualising learning material ('discovery-didactic' etc..) and the results obtained have demonstrated a relationship between personality characteristics and errors made when using a particular type of material. Many interesting additional problems, such as the difficulties caused by lack of unequivocal guidance and whether individuals who are intolerant of ambiguity will show a corresponding superiority on highly structured, linear material await resolution.

The findings also provide a line of thought to be followed by those exploring the pattern of correlations that exist between extraversion and academic attainment.

CHAPTER 3

EXPLORATORY BEHAVIOUR

Introduction

The INTUITION equipment enables students to 'explore' topics that they do not yet understand. When a student indicates that he wishes to explore a topic he is supplied with a two or three line written summary of the subject matter for the topic in question. A student may explore any topic on the board whenever he wishes.

This chapter contains a detailed analysis of the exploration that students engaged in and examines the relationship of exploratory behaviour to personality factors and to other indices of learning activity such as appreciation span.

Exploration

As already stated a student may explore any topic on the board whenever he wishes. An example of the information supplied during the explore transaction is given in Fig. 1. The information is presented to students by means of 35 mm slides projected onto a screen.

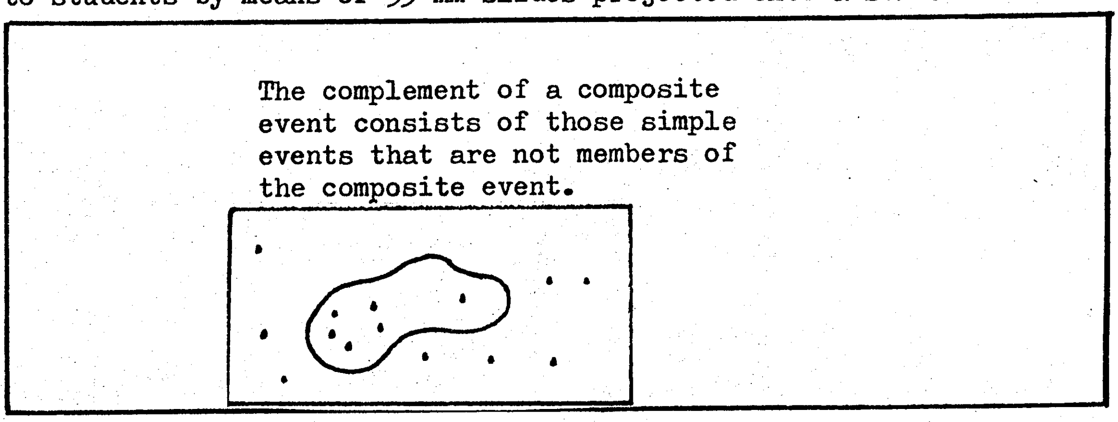

Fig. 1 (A sample 'explore' slide)

The information supplied is not sufficient to enable the student to understand the topic completely but does supply him with a general statement concerning the nature of the topic. In many ways the information supplied during the explore transaction resembles truncated behavioural objectives for each topic, since the student is always given a statement exhibiting the central concept of each topic. The explore slides also fulfil the same sort of function as what Ausubel (1968) has described as 'Advance Organizers'.

Indices of Exploratory Behaviour

It is more difficult to identify consistent indices of exploratory behaviour than it is to identify, say, indices of aiming activity (ie appreciation span). The exploratory behaviour exhibited by students may be examined from different viewpoints. Firstly, it is possible to examine the total number of nodes that a student explores. This gives an index of the amount of exploration engaged in but does not give any indication of whether the exploration is limited to topics near the working region or whether the student explores extensively over a wide range of topics. To gain information concerning this latter factor, it is necessary to examine not only the amount of exploration but also the range (ie distance between node being worked on and node explored); thus two categories of exploratory behaviour can be considered.

a) Amount of Exploration

b) Extensiveness (or range) of Exploration

a) Indices of Amount of Exploration

i) Pre-Working Exploration

Exploratory behaviour is different from the activity involved in specifying an aim or choosing which topic will be worked on next since exploration is not mandatory and a student may complete the whole learning exercise without necessarily engaging in any exploration at all, thus there may be large differences in the amount of exploration that students engage in. The first point at which individual differences in amount of exploratory behaviour may be visible is the amount of exploration that a student engages in before beginning any work on a module, ie the number of topics that a student explores before selecting his first topic to work on. This index of amount of exploration will be known as 'pre-working exploration'.

ii) <u>During work Exploration</u>

Although students may explore topics whenever they wish, in practice they always conducted exploration 'between-topics', that is to say that students' behaviour followed a cycle of

Explore - work-on and pass test for topic -
Explore - work-on and pass test for new
topic........etc.

None of the 15 students observed during these experiments ever broke off from working on a topic to conduct exploration; students only ever explored in the period between completing one topic and beginning another. An examination of the number of nodes explored, compared to the number of nodes completed will be used as an index of the amount of exploration that students conducted once work on a module had begun.

This discussion has indicated two indices of amount of exploratory behaviour;

i) Amount of 'pre-working exploration'

= No. of nodes explored prior to selection of <u>first</u> topic

ii) Amount of 'during-work' exploration'

$$= \frac{\text{Total No. of nodes explored}}{\text{Total No. of nodes worked on}}$$

In a sense both of these indices indicate the amount of information that a student samples prior to taking action to choose a topic. Individual consistencies in such behaviour could represent preferences for students to 'look before they leap' or alternatively 'leap before they look' and could be related to stable personality characteristics. Alternatively, exploratory behaviour could be entirely situation-specific and independent of underlying dispositions.

Before examining the correlates of such activity it must be ascertained that the indices chosen are reliable measures. The method for estimating reliability is the same as that applied to the data concerning appreciation span where students scores for each module were correlated with each other.

Reliability and validity of amount of exploration measures

Pre-Working Exploration

Appendix (3) shows graphically the exploration conducted by each student. The data concerning pre-working exploration are given below.

	Pre-working Exploration	
Student No	No of topics explored Module 1	Module 2
1	3	3
2	0	0
3	3	0
4	4	4
5	2	2
6	3	1
7	0	0
8	0	0
9	10	4
10	3	4
11	6	-
12	3	-
13	0	-
14	11	-

Table 1 (Topics explored before choosing a first topic to begin work on).

The product-moment correlation coefficient for students who completed both modules = 0.70 (N = 10)

∴ Spearman/Brown reliability coefficient for combined scores = 0.82

These results show that the relative number of nodes that a student explored before beginning work is consistent from module to module.

To increase reliability the scores for modules 1 and 2 were combined.

This was done by computing standard (Z) scores and combining them.

Student No	Mod. $\frac{1+2}{2}$ (Z scores)
1	+0.365
2	-0.97
3	-0.46
4	+0.81
5	-0.08
6	-0.185
7	-0.97
8	-0.97
9	+1.83
10	+0.64

Table 2 (combined (Z) scores $\frac{\text{Mod 1 + Mod 2}}{2}$)

Thus students consistently explored relatively few or many nodes before beginning work and a reliable index of this activity is the combined scores for modules 1 and 2.

During-Work Exploration

The data in appendix (3) can also be used to compute the during-work exploration conducted by each student. Relevant data are given below.

Student No	During-Work Exploration	
	$\frac{\text{No topics Explored}}{\text{No topics Completed}}$ Mod 1	$\frac{\text{No topics Explored}}{\text{No topics Completed}}$ Mod 2
1	0.43	0.22
2	0.14	0.0
3	0.64	0.95
4	1.64	1.71
5	0.46	0.58
6	0.23	0.05
7	0.07	0.0
8	0.0	0.0
9	1.62	0.26
10	1.56	1.00
11	1.19	-
12	0.83	-
13	0.38	-
14	1.09	-

Table 3 (During-work exploration)

The product-moment correlation coefficient for students who completed both modules $= \underline{\underline{0.73}}$ (N = 10)

$\therefore$ Spearman/Brown reliability coefficient for combined scores $= \underline{\underline{0.84}}$

During-work exploration is also a reliable index and, again, combined scores will improve reliability.

Student No	Mod $\frac{1+2}{2}$ (Z Score)
1	-0.41
2	-0.82
3	+0.38
4	+1.79
5	-0.08
6	-0.71
7	-0.87
8	-0.93
9	+0.52
10	+ .12

Table 4 (Combined (Z) Scores $\frac{\text{Mod 1 + Mod 2}}{2}$)

<u>Validity of Measures</u>

Whenever a student explores he is requesting, and receiving outline information about topics that he does not yet understand.

It is possible to describe two extreme forms of behaviour that people may engage in when involved in complex learning exercises, given the proviso that they have some, maybe limited, choice about the route that they will take through the topics covered; but that the topics must be accessed in some specified order (ie as in 'INTUITION' when some topics are prerequisites for others).

At one extreme a student may begin by considering only information that is immediately available (in the case of 'INTUITION' this is the topic names) and make a choice of which topic to work on. Having worked on his first topic he may then base his choice of next topic on immediately available information (in the case of 'INTUITION' this amounts to his knowledge of the topic just completed and future topic names). A student may follow this procedure all the way through the learning material without ever making any request for information over and above that with which he is immediately confronted. Thus a student behaving in this way is taking a limited sample of the potential information available to him and makes decisions on this basis.

At the other extreme a student may attempt to survey much more of the available information. The measures of amount of exploration discussed above are attempts to quantify student behaviour along this dimension of information sampling.

b) Indices of range of exploration

It has already been shown that students differ in the amount of exploratory behaviour that they engage in. Some learners may confine their exploratory behaviour to nearby nodes whereas others may explore nodes some distance away from their working region.

Relationships between Range of Exploration and other indices

i) Appreciation Span

The relationships between range of exploration and other indices of learning activity are important. The relationship between appreciation span and exploratory behaviour has already been discussed in Chapter 2. It was noted that students who exhibit a small appreciation span would not engage in wide ranging exploratory activity. If students who exhibit a small appreciation span do consistently engage in wide ranging exploration this would cast doubt on the validity of 'measured' appreciation span as an indicator of 'true' appreciation span. In practice inspection of the charts at appendix (3) shows that appreciation span and range of exploratory behaviour are closely related and do not often explore beyond their aim.

ii) Amount of Exploration

The relationship between range and amount of exploration can also be evaluated by inspection of the charts at appendix (3). The earlier discussion has distinguished between range of exploration and the two indices of amount of exploration. The conceptual distinction is clear, but in practice it may be that people who explore most are also those who explore furthest ahead, and amount and range of exploration may be closely related.

Examination of the charts at appendix (3) reveals that amount and range of exploration are not closely related. Some students who explore a great deal do so over a very limited range, whereas others show a wide range; conversely students who explore very little exhibit both large and small ranges of exploration.

Personality Dimensions related to exploration

The preceding discussion distinguished between measures of amount and range of exploratory behaviour. In what follows attention is concentrated on possible relationships between personality dimensions and measures of amount of exploration.

Extraversion/Introversion

The Eysenck Personality Inventory has already been discussed and a typical descriptive passage relating to extraversion and introversion has been quoted. For the sake of completeness part of this passage will be given again. An extravert is, "Impulsive, takes chances and acts on the spur of the moment". An introvert, "tends to plan ahead, 'looks before he leaps', distrusts the impulse of the moment and likes a well ordered life".

It was suggested earlier that introverts would be expected to plan ahead to a greater extent than extraverts and the results showed that introverts did not, in fact, appear to plan further ahead in the particular situations studied; though the question of whether or not introverts planned ahead in more detail and with more care was left unresolved. The difference between extraverts and introverts can also be looked at from the point of view of information collection.

The implication of the passages quoted above and of other writing concerning extraversion/introversion is that extraverts will tend to collect very little information on which to base action and will continue to make impulsive decisions based on a limited range of information. By contrast the introvert will, as Eysenk puts it, 'look before he leaps' and collect a wider range of relevant information before committing himself to action.

Thus it could be predicted that extraversion/introversion will be related to amount of exploration. This prediction is based on the hypothesis that some people will consistently tend to collect a wider range of information than others before taking action; and that such a tendency is related to differences in extraversion/introversion and will be exhibited in learning activity.

The information collection dimension suggested above is in some ways similar to a cognitive style dimension, Impulsive-Reflective, proposed by Kagan. See Kidd and Rivoire (1966). Eysenck has claimed that the reflective-impulsive dimension can be subsumed by extraversion/introversion.

However, the reflective-impulsive dimension describes the degree to which a person, "reflects upon alternative classifications of a stimulus or alternative solution hypothesis in situations in which many are available simultaneously"; Kagan in Kidd and Rivoire (p488).

This dimension may be related to amount of information collection but appears to be more concerned with the tempo of activity. The dimension of information seeking considered here concerns the extent to which an individual will collect available information before taking action.

Information seeking behaviour, referred to as exploratory behaviour has been studied extensively by Berlyne (1960), (1965). He provides a three factor theory of motivation to seek information. The tendency to seek information on a particular topic will increase with a) degree of uncertainty, defined in terms of the number of options available and their equipotentiality b) importance, defined in terms of the relevance of the information for action decisions; and c) subjective probability of success, or the likelihood that a reliable source of information is available to shed light on the topic.

In effect these are the situational factors that determine information seeking behaviour. The suggestion raised earlier that amount of information seeking will be related to extraversion-introversion raises the possibility that individual difference factors as well as situational factors are determinants of information seeking behaviour.

An Alternative Prediction

Westcott (1968) has studied information demand directly and found that low information demanders could be distinguished from high information demanders on the basis of certain personality characteristics. The significant results he reported were based mainly on an item analysis of subjects' responses to the California Psychological Inventory. Westcott identified discriminating items then grouped them into clusters that appeared psychologically coherent. He summarized the differences between high and low information demanders under 6 categories, based on 32 discriminating items.

1. Confidence
2. Physical Wellbeing
3. Reactions to Order and Restraint
4. Commitment and Focus
5. Social Skill and Responsibility
6. Doubt, Introspection, Questioning.

One of Westcott's conclusions is that low information demanders were more introverted and inner-directed than high demanders. The items on which he bases this conclusion appear to be more closely related to social extraversion than impulsiveness but do, nevertheless, cast some doubt on the suggestion, raised earlier, that extraversion is positively related to low information demand.

As Westcott notes his results concerning personality correlates of information demand could have been interpreted differently. They do not provide a definitive statement of the differences between high and low information demanders but simply attempt to give meaningful suggestions. It would probably have been possible to use his findings to generate some hypotheses relevant to the current study, however, since it is not possible to follow every possible avenue of exploration, this has not been done.

It is also worth noting that Westcott's results cannot be attributed great confidence from a purely statistical point of view since with a scale such as the CP1 (500 items) he could expect to find, by chance, 25 items where there was a significant difference between high and low information demanders. He, in fact, identifies 32 discriminating items.

Nevertheless the theoretical statements concerning extraversion/introversion suggest that introverts will explore more, whereas the empirical data from Westcott suggests the reverse. This apparent conflict might be resolved by taking the view that introverts will explore more in their own minds and will perhaps consider the effects of a variety of possible courses of action and the importance and relevance of information - ie in Kagan's terms they will be more 'reflective'. By contrast extraverts will operate more on the external world and may actually request more information when it is necessary to interact with the external world to do so. As far as students working on INTUITION are concerned they have to take action and make a specific request before they are given information. Introverts may, in fact be inhibited and although they prefer to 'look before they leap', the actual activity of requesting information may constitute a 'leap' that they prefer not to make.

Bearing these points in mind it is rather difficult to develop directional hypotheses concerning the relationship between extraversion-introversion and exploratory behaviour on INTUITION. It is more sensible to examine the null hypothesis that there is no relationship and to interpret results on an ad-hoc basis. This is the course of action to be followed.

Hypotheses concerning Exploration

The following hypotheses were examined.

Hypothesis One - Degree of extraversion-introversion is not related to amount of pre-working exploration.

Hypothesis Two - Degree of extraversion-introversion is not related to amount of during-work exploration.

Before examining the data relevant to these hypotheses two further hypotheses will be developed.

The development of an instrument to measure Information Collection

It has been suggested that extraverts and introverts may exhibit differences in information collecting activity. To increase confidence in the eventual interpretation of results, particularly since no clear predictions can be formulated in advance, a test aimed specifically at measuring information collecting behaviour was constructed by the writer.

Development of information collection test

The test was needed as an indicator of the amount of information collected prior to decision making or action. As such it had to satisfy a number of essential criteria.

1) Participants must be required to make a decision at some time.

2) They should be given the freedom to collect different amounts of information prior to decision-making.

3) It should be possible to measure the amount of information collected.

A brief outline of the test is given below and is followed by a more comprehensive description of the test materials, administration and scoring procedure.

Outline of Test

Students are given 32 possible answers from which to choose the correct one. They can request items of information to help them decide which answer is correct.

Each item of information requested reduces the number of possible correct answers by half.

Thus if students request one item they have 16 possible answers. Two items cuts down the possible correct answers to 8 and so on as in Fig. (2).

0 items	32 possibilities
1 item	16 possibilities
2 items	8 possibilities
3 items	4 possibilities
4 items	2 possibilities

Fig. (2) (Range of possibilities in Information Collection Test).

Students are only ever allowed to request a maximum of 4 items so that they always have to choose between 2 possible correct answers. They are told that a scoring system operates so that the earlier they guess the more points they will gain if they are correct and the more they will loose if incorrect.

The test consists of ten different trials. On each trial the student requests 1, 2 3 or 4 items of information and then makes his response. A score representing the mean amount of information collected by each student over ten trials can be calculated.

Test materials and administration

The test was administered to students on an individual basis during a session that lasted 30-50 minutes per student.

Students were told that they were about to take part in an exercise designed to assess their ability to 'make accurate judgements about other people'. The verbal introduction was kept to a minimum and students were then given the written introduction, together with the two page list of 32 possible combinations, shown at appendix (6).

Scoring Procedure

On eachof the ten test sequences the student could guess at any of four different points. (A, B, C or D) A - after receiving one item of information plus the occupation of the person in question.

B, after two items
C, after three items
D - after receiving

4 items of information. When a student guesses after having been supplied with one item of information he is, in effect, ignoring $\log_2 16$ ie four bits of information. The later a student guesses the less information he has ignored - so that, for example, if he does not guess until he has been given four items of information (excluding occupation - which is always given after item number 1)

he is only 'ignoring' $\log_2 2$ ie one bit of information.

For each of the ten sequences that constitute the test the number of bits of information ignored by each student can be computed; and hence an average score for the whole test

ie $\quad$ Ab (1...10) = No. of bits not requested(ie ignored)

$$\frac{\text{Ab }(1...10)}{10} = \text{Average No. of bits not requested}$$

Discussion of test format and context

It is clear from the description of the test that it satisfies the three essential criteria mentioned earlier - however the test could have been developed in a variety of different ways and still satisfied these criteria. It was felt that when students were participating in the test there should at no time be an identifiable 'correct' answer that would enable high ability students to guess earlier, but it was also felt that students should be able to generate some hypotheses about possible 'correct' answers - rather than be expected to make 'pure' guesses. Only a fairly limited number of situations will enable both of these criteria to be satisfied. For example, unfamiliar abstract shapes could be used to minimise the possibility of there being a correct response - but without the use of training schemes and so on, students would have little rational basis for choosing alternative solutions in the absence of full information.

The situation chosen was one of only a limited number that could have been used that would give students sufficient information to make a choice but not so much that one answer would be unambiguously recognised as correct.

Reliability of the test

The reliability of the test can be examined by use of the split half technique. This involves dividing the test into two equivalent halves, correlating the two halves with each other and then applying the Spearman/Brown formula to obtain a reliability coefficient for the test as a whole.

This method for estimating test reliability is sometimes criticised, particularly in the case of personality tests when individual items can be put in any position. The criticism, (see for example Garret 1966) is that the test can be factored into halves in a number of ways, so that the resulting reliability coefficient is not a unique value.

To minimize this problem the test was divided into halves using two of the more normal procedures.

i) Odd and Even numbers

ii) First and second half

An average reliability coefficient was then computed.

The data are shown below.

Student No	Information Collection Test				Total Score
	Odd	Even	1st half	2nd half	
1	0.6	1.1	0.8	0.9	1.7
2	1.1	1.1	1.1	1.1	2.2
3	1.0	1.0	1.0	1.0	2.0
4	0.7	0.8	0.8	0.7	1.5
5	1.0	0.9	0.9	1.0	1.9
6	0.8	0.8	1.1	0.5	1.6
7	0.8	0.7	0.7	0.8	1.5
8	1.3	1.4	1.3	1.4	2.7
9	0.6	0.6	0.6	0.7	1.3
10	1.0	1.4	1.3	1.1	2.4
11	1.4	1.4	1.4	1.4	2.8
12	1.7	1.7	1.5	1.9	3.4
13	0.8	0.9	0.9	0.8	1.7
14	1.0	1.1	1.1	1.0	2.1

Table (5) (Scores on Information Collection Test)

<u>Odd/Even</u>

Pearson product-moment correlation coefficient = 0.85

<u>1st/2nd</u>

Pearson product moment correlation coefficient = 0.79

∴ Spearman/Brown reliability coefficient for whole test = 0.90

Thus the test is satisfactorily reliable.

The following hypotheses, concerning the information collection test were examined.

Information Collection Test

Hypothesis Three

Low scorers (ie people who collect a lot of information) on the information collection test will exhibit higher values for pre-working exploration than high scorers.

Hypothesis Four

Low scorers (ie people who collect a lot of information) on the information collection test will exhibit higher values for exploration during work than high scorers.

In addition the relationship between scores on the EP1 and the information collection test will be examined. A significant relationship would support the notion that the two tests tap a general characteristic associated with the degree of information collected prior to decision making.

Ad-hoc Analysis

In addition to the examination of the specific hypotheses stated above an ad-hoc investigation of the relationships between the various indices of learning activity will also be conducted. This investigation will examine the inter-relationships between Pre-working Exploration, During-Work Exploration, Appreciation Span and Errors.

Analysis of Results

Hypothesis One

This concerns the relationship between extraversion-introversion and pre-working exploration. Appropriate data are given below:

Student No	Pre-Working Exploration: No of topics explored Module 1	Pre-Working Exploration: (Z)Score Module $\frac{1+2}{2}$	EP1 scores
1	3	+0.365	19
2	0	-0.97	17
3	3	-0.46	19
4	4	+0.81	12
5	2	-0.08	12
6	3	-0.185	15
7	0	-0.97	7
8	0	-0.97	20
9	10	+1.83	18
10	3	+0.64	11
11	6		12
12	3		13
13	0		5
14	11		22

Table 6 (Pre-Working exploration)

Pearson product-moment r = <u>+0.04</u> (N = 10)

(ie Mod $\frac{1+2}{2}$)

Pearson product-moment r = <u>+0.46</u> (N = 14)

(ie Mod 1 only)

Thus the results support the null hypothesis that there is no relationship between the two sets of scores.

<u>Hypothesis Two</u>

This concerns the relationship between extraversion-introversion and exploration during work. Approppriate data are given below.

Student No	During Work Exploration		EP1
	No of topics explored / No of topics completed Module 1	(Z) Score Module $\frac{1+2}{2}$	
1	0.43	-0.41	19
2	0.14	-0.82	17
3	0.64	+0.38	19
4	1.64	+1.79	12
5	0.46	-0.08	12
6	0.23	-0.71	15
7	0.07	-0.87	7
8	0.0	-0.93	20
9	1.62	+0.52	18
10	1.56	+1.12	11
11	1.19		12
12	0.83		13
13	0.38		5
14	1.09		22

Table 7 (During Work Exploration)

Pearson product-moment r = -0.02 (N = 10)

(ie Module $\frac{1+2}{2}$)

Pearson product-moment r = +0.02 (N = 14)

(ie Module 1 only)

Thus the results support the null hypothesis that there is no relationship.

Hypothesis Three

This concerns the relationship between pre-working exploration and the information collection test. Appropriate data are given below.

Student No	Pre-Working Exploration: No of topics explored Module 1	Pre-Working Exploration: (Z) Score Module $\frac{1+2}{2}$	IC test scores
1	3	+0.365	1.7
2	0	-0.97	2.2
3	3	-0.46	2.0
4	4	+0.81	1.5
5	2	-0.08	1.9
6	3	-0.185	1.6
7	0	-0.97	1.5
8	0	-0.97	2.7
9	10	+1.83	1.3
10	3	+0.64	2.4
11	6	-	2.8
12	3	-	3.4
13	0	-	1.7
14	11	-	2.1

Table 8 (Pre-Working Exploration and Information test scores)

The hypothesis states that people who collect large amounts of information in the IC test (ie low scorers) will explore many nodes before starting work and a negative relationship between the two sets of scores would be expected.

Pearson product-moment $r = \underline{-0.49}$ (N = 10)

(ie Module $\frac{1+2}{2}$)

Pearson product-moment $r = \underline{-0.10}$ (N = 14)

(ie Module 1 only)

Thus the data do not support the hypothesis.

Hypothesis Four

This concerns the relationship between During-Work exploration and the information collection test. Appropriate data are given below.

Student No	During Work Exploration: No topics explored / No topics completed, Module 1	During Work Exploration: (Z) Scores, Module $\frac{1+2}{2}$	IC test scores
1	0.43	-0.41	1.7
2	0.14	-0.82	2.2
3	0.64	+0.38	2.0
4	1.64	+1.79	1.5
5	0.46	-0.08	1.9
6	0.23	-0.71	1.6
7	0.07	-0.87	1.5
8	0.0	-0.93	2.7
9	1.62	+0.52	1.3
10	1.56	+1.12	2.4
11	1.19	-	2.8
12	0.83	-	3.4
13	0.38	-	1.7
14	1.09	-	2.1

Table 9 (During Work Exploration and Information Collection test scores)

The hypothesis states that people who collect large amount of information in the IC test (ie low scorers) will explore many nodes before starting work and a negative relationship between the two sets of scores would be expected.

Pearson product-moment $r = \underline{+0.21}$ (N = 10)
(ie Module $\frac{1+2}{2}$)

Pearson product-moment $r = \underline{-0.02}$ (N = 14)
(ie Module 1 only)

Thus, the data do not support the hypothesis.

Ad-Hoc Analyses

In addition to an examination of the various hypotheses an examination of the inter-relationships between the four indices of learning activity was conducted.

The relevant correlation matrices are given below.

N = 10 Modules 1 and 2 combined.

	App. Span	Pre-Working Explore	During Work Explore
App. Span	X	+0.57	+0.02
Pre-Working Explore			+0.71
During Work Explore			X

Table 10 (Correlation matrix module 1 and 2 combined)
N = 14 Mod 1 only

	App. Span	Pre-Working Explore	During Work Explore	Errors
App. Span	X	+0.73	+0.47	-0.38
Pre-Working Explore		X	+0.42	-0.54
During Work Explore			X	-0.11
Errors				X

Table 11 (Correlation matrix Module 1 only)

The relationship between scores on the Information Collection test and the EP1 was also examined.

Pearson r = +0.09

The inter-correlations between the two indices of amount of exploration are spuriously high since the score for during-work exploration is, to some extent, dependent on the score for pre-working exploration. When this is taken account of and pre-working exploration is correlated with a score for exploration conducted during work that excludes pre-working exploration, the resulting coefficients reduce to + 0.56 (N = 10) and + 0.37 (N = 14).

Impulsiveness

As noted in Chapter 2 it has been shown that extraversion has an impulsiveness component and a sociability component. Again it could be argued that impulsiveness,rather than sociability would relate to information collecting activity. The EP1 impulsiveness scores given earlier (Chapter 2) were used to examine the interrelationships between exploratory activity (on INTUITION), impulsiveness and scores on the information collection test.

The following correlations were obtained.

	Exploratory Behaviour				Information Collection Test
	Pre-Work		During-Work		
	Mod 1	Mod 1+2	Mod 1	Mod 1+2	
EP1 Impulsiveness Score	+0.28	-0.01	+0.005	-0.01	+0.44

Table 12 (Correlation matrix-Impulsiveness)

Ability

As in Chapter 2 students scores on AH5 were included in the analysis.

The following correlations were obtained.

	Exploratory Behaviour			
	Pre-Work		During-Work	
	Mod 1	Mod 1+2	Mod 1	Mod 1+2
AH5	-0.2	-0.35	+0.07	+0.12

Table 13 (Correlation matrix-ability)

Discussion of results

General Findings

The experiments have provided an opportunity to examine students' reactions when confronted with a fresh body of subject matter. The students studied displayed considerable individual differences in the extent to which they explored the subject matter before beginning work on it. Some students plunged in almost immediately, taking very little opportunity to survey what was to come; others appeared to try to get a general picture of the whole area before beginning work on any one particular part. Having begun work students displayed consistent individual differences in exploration. Some explored many of the areas to come whereas others explored little or not at all. Differences in the amount of exploration conducted after work had begun were related to differences in the amount of explor ation conducted before beginning to learn (r = +0.37, +0.56).

The data analysis showed that people exhibit great consistency in the relative amount of exploration that they engage in both before and after beginning work. Range of exploration was not closely related to amount of exploration thus indicating that people who explored most did not necessarily explore furthest ahead. This finding is interesting in itself and raises the possibility that when people are offered previews of material that they are about to learn, interest in the details of what is to come may be independent of interest in looking a long way ahead into the material.

Student behaviour on this equipment has demonstrated that there are wide individual differences in the information collection approaches that learners adopt. In fact student behaviour was both highly internally consistent and highly idiosyncratic with common factors somewhat elusive.

Examination of Hypotheses

The nature of the results obtained makes it unnecessary to discuss each hypothesis separately. The basis for the experiments conducted was a hypothesis that information collection was influenced consistently by stable underlying dispositions and that people would consistently collect large or small amounts of available information on which to base action. The data revealed no consistent nor statistically significant pattern of relationships between extraversion-and introversion and exploratory behaviour on INTUITION. The implication of this finding is that students' information collecting behaviour on INTUITION is not related to the underlying disposition of extraversion-introversion.

Impulsiveness

It is possible to obtain separate impulsiveness scores by examining selected items from the EP1. The data reveal no significant relationships between this impulsiveness score and exploratory behaviour on INTUITION.

Introversion-extraversion is not a pure measure of a person's tendency to collect information prior to acting. Because of this, it was felt advisable to take a second measure designed to assess this characteristic more directly and an instrument was constructed specifically for this study. The results concerning this test are important.

There is again no statistically significant relationship between scores on this test and extraversion-introversion; however when the relationship between impulsiveness scores and the information collection test is examined a correlation coefficient of 0.44 indicates that perhaps the two tests do relate to a common factor.
Furthermore it suggests that information collecting activity is not entirely situation-specific and may, to some extent, be related to underlying dispositions relating to extraversion-introversion, ie impulsiveness.
The implication is that impulsiveness and the amount of information that people collect before decision-making are related. What then is the explanation of the lack of relationship between either of these measures and exploratory behaviour on INTUITION? The basis for an explanation lies inthe complexity of the situations studied. The information collection test was designed specifically as a test of information collection and in the design of the test attempts were made to minimise the possible contaminating effects of other variables or situational factors. Any influence due to underlying impulsiveness would have maximum opportunity to have an effect on the behaviour of the participant in this test.

The INTUITION situation is much more complex, and there are many possible contaminating effects that could mark the influence of extraversion-introversion or impulsiveness.

<u>Differences between information collecting on INTUITION and during the information collection test.</u>

The two situations differ from each other in what may be a crucial way.

When a student is working on INTUITION he must actually take action to obtain information; with the information collection test the reverse is the case and a student must take action (ie guess at the correct answer) in order to avoid being given further information.

It was suggested earlier that extraverts would tend to interact more with the external world than introverts. It is possible that the lack of differences in exploratory behaviour observed when students worked on INTUITION may be due to this complicating factor.

Extraverts are more inclined to interact with the external world and their actual amount of exploration on INTUITION is inflated; introverts, by contrast, although they prefer to 'look before they leap', are inhibited and their actual amount of exploration is constrained: thus no differences in amount of exploration are detectable.

With the information collection test the situation is different and the tendency to 'prefer action to thought' or more specifically to behave impulsively will bring about different results. The reflective introvert who prefers to collect information and reflect on it without having to interact with the external world can do so simply by not taking a decision (ie not guessing at the answer). The impulsive individual who wants to 'do something' will guess at an early stage on the basis of relatively little information. The results obtained are in accordance with this point of view.

Situational Factors.

This discussion has indicated the probable importance of situational factors in the exploratory or information collecting behaviour displayed by learners.

Data provided by Westcott also supports the conclusion that information collection exhibits high reliability within a situation but is likely to differ from situation to situation; although as noted earlier, he also provides some tentative evidence that information demand may be consistently related to personality factors.

Consideration of individual cases further supports the point of view that information collecting behaviour is situation-specific. For example, student No 7 scores as an introvert on the EP1 and collected large amounts of information on the information collection test (score = 1.5) yet he only explored one topic throughout the whole of his work on modules 1 and 2. A more detailed examination of this student's records shows that he frequently did not examine any of the demonstration materials and that he worked through the material extremely quickly, only ever completing the minimum number of nodes. It became apparent as early as the first session that this student was particularly keen to complete the learning exercise before any of his fellow pupils did. At each session he invariably enquired about the progress of other students and always worked as quickly as possible. Reminders from the experimenter that speed was unimportant had no effect on his rate of progress. This particular student clearly felt that any activity such as exploration that was not mandatory was not worth doing, as it would slow his progress. Exploratory behaviour and demonstrations not absolutely essential to understanding were not conducted in the hope of keeping up his very rapid rate of progression. Close study of other students' records reveal similar idiosyncracies confirming the importance of situational factors in determining information collecting behaviour.

The oonsistency of information collection patterns

Although information collecting behaviour seems to be situation-specific the extremely high reliability of people's information collection behaviour under various conditions is interesting. For example the information collection test produced a reliability coefficient of 0.9 and the indices of amount of exploration produced coefficients in excess of 0.8; yet there were no consistent relationships between these indices of information collection. It seems that information collecting activity is highly situation-specific and that people behave extremely consistently in similar situations and display stable levels of information collection; when circumstances change they will establish new, probably different, but equally consistent patterns of information collection.

Advance Organisers

This study has shown that, in practice, many students do not appear to "advance organisers" when they are available. This may be for several possible reasons; the organisers may not be good enough, or students simply do not know what is in their best interest, for example. It could, however, be that advance organisers are not appropriate for all students in all situations and they will not always facilitate learning. Ausubel (1968) has said that "...the principal function of the organiser is to bridge the gap between what the learner already knows and what he needs to know before he can successfully learn the task at hand". It seems, at the very least, that some students feel that they need to know very little in the way of organising information before they begin learning, whereas others prefer to find out a great deal.

Summary

The work reported in this chapter was an attempt to examine an aspect of learning strategy concerned with getting an overview of the subject to be learned.

This feature of learning strategy could be quite important from a pedagogical point of view since it can be clearly related to many existing learning situations. The studies reported in this chapter have shown that there does not appear to be a stable information collection disposition influencing behaviour consistently in a variety of situations.

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The indication is that people quite rapidly adapt to a situation and begin to exhibit stable patterns of information collection but, though different indices of information collection exhibit high internal consistency, they are not closely related to each other.

The available evidence shows that the extent to which students will look ahead and explore learning material in advance is not related to extraversion-introversion in any straightforward fashion. There is no apparent relationship between the amount of information collected by students working on INTUITION and extraversion-introversion. It has been suggested that this may be due to the fact that INTUITION requires students to take action and interact with the external world to obtain information. This may, in practice, inhibit the information seeking behaviour of introverts and enhance that of extraverts.

The analysis of inter-relationships between the various indices of learning style does show a consistent pattern indicating that people who planned furthest ahead (Ch. 2) tended to explore more topics before beginning any work. The coefficients, however, are not statistically significant and the nature of the inter-relationships between appreciation span, range and amount of exploration remains unclear.

The two indices of amount of exploration and appreciation span are all negatively related to errors suggesting the (intuitively reasonable) conclusion that people who proceed less impetuously by exploring future topics and planning ahead make less errors; however, the relationships are again not consistent enough for any firm conclusions to be drawn. Both of these are interesting possibilities and could perhaps be useful subjects of further study.

Future Work

The results obtained indicate that future work seeking to establish relationships between underlying personality dispositions and amount of information collected will need to take account of situational factors that may be of importance and, for example, the sort of interaction discussed earlier that may exist between situational factors and the influence of extraversion-introversion.

Another possible direction for future work is to examine exploratory behaviour itself more closely, or, as suggested above, to examine the inter-relationships that exist (within a specific situation) between the indices of learning. The experience gained from the current study has revealed a number of ways of improving the efficiency of such investigations. The equipment used here was designed with multiple aims in mind and not specifically to examine learning style variables, thus experience has indicated some possible design changes for future learning environments aimed specifically at examining learning styles.

The modifications occur in 2 areas.

- i Information supplied without request
- ii Type of information available

INTUITION ensures that students are supplied with a concept (or topic) map together with topic names representing the subject matter that they are about to learn.

All students are confronted with this display and can study as little or as much as they wish. It is difficult to tell how much attention students give to this display or when they are making use of it. This fact is a possible source of error when attempts are made to measure Exploratory behaviour. This problem could be partly remedied by not supplying students with <u>any</u> unrequested information - other than perhaps an indication of the general area of the subject matter. Wetherick and Dominowski (1976) have recently described a procedure for conducting simple concept attainment experiments in this way. Further information would only be available on request. This procedure would, of course, present new problems, such as whether the information should be supplied and then removed, or should it remain visible to the student once it has been requested.

The suggestion of making all information contingent on student requests draws attention to a second possible change. On the INTUITION equipment when a student explores a topic he is given certain, pre-specified, information. He is not given any choice of the sort of information he wishes to be given.

With a modified system students could be given at least three alternatives:

(a) Topic name

(b) Relationship to other topics

(c) Details of topic, similar to existing information

This modification would help to provide data about the category of information that students were interested in.

The modification mentioned above simply represents an extension of the existing set-up and the categories of information are dictated by the existing pattern. A more radical alternative would involve preparing a taxonomy of 'types of information' and provide opportunities for students to request and obtain information belonging to the different categories. The methodological implications of this study are pursued further in Chapter 6.

CHAPTER 4

THEORETICAL DISCUSSION OF ATTENTION DEPLOYMENT

Introduction

When students work on the INTUITION equipment they have to choose a route through the topics that make up the subject matter. Chapter 5 is concerned with the identification of individual consistencies in type of route taken and examines the relationship between certain categories of route and various personality factors.

When working on INTUITION students are presented with a body of subject matter divided up into a collection of interrelated topics. The eventual objective for all students is to understand the three head topics. There is no single, predetermined route that students must follow. Within the constraints discussed earlier (see Chapter 1) they may work on topics in any order. The choices that students make may represent consistent learning style differences.

Before generating predictions concerning the relationships between route taken through the INTUITION material and personality factors some preliminary discussion of attention deployment will take place.

This discussion is essential since attentional factors will be used as central explanatory concepts in the examination of student characteristics that takes place in Chapter 5.

An Examination of Attention Deployment

A historical perspective

As a concept attention has undergone many shifts in popularity. Early psychologists such as William James (1890) gave it an important position in their accounts of human mental processes. The following is illustrative of the importance that James allocated to attention.

"Millions of items of the outward order are presented to my senses which never properly enter into my experience. Why? Because they have no interest for me. My experience is what I agree to attend to. Only those items which I notice shape my mind - without selective interest experience is an utter chaos".

The appropriateness of these words is as clear today as it was 85 years ago, however it is only in the last 20-25 years that attempts to approach the problem of attention have met with any real degree of success. For much of the intervening time attention was rejected as a mentalistic concept. Unfortunately problems clearly related to attention have consistently recurred as stumbling blocks in explanation of human (and animal) behaviour. Any higher animal is ceaselessly faced with a multitude of stimuli that are competing to exert some influence over his behaviour - to function with even a moderate degree of success the animal must have some mechanism for controlling the extent to which he is influenced by these competing stimuli - without such mechanisms - as James points out "....the consciousness of every creature would be a gray chaotic indiscriminateness impossible for us even to conceive".

Models of Attention

The problems of attention are essentially problems of selectivity and intentionality. It is clear that we cannot notice more than a certain number of stimuli at once nor carry out more than a limited range of activities simultaneously. Investigation of this phenomenon really represents the starting point for the systematic study of attention. Broadbent (1958) developed a theory of selective attention which has been the major stimulus for much further work. He postulated that inputs are processed simultaneously in the sensory registration and preliminary storage systems - but are then transmitted via independent channels to a selective filter. The filter blocks some (irrelevant) messages and admits other (relevant) messages to a single decision channel of limited capacity which has access to a long-term memory store.

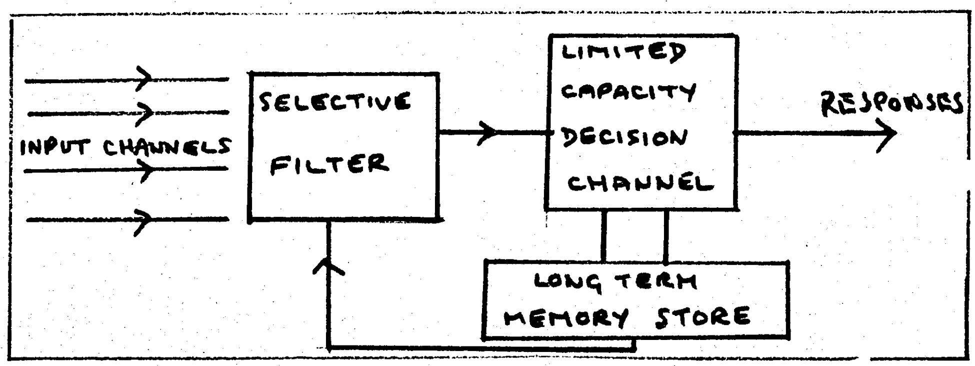


Fig. 1 (Broadbent's theory)

The model suggests that selection is based upon the receptor at which the information entered the system or upon physical distinguishing characteristics of the message. Apparent division of attention between channels is explained by suggesting that there is a limit on the rate at which attention may be shifted and that a short-term store, prior to the filter, holds messages coming in on one channel while those on the other are dealt with. This theory is consistent with early experimental results where it was found that humans are unable to recall many of the features of a 'non-attended' message,Cherry (1953) and have little memory for any of the words, Moray (1959), unless the shadowing of the 'attended' message is momentarily disrupted when the second message is presented,Mowbray (1964). These results alone would imply a single channel of attention which accepted the material contained in one message and rejected the information contained in the other. Further experimental evidence eg Moray (1959),Gray and Wedderburn (1960), Treisman (1960, 1964a, 1964b) has demonstrated that this is not the case.

Division of Attention

Moray's experiment amounted to an experimental demonstration of the 'cocktail party problem'. This is exhibited when we are (supposedly) completely involved in one of many conversations taking place at a cocktail party and yet the mention of our own name in another conversation will be recognised. Such a finding is difficult to explain in the context of Broadbent's original theory. Treisman (1960, 1964, 1969) invokes a two stage theory - to accommodate the experimental findings already mentioned and others. She suggests that at the first stage signals are analysed for their physical characteristics and, then, differentially attenuated as a function of their relevance to the task in hand.

In the second stage all signals whether attenuated or not are read into a pattern recogniser comprising a large number of dictionary units with different, but variable, response thresholds - such that, for example, emotionally important units have permanently lowered thresholds. Such a theory caters for the cocktail party syndrome since although the 'unattended' message would be attenuated the relevant dictionary unit for one's own name would have a low threshold.

This theoretical development represented a major departure for filter theory since it accepted the possibility of parallel processing. The evidence that led Treisman to revise the original filter theory led Deutsch and Deutsch (1963) to propose an even more radical reformulation. They suggested that a "message will reach the same perceptual and discriminatory mechanisms whether attention is paid to it or not".

Their theory postulates that all inputs are fully analysed in a pattern recogniser comparable to the one proposed by Treisman (dictionary units). Each structure has a preset weighting of importance, which reflects momentary intentions and among concurrently active structures the one with the highest weighting of importance is used to control awareness and response. This system like Treisman's ensures that important signals embedded in an irrelevant message will achieve precedence over less important signals. The distinction between the Deutsch and Deutsch theory and filter theory is most apparent in the area of divided attention. Filter theory suggests that division of attention among concurrent stimuli is impossible since attention can only be directed at one channel at a time - the Deutsch theory implies that detection will be easy whether the signal is on an 'attended' channel or not. As shown below the balance of the evidence would seem to indicate that both points of view are wrong - there appears to be more division of attention than filter theory would allow and less than the Deutsch and Deutsch or the later Norman (1968) theory would allow.

Various studies have shown that the division of attention is not easy and sometimes leads to very poor performance. Mowbray (1953) found that subjects could not listen to one story while reading another. Webster and Thompson (1954) observed very poor handling of simultaneous auditory messages except when these were highly redundant. Mowbray (1964) (1962), Treisman and Geffen (1968) have shown that when subjects are shadowing one message and listening for a target in another concurrent message, shadowing is disrupted when the critical work is presented. Treisman and Geffen (1967) and Treisman and Riley (1969) have conducted other experiments indicating that attention may not be divided as successfully as the Deutsch theory would predict.

On the other hand other studies have demonstrated that parallel processing of concurrently presented stimuli can be conducted successfully.

Lindsay, Cuddy and Tulving (1965), Tulving and Lindsay (1967), Treisman (1970), Treisman and Fearnley (1971), Levy (1971), Ninio and Kahneman (1973) have all presented evidence (reviewed in Kahneman 1973) indicating that people can and do conduct an amount of parellel processing that would not be predicted by filter theory. Many of the terms and concepts of filter theory have been widely applied ,in particular the image of filtering as an operation that opens one channel and closes others. Broadbent generated this image after a study of auditory attention - in particular dichotic listening. He defended this choice on the grounds that auditory attention can be studied without the problems of movement which dominate vision. The listener must rely on central mechanisms to direct his attention - this is not the case with the visual modality. The fundamental idea of filter theory that still survives today is that selective attention is an inhibitory process and that some inputs are 'blocked' or 'filtered out' in some way.

Neisser (1967) (1969) has shown that an alternative point of view is possible. He considers along with other authors the possibility that perception is enactive and that selective attention involves a distribution of available processing capacity. This means that when something is not attended to, processing capacity has not been allocated to it. He summarises his point of view by the following analogy.

> "If a man picks up a sandwich from a dozen offered to him we do not ordinarily say that he has blocked ar attenuated the others; he simply hasn't picked them up".

He also states - presumably to accommodate the sort of evidence that encouraged Treisman to revise Broadbent's theory

> "......We might also think of him keeping his fingers lightly on the other sandwiches both <u>before</u> and <u>during</u> his activities with the one he selects, to make sure that nothing untoward is going on".

Neisser also pointed out the relevance of pre-attentive mechanisms to the process of selective attention.

All of the models of selective attention discussed so far imply that pre-attentive processes exist to conduct analytic and decision making processes which take prior to, and thus without awareness of, the total sensory inflow from which selection is to be made. As Moray (1969) has remarked when discussing the Deutsch and Deutsch theory.

> "Recognition by the pattern recognising mechanisms of the brain of the precise nature of an incoming signal occurs at an earlier stage than that at which the observer is conscious of the nature of the signal".

Common Features

This rapid review of theories of selective attention has been presented for two related reasons. The first is to ensure that an appropriate perspective exists for the discussion of possible individual differences in attention deployment and that any subsequent consideration of differences in attention deployment is compatible with existing knowledge concerning the nature of attention. The second reason is so that fundamental similarities of approach that represent the 'concensus view' on the nature of attention can be identified and used to generate a conceptual platform for the more detailed study of relationships between attentive mechanisms, general cognitive processes and cognitive structure.

There are abundant similarities between the theories of selective attention presented here (and others not considered) but only two are of critical importance for the present discussion. The first point of agreement is made apparent by consideration of the theoretical position adopted by Neisser. In short, all theorists relate selective attention to the allocation of processing capacity. When one message is designated as relevant and another is designated irrelevant all theories imply that a larger amount of processing capacity is allocated to the relevant message - they only differ when it comes to the means of ensuring that this occurs. Thus selective attention may be equated with the selective allocation of processing capacity.

The second point of agreement concerns the status of 'unattended' messages. At one time, as indicated, filter theorists claimed that irrelevant messages would be blocked completely. Repeated experimental demonstrations have shown that this is not the case and revisions of the original theory have acknowledged the fact by postulating an 'attentuation' rather than a 'blocking' mechanism. The other theories considered also acknowledge that seemingly unattended messages are rarely completely unattended. Thus the second point of agreement involves the idea that the selective allocation of processing capacity is not perfect and some capacity is allocated to both relevant and irrelevant stimuli. Again the theories differ considerably on the exact nature of the mechanisms that are responsible for the observable outcome of such a distribution of capacity - and also on how the capacity is distributed.

A further point of interest when one examines theories of selective attention relates to the potential adequacy of any of the theories considered for explaining the experimental results. It seems clear that theories postulating <u>purely</u> serial processing are not compatible with experimental findings, neither are theories that postulate the extensive sort of parallel processing proposed by Deutsch and Deutsch.

It is also likely to be the case that a theory postulating purely enactive or facilitative selectivity is as unlikely to be successful as one postulating inhibitory selectivity. It seems then that some sort of integration of serial and parellel processing together with facilitative and inhibitory mechanisms may provide a theory that is likely to be more able to explain the current experimental data.

Indeed, although it is often dangerous to relate psychology and physiology at too early a stage in theorizing, there is some recent physiological evidence that lateral inhibition may be the outcome of attentional activity. Walley and Weiden (1973) cite evidence in support of a theory of cognitive masking which postulates that the processing of one stimulus interferes with the processing of another. The interference is termed cognitive masking and is attributed to recurrent lateral inhibition between neurons in the association cortex. Shallice (1972) has developed a more general information processing theory of consciousness and at one point makes the assumption that "No more than one action system may be strongly activated (ie become dominant) at any given time. This results from the activation of each action system being inhibited by every other action system by an amount which increases monotonically with the others activation".

Capacity

A somewhat different but compatible point of view has been suggested by Kahneman (1973). He suggests that individuals possess a limited amount of attentional capacity and that this capacity is distributed differently over focal and peripheral attention. His theory is also able to explain many of the experimental findings previously discussed.

For example, he suggests that when a person is conducting a task in focused attention only 'spare capacity' is allocated to irrelevant material and, "Consequently, the perceptual interpretations that correspond to these stimuli are impoverished, and awareness of them is slight".

In terms of a capacity theory the reason for the demonstrable inability of individuals to conduct a large range of activities simultaneously is due to a limitation of total available capacity. The possible importance of inhibition is not made explicit in Kahneman's theory. However he does cite considerable evidence in favour of a theory first put forward by Easterbrook (1959) concerning the relationship between arousal and attention - much of which could be interpreted by invoking an inhibition hypothesis. Easterbrook attempted to explain the Yerkes Dodson Law (1908) which stated a relationship between arousal and performance. The Yerkes-Dodson Law indicates that the relationship between arousal and performance corresponds to an inverted 'U' shape.

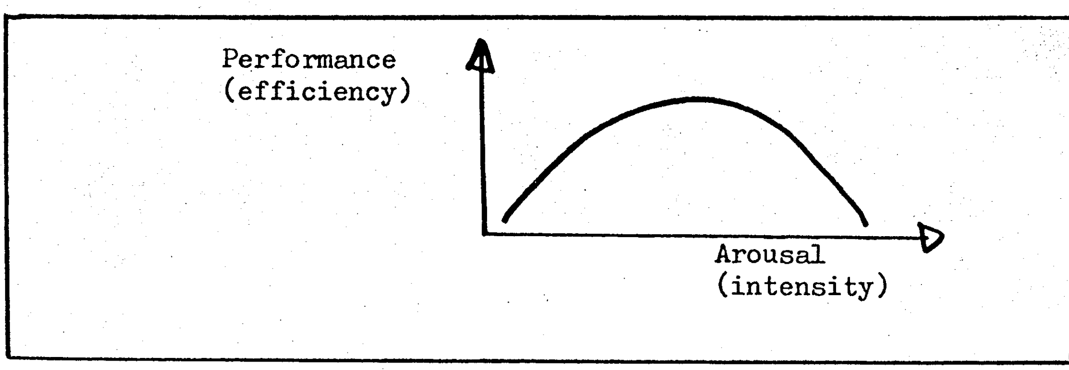


Fig. 2 (The Yerkes-Dodson Law)

Easterbrook hypothesised that as arousal increases attention becomes narrower; when arousal is low attention is relatively non-selective and many clues (including irrelevant ones) are processed. As arousal increases so does selectivity until at a certain point only task relevant cues are accepted and other are rejected. Beyond this point - when arousal increases still further some task relevant cues also begin to be rejected and performance begins to deteriorate. A number of experiments are quoted by Kahneman in support of this hypothesis and although he notes that the evidence is not entirely supportive he does conclude that "...the weight of the evidence does favour the conclusion that high arousal restricts the range of cues among which attention may be divided". Walley and Weiden suggest that such an effect may be due to increases in inhibition that occur as arousal increases. "Consequently the greater the complexity of the task, the greater would be the arousal induced and the narrower the range of cue utilisation".

Summary

By way of a summary the following points are put forward.

1 The selective allocation of attention is synonomous with the selective allocation of processing capacity.

2 Processing is neither always serial nor always parallel.

3 The range of processing activities that may be conducted at any one time is limited both by available capacity and the inhibitory effects of each activity.

4 As arousal increases attention becomes increasingly selective.

Individual differences in width of attention

So far the discussion has concentrated on the general concept of attention and attempted to examine it from a point of view of individual similarities. It has not been suggested that there may be consistent individual differences in the mechanisms of selective attention discussed. The next part of the discussion is concerned with this possibility. In particular an examination of one particular possible source of individual differences in attention deployment will be conducted - that of attentional breadth. Terms like breadth or extensiveness of attention are extremely seductive as concepts - possibly because they can be identified closely with everyday experiences. Day to day activity is littered with examples of events that can in some way be related to breadth of attention. Unfortunately the literature relevant to the concept of breadth of attention is not always as illuminating as it might be. The principal reason for this relates to incomplete specifications of what is meant by attentional breadth. One major source of confusion is rooted in the misconception that there is only one variety of breadth of attention. An examination of the literature relevant to the concept of breadth or narrowness of attention clearly indicates that it is not appropriate to talk about a single dimension of attentional breadth.

Wachtel (1967) discussed the concept of breadth of attention and distinguished at least two kinds. He refers to experiments by Schlesinger (1954) who attempted to demonstrate the operation of a control principle called focussing " a tendency to experience the world in a narrow discriminating way". Schlesinger's idea of narrow attention was taken from Freud's (1926) concept of isolation. The isolator is described by Schaffer (1948) as exhibiting a tendency to keep ideas separate from one another. Freud suggested that this was accomplished by narrowing and focussing the field of attention. Shortly after Schlesinger's work Gardner et al (1959) demonstrated that people exhibit consistent differences in the extent to which they scan a stimulus field and examine many different aspects (high scanners) or fixate on relatively few different areas of the field. They (ie Gardner et al) also cite Schaffer's description of an isolator - but refer to a different part of his description where he notes that isolators have an increased repertoire of consciously accessible ideas - and suggest that this is related to the kind of broad attention exhibited by high scanners.

As Wachtel notes isolators appear to display both broad and narrow attention. He suggests that the apparent paradox is caused by the suggestion that there is only one kind of broad or narrow attention. To unravel the confusion he makes use of an analogy by Hernandez Peon (1964) who suggested that attention could be compared to a "beam of light in which the central brilliant part represents the focus, surrounded by a less intense fringe".

Wachtel suggests that the type of broad attention identified by Gardner (scanning) represents the movement of the beam around the field. High scanners move the beam frequently to sample many aspects of the attentional field, others (low scanners) show an opposite tendency.

He relates the narrowing of attention inferred by Schlesinger from Freud's writing to the width of the beam. When attention is narrowed the beam width is narrowed and a limited range of cues are processed. This sort of distinction has been accepted by other authors. As previously noted Kahneman (1973) states that attention can vary from wide to narrow; and that when attention is narrowed performance is impaired for tasks that "require deployment of attention over a broad range of information processing activities." Eriksen and Rohrbaugh (1970) state that at certain times attentional focus is at a "low power setting with a wide field of view".

This dimension of attentional width can also be related to Neisser's analogy referred to earlier where scanning is associated with the movement of the hand from one object to the next and beam width relates to the extent to which the person concerned receives and processes information from his fingers concerning the other, non chosen, objects.

However, these analogies are only of limited use - indeed it will be shown that to identify scanning as an index of attentional width is probably misleading. An illuminating picture of the central processes involved can be gained by looking at the situation from the point of view of control systems. Pask (1966) discusses the nature of cognitive systems and distinguishes (at least) two levels of operation.

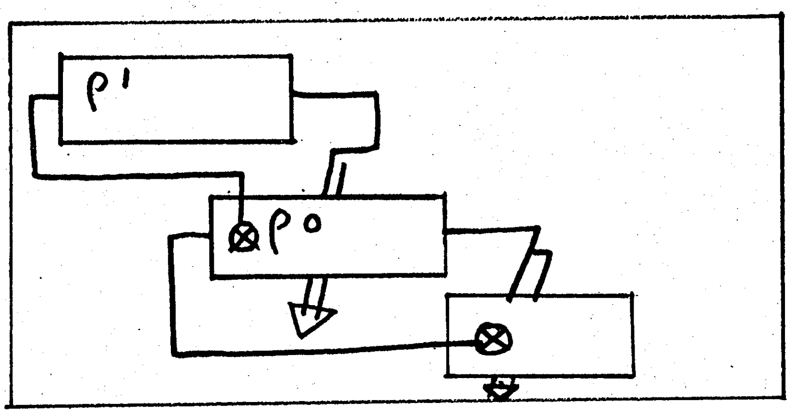


Fig. 3 (A control-system representation of attention directing mechanisms)

The box labelled ρ^0 contains an organisation resembling a TOTE or collection of TOTE UNITS as described by Miller, Galanter and Pribam (1960). The important point for the present discussion is that systems at ρ^0 operate on and sense properties of the environment, whereas the ρ^1 box represents control systems which recognise and direct overall properties of ρ^0 performance. Thus much of the actual expenditure of processing capacity referred to earlier takes place at the ρ^0 level whereas the allocation policy is controlled at ρ^1. As Pask notes, "the (ρ^1 attention directing) mechanism overlooks a collection of goal seeking systems operating below the level of commitment and one above this threshold".

ie

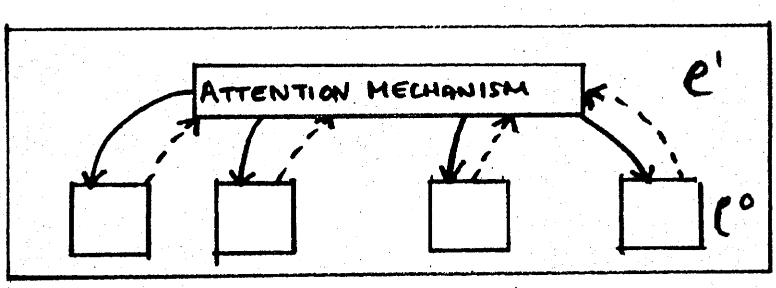


Fig. 4 (Goal seeking systems)

This formulation affords a better understanding of the status of scanning control as an attention deployment mechanism.

At first sight it may be tempting to relate scanning to changes from one ρ^0 system to another - however this is not appropriate. Consider a fairly simple situation where a person is searching a stimulus display in the hope of finding a particular configuration (eg searching an old school photograph for a friend). The $\mathcal{C}^{o}$ system does not change but the searcher would almost certainly give behavioural evidence of scanning the picture. Thus scanning may occur when the $\mathcal{C}^{o}$ system is unchanged.

Scanning represents a shift from one external object of attention to another - and does not represent a change from one goal directed sequence to another. This demonstrates that scanning control represents a very specific sort of broad attention. Some authors have associated scanning control with lability of attention. In terms of the present discussion this would imply that high scanners are continually re-assigning capacity from one goal directed sequence to another - this is clearly not <u>necessarily</u> the case. There is no reason to suppose that someone engaged in extensive scanning could not have an extremely stable allocation of capacity to a particular goal directed sequence. Indeed in the case of some individuals diagnosed by clinicians as obsessive this would seem to be the case. These individuals sample a wide range of information but do so very selectively and ignore anything not in accordance with their own point of view.

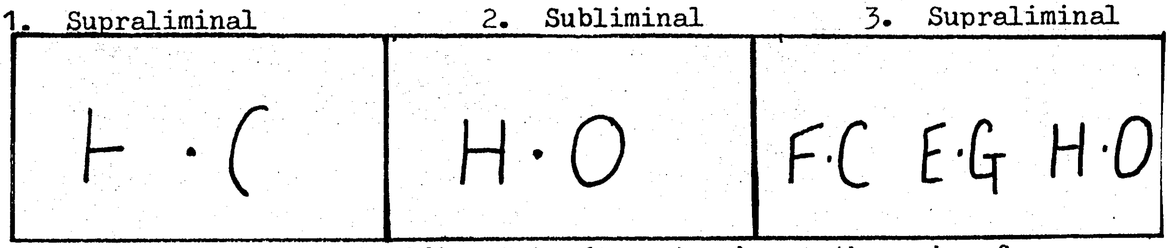
The status of the dimension of attention breadth referred to by Wachtel as beam width (from now on called width of attention) can also be examined more closely. In terms of the control systems formulation used above the width of attention refers to the range and extensiveness of $\mathcal{C}^{o}$ procedures operating concurrently. Thus, in general, when arousal is high and a task is being conducted the $\mathcal{C}^{o}$ procedures relevant to the dominant aspects of the task will be allocated relatively high amounts of capacity and peripheral activity of less immediate relevance to the task will not be conducted. So that, for example, in studies of incidental learning wide attention would be exhibited as higher recognition or recall scores for the incidental elements.

Attention and awareness

It is now appropriate to discuss the problem that is a particularly difficult one for a 'scientific' psychology to cope with - that is the relationship between conscious awareness and attention. To conduct an adequate discussion of the width of attention without addressing this problem is impossible. It is customary to suppose that there is a fairly direct relationship between attention and awareness ie stimuli that we do not become aware of have not been processed. As already noted the theories of selective attention discussed so far quite clearly imply that some sort of initial processing without awareness takes place ie pre-attentive psychologically 'silent' processes exist. What is not clear is the amount of psychologically silent processing that can take place after sensory registration of stimuli. Consider Treisman's theory which implies that a combination of stimulus characteristics and dictionary unit theshold determines whether or not a particular input will enter consciousness. The suggestion that unconscious processing takes place appears to be a contentious one - but nonetheless can be supported by considerable experimental evidence. Much of the evidence is contained in studies relating to subliminal perception and summarised by Dixon (1971). Although there is some criticism of the suggestion that subliminal perception exists the weight of evidence in favour of it is overwhelming. It is proposed here that evidence for the existence of subliminal perception can be construed as evidence of processing without awareness. In this context subliminal perception is assumed to have occurred when a stimulus elicits contingent responses from a subject when the stimulus is below an experimentally determined absolute awareness threshold and the subject reports no phenomenal representation of the stimulus. It will become apparent later in the discussion that an appreciation of the possibilities of processing without awareness or conscious control and the possibility of this affecting behaviour is critically important when considering the relationship between width of attention and other factors. Some of the evidence for processing without awareness and the conditions under which it is most likely to take place is given below.

A series of studies by Murch (1965, 1967, 1969) indicate the effect that subliminal stimulation can have on behaviour. In a typical experiment he presented subjects with displays on a three field tachistoscope. Stimuli in the first field were supraliminal presentations of incomplete letters, the second field contained subliminal possible completions of the incomplete letters, and the third field showed supraliminal possible completions. Subjects were asked to select letters from the third field which represented complete versions of the incomplete letters shown in the first field. The stimuli used are shown below.

1. Supraliminal 2. Subliminal 3. Supraliminal



Subjects exhibited a significant tendency to choose the pair of letters in the third field that had been presented subliminally in the second. Murch also noted that the effect of the stimuli "appears to require, however, a certain receptiveness on the part of the S. If S's respond without analysing the problems (ie intuitively) the incidental stimuli had a greater effect. Perhaps conscious processes are able to override the influences of incidental stimuli".

This is a finding that is repeated many times in research on subliminal perception ie that it requires a state that is antithetical to that of selective attention - the person involved should be in a relaxed passive, and non-attentive state. (Allison 1963, Fisher and Paul 1959, Murch 1969). The significance of this finding will be referred to later.

Rather than quote the many other positive findings - together with criticisms of one sort or another most of which are covered by Dixon (1971) it is sufficient to conclude that, if nothing more, the available evidence indicates that subliminal perception has been shown to occur. Of more interest to the present discussion are a number of related points.

As noted above the conditions under which subliminal perception takes place most easily are antithetical to those of selective attention. This is in keeping with the idea raised earlier that selective attention exerts a restricting effect on processing and (Easterbrook and Kahneman) as arousal increases attention is progressively narrowed.

Towards the end of his discussion of attention, after considering a large number of experimental studies, Kahneman concludes that attention <u>is divisible</u> and that the allocation of attention is a matter of degree. At high levels of task load it becomes more nearly unitary. He also makes the following comments about people attempting to conduct two tasks at once. "In the recognition experiments c conducted in my laboratory, subjects appear to adopt a passive attitude during the presentation of long (31 words/ear) dichotic lists of words. The phenomenology of the situation is suggestive; subjects report that they deliberately refrain from paying particular attention to any word". A quick experiment reveals the truth of this statement. Attempt to write down the numbers from say, 1 - 20 while repeating the alphabet at a slow, steady rate.

Dixon actually gives a detailed physiological explanation of subliminal and supraliminal processing and claims that they are dependent on the activation of two different arousal systems. Processing associated with supraliminal stimulation is influenced by the classical arousal system whereas subliminal processing is dominated by the limbic arousal system. Furthermore he associates processing of the second type with the psychoanalytical notion of primary process thinking and quotes experimental evidence to support this view. However it is unnecessary for the purposes of the present discussion to examine the physiology of the situation in any detail. Essentially it is suggested here that attention may vary from wide to narrow in the way described earlier. When attention is wide a larger range of information processing activities take place only some of which are represented in consciousness and that it is not necessary for processing to be phenomenally represented for it to exert an effect on behaviour. Furthermore it is postulated that when attention is more nearly unitary and focussed on the dominant aspects of a task the thinking that takes place is 'analytic' as opposed to 'intuitive', Bruner (1960) whereas when attention is wide the thinking is more likely to be intuitive. Neisser (1963) comments on Bruner's distinction.

"Analytic thinking characteristically proceeds a step at a time. Steps are explicit and usually can be adequately reported by the thinker to another individual. Such thinking proceeds <u>with relatively full awareness of</u> the information and operations involved.

Intuitive thinking characteristically does not advance in careful, well planned steps. Indeed it tends to involve manoeuvres based seemingly on an implicit perception of the total problem. The thinker arrives at an answer which may be right or wrong <u>with little if any awareness</u> of the process by which he reached it".

Neisser also groups intuitive thinking with the creative process, dreams, subliminal perception and other 'prelogical' experience as opposed to the logical processes of reason.

It is contended that the above formulation is not at odds with any of the general experimental findings related to attention and although it may be in contrast to certain theoretical points of view it essentially represents a synthesis of a number of slightly differing styles of examining the same problem.

Attention deployment and creativity

A person's width of attention can vary from being highly selective and focussed to the other extreme when during REM sleep, attention appears to be at its least selective and stimuli applied during or before sleep will elicit complex imagery and primary process associations (Fiss et al) (1966). The fact that intra-individual differences in attention deployment exist does not preclude the possibility that there are consistent inter-individual differences in attention deployment, Indeed the very fact that intra-individual differences do exist make it highly likely that inter-individual differences exist. The problem is whether the individual differences are first , unitary and secondly, large enough to exert a significant effect.

A number of investigations have, (at least implicitly) assumed that such differences do exist. Much of the pertinent experimental work has involved attempts to relate wide attention deployment to high creativity - a relationship that should be positive according to the preceding discussion. Various studies eg Mendelsohn and Griswold (1964), (1966), Laughlin (1967). Laughlin, Doherty and Dunn (1968) have examined the relationship between scores on a measure of creativity (Remote Associates Test) and indices of wide attention such as incidental learning. Although there are difficulties involved in disentangling the confounding effects of intelligence the general direction of the results in these studies indicates a positive relationship between incidental learning and creativity. As Bolton (1972) notes "It seems plausible to express the essential difference between incidental and intentional learning by saying that the one involves learning at the level of subsidiary awareness and the other learning at the level of focal awareness".

The idea of diffuse awareness accompanying creative thinking is not new and has been suggested by a number of other authors eg Ehrwenzweig (1967) Ghiselin et al (1964). The latter authors compared 'successful' and 'creative' scientists. They noticed a difference in the state of attention that the two scientists reported at the 'culminative moment of creative activity'.

Both report some flexibility, wavering and ranging of activity, but for the successful scientist this is heavily qualified by use of terms like "focused" and "sharp". As the authors note "... focus is concentrative and preclusive. Thus the adjective 'diffused' the opposite of 'focused' indicates an enormous advantage for the creative scientist, whose experience it characterises".

Thus a recurrent theme in the literature is that creative thinking is associated with a state very similar to the wide attention discussed earlier. It seems as if some of the thinking (processing) that takes place during problem solving behaviour does not appear at the focus of awareness - indeed it may not appear in awareness at all until the solution stage. Consider the reports of scientists who indicate that frequently when engaged in less mentally demanding activities they suddenly 'intuit' the solution to a difficult problem. Experiments by Fulgosi and Guilford (1968) and Dristadt (1969) testify to the usefulness of rest periods during problem solving which allow for 'incubation' Wallas (1926) when the unconscious takes over. De Groot (1965) who presents one of the most convincing arguments for the serial nature of (observable) complex thought notes that on occasions "... we are concerned with 'calculational serendipity', that is during routine calculations there may be a coincidentally evoked means-abstraction to the main goal". Phelan (1965) conducted experiments which suggested that premature attempts to verbalise (which presumably involves bringing into focal attention) may disrupt the more intuitive process needed during concept attainment. This finding is interesting in itself when one considers the increasing use of subjective, introspective reports - 'protocols' being used to investigate human cognitive processes eg Newell and Simon (1965) - and may explain why such investigations produce evidence for the serial nature of complex thought.

Summary

It is now appropriate to halt the discussion and to attempt to make explicit the central points that have been made.

1. Allocation of attention is synononomous with the allocation of processing capacity.
2. Processing is neither entirely serial nor parallel.
3. Attention can vary from wide to narrow. When attention is narrow processing capacity is allocated almost exclusively to the task at hand. When attention is wide activity is more distributed and cues less related to ongoing activity are more likely to initiate processing activity.
4. As arousal increases attention becomes more selective.
5. Some processing must take place without awareness or conscious control - but may still affect behaviour and conscious thought.

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6. Individual differences in width of attention are related to differences in creativity.

With the possible exception of the first - since it simply represents a universal theoretical assumption it has been shown that each of these points can be substantiated by experimental evidence. The points stated above are not intended to represent a new theory (or even point of view) but are merely intended to make explicit the direct implications of recent experimenting and theorising relevant to the concept of attention in general and of width of attention in particular. This was done so that the relationship of width of attention with an individual's learning style and cognitive structure could be studied. The preceding discussion was presented with the aim of supplying a theoretical perspective so that predictions could be made concerning the nature of such relationships and that any relationships found may be interpreted in a wider and more general context than that of one specific experimental situation.

On a more general level it is also felt that the study of attention and attention deployment has generated an extremely large amount of theoretical and experimental work - but much of this work has been confined to a fairly limited area. If this work is to be valuable in anything other than eg studies of vigilance and habituation it must be interpreted in a much more general field. An attempt at such an interpretation constitutes the next stage in this discussion.

General theories of cognition

Before examining the relationships that could be expected to exist between attention deployment and complex learning behaviour the construct of wide or narrow attention will be related to more general theories of cognition. Many current theories of cognition have something in common with the formulation suggested by Miller Galanter and

Pribram (1960) who introduced the notion of TOTE Units as sub processes or operations which may be organised into sequences of goal directed activity. Others eg Newell and Simon, Pascual Leone and Smith (1969) - in Case 1974, Pask (1971), Shallice (1972) concern themselves with related ideas such as schemes, procedures and action systems.

In these formulations it is suggested that humans function through the operation of processes which may operate serially or concurrently and under the guidance of executive programmes or plans may be integrated to form complex goal-directed systems. For the present discussion the factor of central importance is the consideration given to the possibility of activating more than one procedure at once. In some ways this corresponds to the ability to perform two tasks simultaneously - most people can drive a car and talk at the same time - however, when a difficult traffic situation occurs the driver will often interrupt his conversation, ie as noted before when the difficulty of the focal task increases performance of peripheral activity deteriorates. Allport, Anetonis and Reynolds (1972) have supplied experimental evidence that people can effectively conduct two tasks at once. In the experiment subjects were asked to shadow (ie repeat back) continuous prose passages read at a rate of 150 words/ minute - while they were sight reading music and playing the piano at the same time. The experimenters found that subjects could do this. Sight reading was as good with divided as with undivided attention. Also there was little or no effect under dual task conditions on the accuracy of speech shadowing. They claim that their results are wholly <u>in</u>compatible with a single-channel hypothesis though they do add the proviso that, "We do not wish to deny that the brain may, in certain circumstances, exhibit 'single channel' operation as a whole. This may occur when someone concentrates on a particular task: most, or all, of the specialised processors are being held 'on call' to the same message source whether they are in fact being used or not". The extent to which the tasks involved are routinised and 'easy' for the subject to carry out probably has considerable bearing on how successfully two tasks can be conducted in parallel. As already noted Shallice (1972), in his theory, also accommodates the possibility that thought is non serial by allowing for the concurrent operation of dominant and non-dominant action systems.

In the previous discussion of attentional styles it was suggested that modes of operation could vary from that of highly peaked attention, focused on one particular aspect of experience to more diffuse attention addressed to several aspects at once and characteristic of creativity, dreams, subliminal perception, intuition and other pre-logical experiences. This constitutes instituting several schemes, action systems or procedures at once. Any individual differences that exist (assuming that situational variables and other factors are not so obtrusive that individual differences are obscured) will be reflected as a common factor in studies of attention deployment, learning, problem solving and cognitive structure. Thus in problem solving or complex learning people will tend either to limit cognitive activity and progress through one goal directed sequence until at some point they cease and begin another or, at the other extreme they will attempt to develop several sequences together. Only a limited number of experimental situations are sufficiently rich and complex in terms of task requirements and process-oriented enough in terms of data collection to allow an examination of whether or not such differences can be observed.

Demonstrations of individual differences

In complex learning and problem solving situations people should exhibit the type of broad or narrow cognitive activity described above. Such differences have been observed in experimental situations.

Bruner et al (1956) examined the strategies used by people on concept formation tasks. These investigators began by distinguishing 'ideal' selection strategies - and then observed how the behaviour of individuals conformed to these strategies. In practice they found that individuals employed two forms of approach which could be interpreted as modifications of two of the 'ideal' strategies already identified. People could be classified as either 'focussers' or 'scanners'. The strategies that these people employed correspond fairly well to what would be expected on the basis of the type of broad or narrow cognitive style discussed above. Consider the description of how a focusser modifies the ideal Strategy "...the subject ceases to attend to those attributes of the focus card that have proved irrelevant when he makes new choices of instances to test. In a sense, this modification of the strategy consists of reducing the focus to those features that still count". A scanner is described below. "Instead of testing an hypothesis against chosen instances until it was found wanting and then going on to test another hypothesis 'de Novo' in the same way, subjects tried to remember the status of as many past instances encountered as possible so that they would not be starting from scratch with a second hypothesis". The authors note that subjects classified as scanners were in fact, combining features of 'ideal' strategies described as simultaneous and successive scanning. Simultaneous scanning requires the subject to keep track of every possible hypothesis and gradually eliminate them - successive scanning involves testing one hypothesis at a time. [Simultaneous scanning is, of course, very difficult and usually calls for pencil and paper aids].

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Unfortunately these authors do not supply much information concerning the consistency with which individuals choose different strategies although they do indicate that, for instance, people behave consistently as focussers or scanners over a series of three similar problems.

Newell and Simon (1965) investigated information processing during the solution of a chess problem. They also began by identifying theoretically extreme strategies described as "breadth first" or "depth first". In a "depth first" strategy once a particular position has been generated all deeper search beyond that position is carried out before that particular branch is abandoned. A breadth first strategy completes all positions at one level before going on to the next. To use an example other than chess; a depth-first approach would be displayed by a politician who examined, in detail all the possible effects of one policy option before giving any consideration to any other option. By contrast a breadth-first approach would be displayed by someone who took a quick, more or less simultaneous, look at some of the implications of several different options.

Newell and Simon go on to compare the 'protocol' (ie verbal commentary of what he is thinking) of a real subject with these extreme strategies. This comparison reveals that the <u>reported</u> strategy of the subject appears to lie somewhere between a breadth and depth first strategy. It can be construed, in fact, as a depth first strategy with additional short branches. Pask and Scott (1973) have studied the strategies exhibited when people are engaged in complex learning environments. They have identified differences in the tendency of learners to adopt various strategies. Of interest here is their distinction between holist and serialist strategies.

Serialist behaviour is characterised by the existence of only one goal, a propensity to move step by step usually in small increments. By contrast the holist may access several topics at once and develops his understanding on a broad front. As the authors note "... the serialist proceeds from certainty to certainty; the holist also achieves certainty at the points where explanation is required. But these points are embedded in a nexus of dimly perceived but often correctly perceived relations". This description has many similarities to Neisser's (1963) description of analytic and intuitive thought - a distinction that has already been related to wide and narrow attention.

All of these examples correspond to the sort of differences that would be expected on the basis of individual differences in width of attention.

<u>Summary</u>

It is suggested that there are stable individual differences in modes of deploying attention; ie some people will tend to operate with consistently narrower attention than others. Operationally this means that they will be relatively insensitive to the influence of peripheral information sources. It is suggested that width of attention is an underlying, consistent aspect of an individual's cognitive style (ie that it is useful to use this particular dimension as a way of describing and comprehending differences in cognition).

Differences on this dimension would be expected to be observable as differences in learning activity. A person with wide attention would be expected to behave in an 'holistic' fashion, processing and integrating a wide range of information; whereas a person with narrower attention would operate in a more 'serialist' fashion and would severely restrict the range of information used.

An investigation of the relationships between attention deployment learning activity, and cognitive structure is the subject of the next chapter.

CHAPTER 5

ROUTE TAKEN DURING LEARNING, ATTENTION DEPLOYMENT AND OTHER FACTORS

Introduction

As noted in Chapter 1 when students work on INTUITION they have to choose a route through the topics that make up the subject-matter. There is no single, pre-determined route for them to follow.

Earlier work using a learning environment similar to INTUITION* has shown that learners exhibit some consistencies when selecting routes through a large body of subject matter. As discussed in Chapter 4 Pask and Scott (1972, 1973) identified learners who behave as 'Serialists' or 'Holists'. Full details of the experimental method and the empirical and theoretical distinction between Holists and Serialists can be found in the papers cited. The aspect of the distinction most relevant to the present study concerns the number of topics that the different types of learners will work on at any one time.

Typically serialists will work on one topic at a time and when that is completely understood, move on to the next. The learner behaving as a holist will, in contrast to the serialist, frequently work on more than one topic at a time. Some qualification of the statement, 'work on more than one topic at a time', is called for, since it is difficult to imagine a student working on two topics at once in the sense that he is reading material from both at the same time. This does not, of course, happen. When a student is described as working on more than one topic at once this means that he has accessed one topic and has then obtained material for a second topic before demonstrating his understanding of the first. Thus the serialist accesses one topic at a time examines and uses the appropriate material

Footnote - * CASTE (see Chapter 1).

until he understands it completely and then moves on to a new topic. The holist will frequently access more than one topic at a time and appears to develop his understanding of topics to some extent simultaneously. These differences in learning behaviour have been demonstrated on various occasions by Pask and Scott and appear to be fairly stable modes of activity. The serialist/holist distinction has been further refined, Pask, (1973), (1975) and includes a consideration of the extent to which learners develop their understanding on a 'local' or 'global' basis and distinctions between operation and comprehension learning. A non-technical discussion of these ideas is provided by Daniel (1975). Interest here is centred on the demonstration that, in general terms, some people conduct their learning activity in a controlled, localised fashion and introduce minimal complexity or breadth. These people prefer to work on a single topic at a time, gain full understanding of this and whenever possible continue within the same area of subject matter using the same terminology along an orderly, inferential route.

Conversely there are learners whose activity, from an external observer's point of view, appears less orderly and less predictable and who appear to extend their understanding in a global fashion by investigating more than one area of work more or less simultaneously.

The work described in this thesis using the INTUITION equipment was the first concerted effort to use the equipment as a teaching instrument with a complete course and a number of subjects. However, the differences described above were expected to be manifest when students used INTUITION since in many essential ways INTUITION is similar to situations used earlier ie

1. Discrete named topics to be learned are displayed to the

student.

2. Some topic relations (specifically entailment and analogy) are displayed.

3. Certain fundamental rules operate that restrict the order in which students may attempt to learn topics.

4. There is an eventual aim so that the student can recognise when he has finished the exercise.

This situation is clearly different from others that learners may have found themselves in, for example a lecture where topics are presented in an order determined by the lecturer who may or may not specify various topic relations and correspondences.

Differences in Route Taken

The complete topic display and interrelationships for modules 1 and 2 is shown at appendix (1). The routes taken by each student are also shown at appendix (7). The records show that no students do, in fact, access two nodes at any one time, however there are large and consistent differences in routes taken that indicate that some students move forward in a compartmentalised fashion within a restricted, canalised area of the subject matter; whereas others move forward on a much broader front, improving their understanding of a number of different areas more or less simultaneously. These differences are visible when the extent to which students adopt a 'depth-first' or 'breadth-first' approach are examined. A depth-first approach would be displayed by a student who, for example, began work on the lowest topic of the Real world, then progressed through all of the other topics in the Real world without working on any topics in either the Analogical or Abstract areas until he had completed all of the Real world. Thus a student displaying a perfect depth-first approach would begin work on a particular area (Real or

Abstract) and confine his activity to this area until all relevant topics were understood. Then he would move on to a new area.

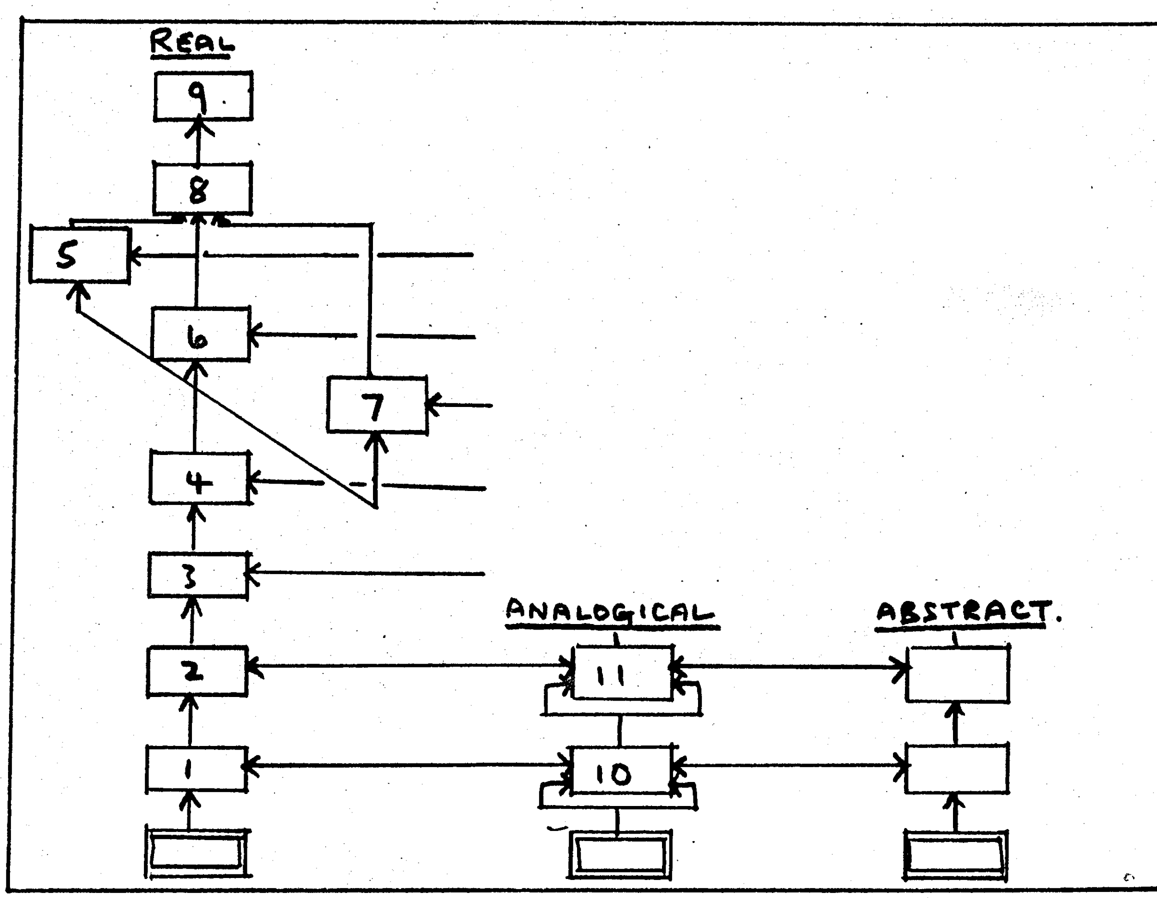

Fig. 1 (Example of Depth-First Approach)
(Student No 7, part of module 2)

Conversely a breadth-first approach would be displayed by a student who, for example, completed one or two nodes in the Real world, then did an Analogical node followed by two nodes from the Abstract world then another two Real world nodes and continued to move from one universe to another as he progressed through the material. In practice, although a number of students adopted a 'pure' depth-first approach (as in Figure 1) none adopted a 'pure' breadth-first approach.

Several students, like the one in Figure 2 adopted an approach that included considerable 'breadth-first' activity.

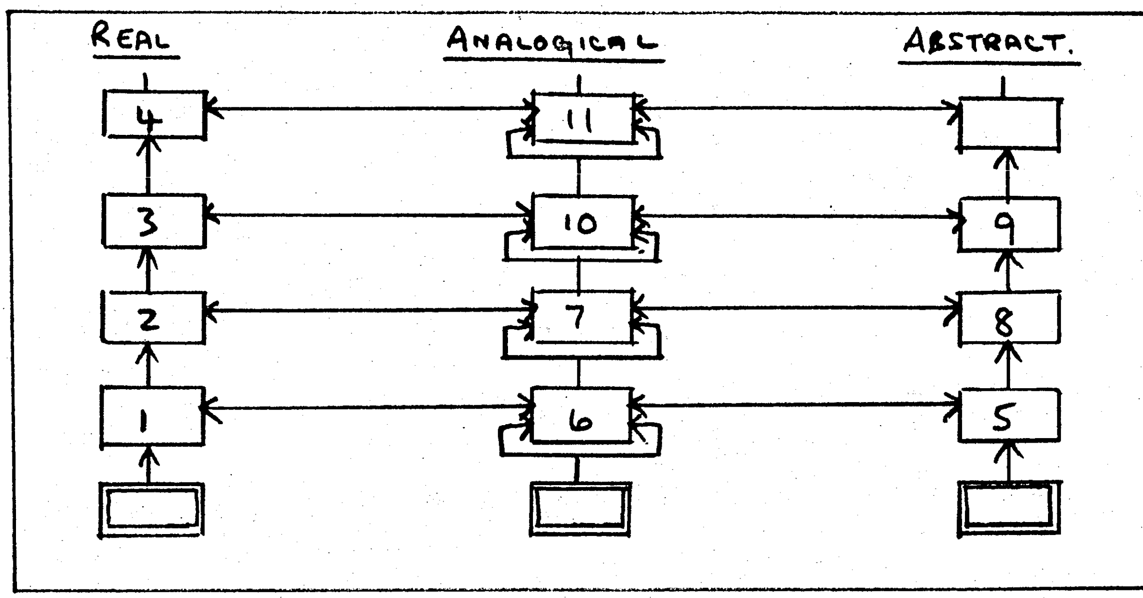

Fig (2). (Example of a Breadth-First Approach)
(Student No 1, part of Module 2)

A student who adopts a breadth-first approach, although he does not actually access two nodes at once, is in effect working on more than one thing at once. Different sets of terminology are used for topics in the Real, Analogical and Abstract areas of the structure and on this basis alone a student who moves through the topics on a broad front can be seen to be extending his comprehension of three different sets of terminology more or less concurrently, compared to the depth-first student who confines his activity to one universe of discourse until he has covered all appropriate topics and then moves on to a new area. It should be noted that it is irrelevant which areas a student learns first The depth-breadth distinction relates only to the extent to which a student advances on a broad front or on a narrow one.

Students' progress can be displayed graphically to indicate the extent to which they advanced on a depth or breadth first basis. This is done by plotting each occasion (ie each topic worked on) against the number of topics already understood that belong to a different area of the subject matter. For instance if on a particular occasion a student is working on a Real world topic the number of Analogical and Abstract topics that he already understands are plotted against the occasion number. Thus the graph for the breadth-first approach will advance in a large number of small steps whereas the depth first graph will show a smaller number of much higher steps.

No of topics understood in different universe

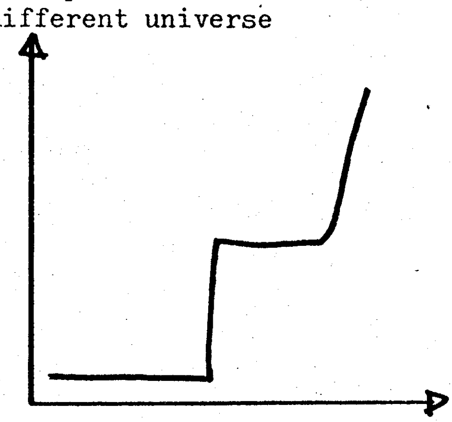

Fig (3) (Illustrative graph of Depth-First Approach)

No of topics understood in different universe

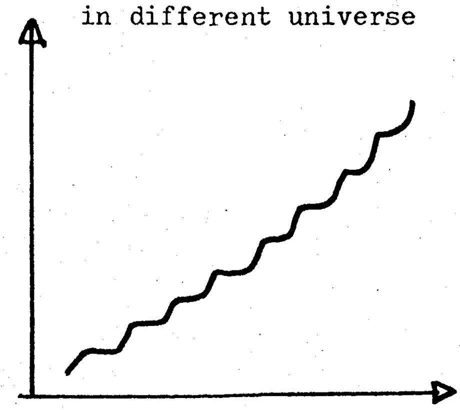

Fig (4) (Illustrative graph of Breadth-First Approach)

This technique gives a clear indication of the extent to which a student moved forward on a narrow or broad front. It is possible to plot two theoretical extreme approaches (ie extreme or 'perfect' depth and breadth first). A complete set of graphs (ie theoretical extremes for each module followed by graphs for each student) are shown at appendix (8).

Reliability

Before possible personality correlates of depth/breadth learning activity can be examined it must be shown that student performance does not vary widely from module to module.

For module 2 the graphs can be used to compute a value which indicates the extent to which a student advances in a depth or breadth first fashion. This is done by comparing the total vertical distance moved with the number of individual vertical jumps taken to move that distance.

ie Score = $\frac{\text{Total vertical distance moved}}{\text{No of vertical jumps}}$

Thus the higher a student's score the more he adopted a depth-first approach. (Scores produced in this way are only ever used in future analyses to rank-order or dichotomise groups of students).

For module 1 it is more difficult to follow this scoring procedure, mainly because there is not an exact correspondence of nodes in the Real, Analogical and Abstract areas and this produces artificial leaps in the graphs. However by inspecting the graphs and the original record sheets it is possible to arrange students in a rank-order, though a number of tied ranks are produced where it is not possible to separate groups or pairs of students.

Student	Module 1		Module 2	
	Rank N = 14	Rank N = 10	Score	Rank
1	2	1	2.125	1
2	6	4	3.6	2
3	6	4	4.0	3
4	6	4	4.5	4.5
5	6	4	4.5	4.5
6	6	4	6.0	6.0
7	13	9.5	9.0	8.5
8	13	9.5	9.0	8.5
9	10	7.5	9.0	8.5
10	10	7.5	9.0	8.5
11	2	-	-	-
12	2	-	-	-
13	10	-	-	-
14	13	-	-	-

Table 1 (Depth-Breadth learning strategy)

A clear relationship between performance on Modules 1 and 2 is apparent from these data. Appropriate statistical procedures are difficult (and perhaps even unnecessary) to find. As a safeguard various correlation coefficients were computed (Rank Order, Biserial, Cureton's Rank Biserial). The most conservative produced a correlation coefficient of +0.85.

Personality variables related to depth/breadth first learning

The major interest of this study is how differences in learning behaviour are related to personality. A personality trait may be viewed as an underlying disposition or characteristic that is related to an individual's overall behaviour pattern. As such, personality traits may be used to predict or explain learning behaviour; so that, for example, someone assessed as self-confident could be expected to display self-confident learning behaviour. This is the sort of relationship looked for in earlier parts of this study (Chapters 2 and 3).

Personality theorists have examined alternative ways of 'cutting the personality pie', and considering cognitive personality factors. Whereas conventional traits are intended to be indicative of stable predispositions to behave in certain ways, cognitive factors refer to individual consistencies in methods of processing and storing information. There is evidence to show that some aspects of an individual's cognitive style will vary depending on how he construes the environment that he is in and factors such as interest, abstractness, familiarity and complexity may encourage variation in style from situation to situation. On the other hand cognitive styles have been shown to exhibit high stablility across situations eg Witkin (1974). Thus aspects of cognitive style may be more stable and more relevant to the study of individual differences than more conventional personality traits. This Chapter is concerned with the relationships between what may be described as cognitive personality traits and the extent to which students adopt a depth or breadth first approach to learning.

Evidence cited earlier (Chapter 4) has shown that learners and problem-solvers may differ in the extent to which they attempt to conduct many or few activities 'at the same time'. It is possible that these differences are manifestations of consistent individual differences in cognitive style. At one extreme of the cognitive style dimension are people who limit cognitive activity and follow through the task at hand to a conclusion without being distracted along other lines of enquiry or assimilating anything other than 'relevant' information. At the other end of the scale are people who seem to be engaged in several uncompleted activities at any given time, who appear to assimilate 'irrelevant' information and develop their knowledge of available topics in a broad, global and to some extent unregulated fashion.

The earlier discussion of attention deployment showed that individual differences in width of attention may exist and demonstated how width of attention could be related to learning and problem solving.

It is hypothesised that a learner with narrow attention deployment will tend to exhibit a depth-first approach to learning, whereas a student exhibiting wide attention will display a breadth-first approach. **(A method of measuring width of attention is described later).**

Cognitive complexity

The growing interest in cognitive personality factors has produced a number of 'new' personality dimensions one of which is the cognitive simplicity -complexity dimension. Some authors eg Bannister and Fransella (1971) warn about the possible lack of generality for this dimension and others eg Vannoy (1965) have demonstrated that there is no single dimension of complexity-simplicity; nevertheless with the exercise of suitable caution cognitive complexity is a profitable area of interest.

A cognitive system is composed of a set of elements that are in varying degrees and kinds of relationship to one another and following Kelly

(1955) the elements can be designated personal constructs.

As Vannoy (op cit) has shown cognitive complexity is not a unitary dimension. Crockett (1965) has distinguished between 'differentiation' and 'hierarchical integration'. Differentiation refers to the number of constructs in a system. The degree of hierarchical integration refers to the complexity of the relationships among constructs and to the degree to which clusters of constructs are related by superordinate integrating constructs. Hinkle (1965) and Makhlouf-Norris et al (1970) have developed techniques for measuring hierarchical integration.

The aspect of cognitive complexity of principal interest here is that of differentiation. Bieri (1966) describes an instrument designed to measure cognitive complexity and states that, "cognitive complexity may be defined as the tendency to construe social behaviour in a multi-dimensional way". The implication of this is that the Bieri test is a test of differentiation. Crockett and other authors eg Adams-Webber (1969) classify it as such and the factor-analytic study conducted by Vannoy indicates that such a classification is appropriate.

Thus the Bieri test can be seen as an instrument for examining a particular aspect of cognitive complexity-differentiation. The development of a complex, multi-dimensional, cognitive system will depend on the cognitive processes involved in extending and elaborating the system (ie learning) and individual differences in cognitive complexity will, presumably, be associated with individual differences in learning and people who learn in a global, breadth-first fashion and develop their understanding of a wide range of topics more or less simultaneously will develop a more multi-dimensional construct system than people who use a depth-first approach.

A specific hypothesis can now be generated.

The hypothesis states that individuals who use a breadth-first approach on INTUITION will exhibit a more complex interpersonal construct system (as measured by the Bieri test) than depth-first learners. Underlying this hypothesis is the belief that the extent to which a learner adopts a depth or breadth first approach is consistent and is not strongly influenced by situational factors or subject-matter. This will be discussed more fully when the data has been presented.

Measurement of Personality Dimensions

The instruments used to measure the personality dimensions considered in this study are described below.

Attention Deployment

The test was required to examine the extent to which individuals distribute their attention and make use of a broad range of cues rather than attending exclusively to those at the focus of awareness. A test of attention deployment developed by Mendelsohn and Griswold (1965) was modified slightly and used to measure width of attention.

Students were supplied with a list of 25 words to learn*. The words were typewritten in list form down the middle of an A4 sheet of plain paper. Students were given the following instructions:

> You will be given a list of words to memorise. They can be learned in any order, and you may use any device you wish to aid you in memorisation. You will have 10 minutes to learn the words and later on you will be asked to write down the words you remember.

---

* All words are five letter words taken from the Thorndike-Lorge list and are approximately matched for frequency of occurrence. Full details of all words and anagrams used are given in Appendix (9).

There is more, however! During the time you are learning the words, another list of words will be played on this tape recorder. You are asked to try to concentrate on the list in front of you and to memorise it as well as you can while the other words are being played in the background. In addition, after your 10 minutes are up, you will be asked to solve some problems. When the problems are over, then you will have a chance to write down the words you remember from the list you have memorised. Do you understand?

The problems were 30 single solution anagrams. Ten of the solution words were drawn from the memory list, ten from the tape list and ten belonged to neither list. As soon as the ten minute learning period was completed students were told that they would be given some anagrams to solve and were supplied with a blank sheet of paper to write solutions on. The anagram cards (Appendix 9) were placed in front of the students and removed, at the rate of one every ten seconds while students wrote down as many solutions as possible.

When all 30 anagram cards had been presented the students were asked to write down all of the words that they could remember from the memory list. They were given a time limit of five minutes though all of the students 'dried-up' well before this limit. Finally they were asked to write down all of the words that they could recall from the tape list.

Thus students are provided with two sets of cues to help them solve the anagrams. One set of cues, the list that they are asked to memorise, are presented at the focus of attention and another set of cues, the tape list, are presented peripherally.

The anagrams solved by each student were categorised according to which list they were originally in (memory, tape or neither) and a score (p/c) was computed to examine the extent to which participants made comparatively greater use of peripheral cues.

$$\text{p/c Score} = \frac{\text{\% Anagrams from tape (peripheral) list solved correctly.}}{\text{\% Anagrams from memory (central) list solved correctly.}}$$

Cognitive Complexity Test

As already noted the Bieri test of cognitive complexity was used to measure the extent to which students construe their environment in a multi-dimensional or uni-dimensional fashion. The test is a modification of the Role Construct Repertory test developed by Kelly. Students were required to list 10 'significant others' (mother, father, etc...)* ensuring that they listed ten real people, not just role names. They were provided with a list of 10 bipolar constructs instead of constructing their own as they do with the normal version of the RCRT. Associated with each bipolar construct is a six point scale from +3 to -3.

Using a 10 x 10 matrix as in fig. (5) with columns to represent significant others, rows as constructs, the student was asked to rate each significant other on each bipolar scale

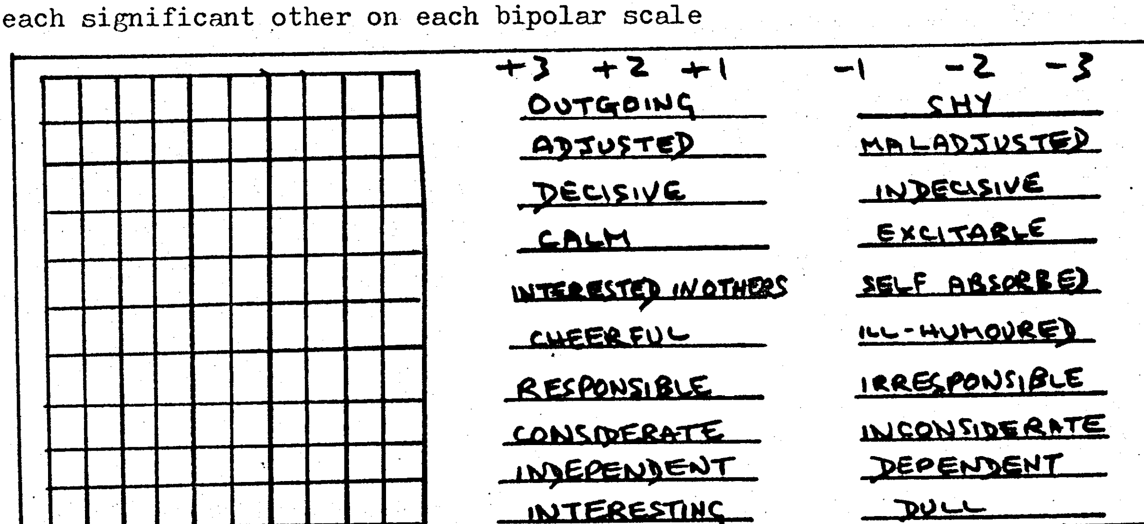

Fig (5) (The Bieri test of cognitive complexity)

* A full list is given at appendix (10).

A cognitive complexity score was then computed by examining one column at a time. The ten cells in each column will give rise to 45 possible pairs - each pair is considered and a mark of +1 assigned every time a pair shows exactly the same score on the six point scale.

Fig (6)	Fig (7)
+3	+3
+2	+1
+1	-1
+3	-2
+3	-1
+3	+2
+2	-3
+3	+1
+3	+1
+3	-2

Thus the column in Fig (6) would be given a score of 22 and a score of 5 would be assigned to the column in Fig(7).

This scoring procedure is followed for each of the 10 columns ie a total of 450 comparisons - making a total possible score of 450.

The matching procedure adopted for scoring this test is similar to intercorrelating all of the rows (constructs). A low score (low correlation) indicates that the respondent is making use of the discriminating power of the 10 bipolar constructs and using them as relatively independent dimensions along which to assess other people. Conversely a high score indicates a high level of interrelationship, or functional equivalence, between constructs and a lack of multi-dimensionality.

Thus the lower a person's score the more multi-dimensional his judgements of others are thought to be. To obtain a low score the respondent must assign a wide range of scores to each person that he is asked to judge and not produce a large number of identical ratings.

Other Measures

As well as the attention deployment and cognitive complexity tests two other measures were used.

Problem-Solving Test (Persistence or Flexibility)

This test was designed by the writer as an attempt to relate problem solving activity to the indices of attention deployment, cognitive complexity and learning that have already been discussed. The test described below was developed specifically for the present study. The object of the exercise was to present students with the opportunity to attempt to solve a problem and to enable the experimenter to observe the degree of persistence or flexibility, shown by students. They could behave persistently and attempt to pursue one possible solution route, only choosing a new route after lengthy and consistent invalidation. Alternatively they could show considerable flexibility abandoning possible routes as soon as any potentially invalidating evidence arises.

It was hypothesised that individual differences in performance on this test would be related to soores on the attention deployment and cognitive complexity test and to depth-breadth first learning. As far as this particular test is concerned it was suggested that people who do not restrict and focus their attention would be easily deflected from any potential route to solution and thus show less persistent behaviour. This prediction was based on the expectation that students with wide attention deployment would be influenced by more 'irrelevant' factors that may incline them to consider an alternative approach to the one currently being pursued; whereas students who pay less attention to 'irrelevant' factors would show less inclination to change their approach once they have established a possible solution route.

It is worth noting that neither of these approaches to problem-solving is necessarily more efficient. One approach could lead to the error of giving up too easily on a correct solution route, the other to persisting for too long with fruitless attempts.

Considerable developmental testing was involved before arriving at the final form of the test - which is described below. Full details are given in appendix (11). The problem posed was made deliberately insoluble so that student behaviour could be observed over a substantial period of time.

The student was placed in a role playing situation where he was cast as the personnel manager of a company. He was given an industrial relations problem to solve.

In the problem situation he was supplied with a list of five separate demands (extra wages, better facilities, etc) being made by union officials within the company, each demand cost a specified sum of money. The student was given an overall limit concerning the amount of money that he could use in complying with union demands. (This was considerably less than the total sum requested). The student was given a few minutes to consider the money available and the union requests and to decide how he wished to set about solving the problem (essentially this must always involve him in offering the union less than they have demanded for each of the five items, but it is up to him to decide which items he will offer relatively little money for and which items he will offer larger amounts for).

Next the student met the union negotiator, played by the experimenter, in a series of meetings*. At each meeting the student stated the offer that he wished to make (this must always be a specific sum of money for a specific single item). The union negotiator stated that he accepted or rejected the offer and the meeting was closed. No discussion whatsover took place.

The student's aim was to secure agreement after the least possible number of meetings. Students were told that whenever they repeated an offer (ie made exactly the same offer at meeting 'n+1'as at meeting 'n') the union would either accept the offer or call a strike. Any subsequent repeated offers would have the same outcome; either the strike would continue or the union would agree to the offer. When a new offer was received the union members would return to work.

It was pointed out to students that they were unaware of the extent of the union's strike funds and it was possible that the union was extremely wealthy and could put up with many weeks on strike, or relatively poor and only able to support strikers for a limited period. So that, possibly, by repeating offers the student could force the union into agreement.

Students were also informed that the board of directors were unconcerned about how many strikes were caused as long as agreement was eventually reached.

For the first twenty meetings according to a pre-determined plan, the negotiator rejected every offer that the student made irrespective of what the offer actually was. From meeting 21 onwards a pre-

* These do not constitute meetings in the normal sense, ie no physical coming and going is involved. The student and experimenter are always in the same room and the student simply indicates that he is ready to hold a meeting.

determined sequence of rejections and acceptances was followed to maintain the pretence and bring the exercise to an end. When questioned afterwards students expressed surprise that the sequence of responses was pre-determined and without exception claimed that they believed that the union negotiator did, in fact, have genuine requirements and if appropriate offers had been made he would have accepted them. The point of interest is the number of repeated offers that students made over the first 20 meetings. The actual number of repeated offers is taken as an index of the extent to which students persisted with possible solution routes in the absence of any validatory feedback

The test was designed in the way described to satisfy several criteria that were important and needed to be met before a successful examination of individual differences in problem-solving could be undertaken.

The test was an attempt to study problem solving strategies, in particular the extent to which students tried different approaches or persisted with a single approach.

1) It was designed so that problem solving attempts could be observed as an integral part of the exercise. The offers stated at each meeting were an integral part of the exercise, but they also exteriorised the student's latest attempt at finding a solution route.

2) The problem presented was deliberately insoluble so that no particular solution attempt would be encouraged or reinforced in favour of any other (During developmental testing consideration was given to agreeing to students' offers on a random basis; however this gave artificial encouragement to specific attempts or procedures and had a contaminating effect

on students' behaviour.

3) The problem was interesting to students and, although it was in reality insoluble, students felt that they were faced with a problem that could be solved.

4) The problem chosen was one that subjects would not have had any first hand experience of and they would not have developed any routinized ways of responding that could mask or bias any individual differences in flexibility or persistence.

5) An index of how persistent or flexible a student had been could be obtained by an objective procedure. (In practice this was done by counting the number of repeated offers).

Self-Consistency Test

This attempted to measure the extent to which people see their own characteristics as compatible, or as incompatible and contradictory. The particular test used was developed by Gergen and Morse (1966). Students were supplied with two lists, each containing 17 trait names. One list contained socially desirable trait names, the other undesirable trait names. (The basis for the lists was a separate study by Gergen and Morse, using another group of subjects who were asked to classify the trait names as positive or negative in character.)

Students were asked to select five traits from each list that most closely represented attributes that they possessed. The trait names were then transferred to a 10 x 10 matrix and students were asked to compare each trait with each other trait and state whether they are seen as compatible or not, using a four point scale ranging from 0 (Entirely compatible) to 3 (Incompatible and contradictory). Details are given in appendix (12).

A self-consistency score was obtained by summing the ratings given

A student obtaining a high score would have marked a large number of his traits as incompatible and contradictory. The hypothesis was that a tendency to view oneself as possessing incompatible, contradictory characteristics will be associated with cognitive complexity and thus breadth-first learning.

Hypotheses Concerning Route Taken

Hypothesis One

People who display a breadth-first approach to learning (on INTUITION) will exhibit wider attention deployment (measured by the attention deployment test described earlier) than those who follow a depth-first approach.

Hypothesis Two

People who display a breadth-first approach to learning (on INTUITION) will be more cognitively complex (as measured by the Bieri test) than those who follow a depth-first approach.

Hypothesis Three

People who display a breadth-first approach to learning (on INTUITION) will display less persistent behaviour (ie make fewer repeat offers on the problem-solving test designed by the writer) than those who follow a depth-first approach.

Hypothesis Four

People who display a breadth-first approach to learning (on INTUITION) will exhibit less self-consistency (as measured by the Gergen-Morse test) than those who follow the depth-first approach.

Relationships between Personality measures

In addition to investigation of the hypotheses the results were examined to determine the relationships between the various personality measures used. The personality tests used should, in fact, be strongly interrelated. Attention deployment, in particular, which is viewed as the most fundamental factor considered, should be related to all three other measures.

The predicted direction for interrelations is given in table (3) below

	1	2	3	4
1. ATTENTION DEPLOYMENT (NARROW = LOW SCORE)	X	-Ve	-Ve	+Ve
2. COGNITIVE COMPLEXITY (COMPLEX = LOW SCORE)		X	+Ve	-Ve
3. PROBLEM SOLVING (FLEXIBLE = LOW SCORE)			X	-Ve
4 SELF-CONSISTENCY (CONSISTENT = LOW SCORE)				X

Table (3) (Predicted direction of correlations)

Analysis of Results

Before the analysis is discussed a means of classifying students as depth or breadth-first learners will be described.

Classification of Students - Module 1

For module 1 students were classified as depth first if and only if they had exhibited 'perfect' depth-first behaviour, all other students were classified as breadth-first. This gives groups of 8 (breadth) and 6 (depth).

This was, in fact, the most sensitive method of treating the module 1 data that circumstances allowed since although it was easy to identify the 'pure' depth-first students there were no 'pure' breadth first students and as noted earlier it was impossible to even put the students in a rank order without many tied ranks. To divide the students into two fairly equal sized groups on the basis of 'pure depth-first' and 'others' seemed to be the most sensible approach for the module 1 data, although it involved a possible slight loss in sensitivity. In fact, dichotomising students in this way probably decreased the likelihood of significant differences being found between the two groups on other tests used and ensured that any hypothesis testing for the module 1 data was rather stringent.

Classification of Students - Module 2

For module 2 the graphs at appendix (8) were used to produce the scores described earlier (see p144) to indicate the extent to which students adopted a depth or breadth first approach. On the basis of these scores the students were divided into two equal sized groups (N = 5).

Because of the difficulty involved in combining scores on this dimension analysis was conducted using data for module 1 and 2 separately.

Numbers of topics worked on

As noted in Chapter 1, because of the correspondences and similarities between topics it is not necessary for students to actually work on all of the topics displayed on the concept-map.

When records are examined very slight differences can be seen between depth and breadth first students concerning number of topics worked on. Breadth first learners tended to work on slightly more topics per module than depth first learners. This is particularly true on Module 2.

Module 1. No of topics worked on		Module 2 No of topics worked on	
Depth First	Breadth First	Depth First	Breadth First
13 13 13 16 16 21 = 92	21 14 14 14 13 16 18 13 =123	19 19 19 19 27 =103	27 24 24 21 19 = 115
Mean = 15.3	Mean = 15.4	Mean = 20.6	Mean = 23

Table 2 (Mean Nos of Topics worked on by Students)

Thus, in some ways, depth first learners took a shorter, more direct route through the material. The differences are not large and this feature is not in any way critical to the distinction between depth and breadth first learners.

Examination of Hypotheses

Statistical techniques

Before examining the hypotheses a brief discussion of the statistical techniques to be used will take place. It could be argued that non-parametric techniques would be more appropriate to the analysis of data presented in this chapter, however McNemar (1969) presents a convincing argument in favour of using parametric techniques even when the assumptions of normality of distribution and homogeneity of variances are violated. He quotes evidence from Boneau who calculated 1000ts for the difference between independent means for each of 20 different combinations of conditions with regard to Ns, shapes of distributions and equality or inequality of variances and found that violated assumptions had negligible effects on the significance of the t values obtained.

McNemar concludes that"....the worry about violating this assumption (of normality) is unfounded".

In the analyses reported in this chapter parametric techniques will be used. When a t test for samples with heterogeneous variances is needed a technique described by McCall (1970) will be used.

Hypothesis One

This concerns the relationship between attention deployment and learning activity. The relevant data are given below.

Student No	Anagrams solved: Total No of anagrams solved	No from Central memory list	No from Peripheral tape list	No Peripheral / No Central	Depth or Breadth Classification: Mod 1	Mod 2
1	12	5	5	1.0	B	(2.125)B
2	14	4	8	2.0	B	(3.6)B
3	12	6	4	0.66	B	(4.0)B
4	14	4	7	1.75	B	(4.5)B
5	9	4	3	0.75	B	(4.5)B
6	11	6	3	0.5	B	(6.0)D
7	13	7	4	0.57	D	(9.0)D
8	14	7	5	0.71	D	(9.0)D
9	13	5	3	0.6	D	(9.0)D
10	12	5	4	0.8	D	(9.0)D
11	14	5	5	1.0	B	-
12	16	4	6	1.5	B	-
13	13	6	4	0.66	D	-
14	9	5	4	0.8	D	-

Table 4 (Scores on attention deployment test)

An examination of scores for the attention deployment test makes it clear that students made use of cues presented both on tape (peripherally) and in the memory list (centrally). This is demonstrated by the number of anagrams solved that belonged to neither list (ie students were not exposed to them during the experiment except as anagrams). The number of anagrams solved that belonged to either the tape or memory list is very similar and a 't' test shows no significant difference. The number of solved anagrams belonging to neither memory or tape list is much smaller and 't' tests show that the number of solved anagrams that belong to neither list is significantly less than the number solved from the tape list($p < .01$, 2 tailed test) or the memory list ($p < .001$, 2 tailed test).

Thus students appear to make use of the cues provided.

The predictions state that students adopting a breadth-first approach on INTUITION should display wide attention deployment; ie they should make use of the peripheral cues to solve proportionately more of the anagrams from the words presented peripherally (on the tape list) and obtain a higher p/c score; where

$$p/c = \frac{\text{\% Anagrams Solved from tape list}}{\text{\% Anagrams solved from memory list}}$$

Relevant data are given below:

Module 1				Module 2			
Breadth First		Depth First		Breadth First		Depth First	
Student No	p/c	Student No	p/c	Student No	p/c	Student No	p/c
1	1.00	7	0.57	1	1.00	6	0.50
2	2.00	8	0.71	2	2.00	7	0.57
3	0.66	9	1.60	3	0.66	8	0.71
4	1.75	10	1.80	4	1.75	9	0.60
5	0.75	13	0.66	5	0.75	10	0.80
6	0.50	14	0.80				
11	1.00						
12	1.50						
	$\bar{x}$ = 1.145		$\bar{x}$ = 0.69		$\bar{x}$ = 1.232		$\bar{x}$ = 0.636

Table 5 (p/c scores for attention deployment test)

The hypothesis is that the p/c score for the breadth first group will be significantly larger than that for the depth-first group; ie breadth-first learners will exhibit wider attention deployment than depth-first leaners.

Module 1

A 't' test for independent groups with heterogeneous variances McCall (1970) shows a significant difference in the predicted direction.

t, critical = +1.982 (for .05 level)

t, observed = +2.29 ($p < .05$, one-tailed test)

Module 2

A 't' test for independent groups with heterogeneous variances shows a significant difference in the expected direction.

t, critical = 2.132 (for .05 level)

t, observed = 2.156 ($p < .05$, one-tailed test).

Thus the data for modules 1 and 2 support the hypothesis.

Further examination of the results shows that there are no significant differences between the depth and breadth-first groups in total number of anagrams solved (t, mod. 1 = 0.385; t, mod. 2 = 0.381), confirming that differences between the depth and breadth first groups are differences in the distribution of the number of anagrams solved from peripheral and central groups, rather than differences in the total number solved.

Hypothesis Two

This concerns the relationship between cognitive complexity (as measured by the Bieri test) and learning activity. Relevant data are shown below:

Scores on Cognitive Complexity Test

Module 1				Module 2			
Breadth First		Depth First		Breadth First		Depth First	
Student	Score	Student	Score	Student	Score	Student	Score
1	102	7	129	1	102	6	191
2	83	8	171	2	83	7	129
3	124	9	119	3	124	8	171
4	107	10	144	4	107	9	119
5	121	13	137	5	121	10	144
6	191	14	114				
11	125						
12	129						
	$\bar{x}$ = 122.75		$\bar{x}$ = 135.67		$\bar{x}$ = 107.4		$\bar{x}$ = 150.8

Table 6 (Scores on the Bieri test of cognitive complexity)

The hypothesis is that the breadth first group will obtain lower scores on the Bieri test (ie will be more cognitively complex).

Module 1

A 't' test for independent groups with homogeneous variances shows that the difference between the groups is not statistically significant (t = 0.99), although it is in the predicted direction.

Module 2

A 't' test for independent groups with homogeneous variances shows a significant difference between the groups in the expected direction ($t = 2.84$, $p < .025$, one-tailed test).

Thus the results for module 1 show a difference in the predicted direction (not statistically significant) and the results for module 2 support the hypothesis.

Hypothesis Three

This concerns the relationship between problem-solving behaviour and learning. Relevant data are shown below:

No of repeats on Problem-Solving Exercise

Module 1				Module 2			
Breadth First		Depth First		Breadth First		Depth First	
Student	Repeats	Student	Repeats	Student	Repeats	Student	Repeats
1	3	7	12	1	3	6	13
2	7	8	12	2	7	7	12
3	6	9	15	3	6	8	12
4	6	10	5	4	6	9	15
5	8	13	12	5	8	10	5
6	13	14	13				
11	8						
12	6						
	$\bar{x}$ = 6.875		$\bar{x}$ = 11.5		$\bar{x}$ = 6		$\bar{x}$ = 11.4

Table 7 (Scores on the problem-solving test)

The hypothesis is that the breadth-first group will obtain lower scores, ie make fewer repeat offers than the depth-first group.

Module 1

A 't' test for independent groups with homogeneous variances shows a significant difference between the groups in the predicted direction ($t = 2.49$, $p < .025$, one-tailed test).

Module 2

A 't' test for independent groups with homogeneous variances shows a significant difference between the groups in the predicted direction ($t = 2.86$, $p < .025$, one tailed).

Thus the data for modules 1 and 2 support the hypothesis.

Hypothesis Four

This concerns the relationship between self-consistency and learning activity. The relevant data are given below:

Module 1				Module 2			
Breadth First		Depth First		Breadth First		Depth First	
Student	Score	Student	Score	Student	Score	Student	Score
1	52	7	25	1	52	6	12
2	36	8	56	2	36	7	25
3	45	9	39	3	45	8	56
4	56	10	62	4	56	9	39
5	35	13	16	5	35	10	62
6	12	14	58				
11	47						
12	18						
	$\bar{x}$ = 37.625		$\bar{x}$ = 42.67		$\bar{x}$ = 44.8		$\bar{x}$ = 38.8

Table 8 (Scores on self-consistency test)

The hypothesis is that the breadth-first group will obtain higher scores (ie be less self-consistent) than the depth-first group.

Module 1

A 't' test for independent groups with homogeneous variances shows that there is no significant difference between the groups ($t = 0.541$)

Module 2

A 't' test for independent groups with homogeneous variances shows that there is no significant difference betweed the groups ($t=0.586$).

Thus the results do not support the hypothesis, nor do they show a consistent trend.

Ability

No hypothesis concerning relationships between the AH5 test and depth/breadth first learning were offered; the relevant data is given below:

Module 1				Module 2			
Breadth First		Depth First		Breadth First		Depth First	
Student	Score	Student	Score	Student	Score	Student	Score
1	38	8	37	1	38	6	48
2	40	8	32	2	40	7	37
3	46	9	21	3	46	8	32
4	48	10	38	4	48	9	21
5	48	13	34	5	44	10	38
6	44	14	42				
11	45						
12	41						
	$\bar{x}$=43.75		$\bar{x}$=34.0		$\bar{x}$=43.2		$\bar{x}$=35.2

Table 9 (Scores on AH5 test of ability)

Module 1

A 't' test for independent groups with heterogeneous variances reveals a statistically significant difference. (T critical = 2.54, t observed = 3.01, $p < .05$ two-tailed test).

Module 2

A 't' test for independent groups with heterogeneous variances reveals no significant difference (t critical = 2.776, t observed = 1.675).

The relationship between the AH5 test and the other measures is given in the table 2 below.

Attention Deployment	Cognitive Complexity	Problem Solving	Self Consistency
-0.345	+0.0131	-0.452	-0.022

Table 10(Correlation of AH5 with other measures)

A summary of results concerning depth/breadth learning is given below:

	Measures on which depth/breadth learners show significant differences	
	Module 1	Module 2
Attention Deployment	*	*
Cognitive Complexity	+	**
Problem-Solving	**	**
Self-Consistency	+	+

Table 11 (Measures on which depth-breadth learners show significant differences)

** $p < .025$, one tailed
* $p < .05$, one tailed
+ no statistically significant difference.

Interrelationships between Personality tests

A correlation matrix showing interrelationships between the personality measures is given below.

	1 AD	2 CC	3 PS	4 SC
1 Attention Deployment (Narrow = Low Score)	X	-0.62**	-0.54*	+0.13
2 Cognitive Complexity (Complex = Low Score)		X	+0.43	-0.29
3 Problem-Solving (Flexible = Low Score)			X	-0.32
4 Self-Consistency (Consistent = Low Score)				X

Table 12 (Correlations between personality measures)

** $p < .01$, one-tailed
* $p < .025$, one-tailed

All coefficients are in the predicted direction (see table 3) and those relating attention deployment to cognitive complexity and problem-solving behaviour are statistically significant.

Discussion of Results

The results obtained justify further discussion of the hypotheses involved including the development of a more detailed analysis. Prior to this some discussion of possible errors and biases that may have contaminated the results is in order.

Bias

Work conducted by Rosenthal on experimenter expectancy (1966) and Orne on demand characteristics (1962) have shown how the results of psychological experiments can be unwittingly biased by the participants. In the experiments under discussion there are occasions where bias may have crept in.

The 'personality' tests were given to students well after they had begun work in the INTUITION equipment, thus the experimenter held clear expectancies about scores that students were expected to produce, and as Rosenthal (op cit) has shown experimenter expectancies may influence experimental outcomes, though his findings are now under some dispute.

Careful study of the conditions under which the tests were administered and of the test procedures shows that little opportunity existed for the experimenter to inadvertantly communicate his expectancies to the subject during, or before either the attention deployment test or the cognitive complexity test. With both of these tests information transfer of a quite detailed sort would have to have occurred to enable subjects to consciously, or otherwise, bias their behaviour in favour of the experimental hypotheses. However, the situation is different when the Problem-Solving test is considered. This test was administered individually to each student by the experimenter, who at the time of testing had a clear idea of the responses each student would have to produce to conform to the relevant hypothesis.

Under these circumstances a double-blind technique would have been a more appropriate procedure; unfortunately due to the time taken to administer the test, (at least an hour) and the availability of students at a limited number of fixed times it proved impossible to arrange for this.

The experimenter made a determined effort to behave in a completely neutral way with each student and students' reports indicated that at the level of conscious awareness he was successful (though there is naturally a possibility that these reports were biased too). Nevertheless the experimenter was closely involved in the experiment and felt a distinct preference for obtaining positive as opposed to neutral or negative results and however remote there is the possibility that his expectancies somehow influenced both individual reponses and the general pattern of each student's behaviour on this particular test.

Of the four 'personality' tests correlated with learning behaviour three showed statistically significant relationships with learning and each other. The fourth test, Self Consistency, did not exhibit a strong relationship with any of the other personality measures nor with learning. This test will be discussed first.

Self-Consistency Test

There are various reasons why this test appears to be the 'odd one out' in terms of results. The most likely being either that the predictions made were correct - but the test does not measure what it was thought to measure, or the test is valid but predictions incorrect (also, of course the test could be invalid and predictions incorrect).

Test Validity

Gergen and Morse (1966) report that the test was found to have acceptable reliability (test-retest = 0.73) and results do not seem to be biased by socially desirable responding [no correlation with the Marlowe-Crown (1960) social desirability scale]. It is difficult to make precise judgements about the validity of the test. Examination of the test procedure and the tasks that participants engage in indicate quite high content/face validity. Gergen and Morse report experiments using the test where results obtained supported several hypotheses derived from Mead's (1934) suggestion that "self-conception is largely the result of internalisation of the views of significant others with whom one interacts". The hypotheses tested were related in various ways to self-consistency and while these results alone do not provide satisfactory evidence of construct validity they do provide some support for the acceptability of the test as a valid measure.

Thus the evidence gives no indication that the test is not valid, indeed what evidence there is indicates good validity.

Experimental Hypothesis

It was predicted that a high level of inconsistency would be related to breadth-first learning. This prediction was made 'indirectly'. It was felt that people who construed their social environment in a multi-dimensional way would be more likely to exhibit unresolved inconsistencies in their view of themselves (or others). Thus people who display inconsistent views of themselves will tend to be cognitively complex (multi-dimensional); and cognitive complexity should, in turn, be related to breadth-first learning.

In practice self-consistency did not relate to complexity or breadth-first learning. This leads to the conclusion that the hypothesis is incorrect and self-consistency is not related to cognitive complexity or breadth-first learning.

Closer consideration of the factors involved also makes it apparent that there is no compelling reason why a person who develops a complex (multi-dimensional) construct system should display more inconsistencies than a person who displays a less complex system. To be more specific: two features of construct systems are of particular importance when discussing inconsistency,

i) the number of constructs (ie degree of differentiation),

ii) the extent to which the constructs are integrated and interrelated.

The more differentiated a system is the more likely it is that an individual will be inconsistent, since there are so many possible ways to be inconsistent.

The greater a system is integrated the less likely it is that an individual will behave inconsistently since potential inconsistencies will have been resolved.

The type of system that is developed by a breadth-first learner (to be discussed more fully at a later stage) is complex in the sense that it is made up of a large number of constructs <u>and</u> the constructs are highly interrelated. Thus the factors that characterise a complex system will exert competing influences on the tendency of the individual to display inconsistencies and there is no basis for suggesting that there will be any relationship between cognitive complexity (as defined here) and self-consistency.

Thus the hypothesis was developed on a poor theoretical basis and its lack of support by the data should have been predictable.

<u>Attention Deployment</u>

The basis for the experimental hypotheses is that there are stable individual differences in attention deployment, seen as the selective allocation of processing capacity. It has been tentatively suggested that at the physiological level these differences are related to differences in the generation of lateral inhibition.

At the psychological level differences in attention deployment may be observed as differences in use made of a wide or narrow range of cues. Thus in the test of attention deployment used in these experiments people who solve relatively more of the anagrams that were embedded in the peripheral material are said to display wide attention. The test mentioned above does not distinguish between activity at the 'input' or 'output' stage of processing (ie stimulus selection or response selection). This means that, for instance, students who did not solve many anagrams from the peripheral list may, at the input stage, have processed information in the same way as other students, but did not use the information concerning peripheral cues in solving the anagram problems (the selection stage). Thus it is possible that at some stage all subjects process a wide range of cues, but only in subjects described as displaying wide attention can evidence of this be inferred from their subsequent behaviour, ie only these subjects 'make use' of the full range of cues. This problem of stimulus or response selection is difficult to resolve and resolution is beyond the scope of this discussion.

Consideration of recall scores obtained in the attention deployment test may however throw more light on the problem of selection.

The recall scores are, in fact, contaminated by interference from the anagram solution stage of the test. For example, it is possible that words that would not have been fully recalled were, in fact, remembered because of the prompt given when an anagram was solved.

In an effort to overcome this problem of interference 'adjusted' recall scores were computed:

Adjusted Focal Recall = No. of words recalled from memory list excluding the ten given as anagrams.

Adjusted Peripheral Recall = No. of words recalled from tape list excluding the ten given as anagrams.

These scores should still act as indices of the extent to which students were able to recall words from the two lists.

The relationships between these recall scores and anagram solution are as follows:

Focal Recall - Focal Solution, r = 0.15

Peripheral Recall - Peripheral Solution, r = 0.32

This indicates a lack of relationship between overt recall of cues and anagram solution.

Mendelsohn and Griswold (using raw scores for recall) also found a lack of relationship between recall and anagram solution;

Focal - Focal, r = .073   Peripheral - Peripheral, r = -.002

When raw recall scores from the current study are used the appropriate coefficients are;

Focal - Focal, r = -0.36   Peripheral - Peripheral, r = +0.79

The significant, positive relationship between peripheral recall and peripheral anagram solution seems anomalous and is probably due to the contaminating effect of anagram solution discussed above; ie anagram solution (involving conscious, overt use of the cue word) has a facilitating effect on conscious recall of the word. Students' reports and the much smaller correlation obtained for adjusted recall scores support this suggestion.

The results obtained concerning recall are somewhat equivocal and it is difficult to draw firm conclusions; though it seems that overt, conscious recall of peripherally presented information is not necessarily related to the apparent use made of peripheral cues in problem-solving.

Attention Deployment and Creativity

Before the specific results obtained in this study are discussed some brief discussion of the relationships of attention deployment to creativity will take place.

Individuals described as displaying wide attention are those who successfully integrate peripherally presented material into problem solving attempts. Whether this is due to either stimulus or response selection, or both, is left open. As already mentioned in Chapter 4 attempts have been made to relate such differences to creativity often using incidental learning material. A series of studies have shown that one particular index of creativity, The Remote Associates

Test is closely related to incidental learning. In fact, Laughlin Doherty and Dunn (1968) found that the RAT was a more sensitive predictor than intelligence for incidental concept formulation; while intelligence was more sensitive than the RAT for intentional concept formation. This and other studies mentioned earlier indicate that people who obtain high scores on the RAT are also more inclined to make use of stimuli existing other than at the level of focal awareness.

The idea that creative thinking is in some way related to unfocused thought processes is certainly not new. Many psycho analytically oriented theorists eg Kris (1953), Ehrenzweig (1967) have developed Freud's (1915) distinction between primary and secondary processes. Kris, for example, elaborated this distinction together with another of Freud's (1905) ideas that in humour the ego makes use of pre-conscious (primary) activity. Kris suggested that in all creative thinking the ego exerts some measure of control over the primary process and coined the term 'regression in the service of the ego' to refer to the capacity of gaining access to unconscious material without being overwhelmed by it.

Ehrenzweig also considers the primary process to be important in creative thinking - but in his formulation the ego 'decomposes' itself and controls the activity of the primary process and in place of adaptive regression there is a reciprocal interaction between primary and secondary processes.

Thus the preconscious primary process is seen as the source of creative ideas that are then shaped to the particular needs of the situation by the more conventional, controlled thinking of the secondary process.

Unfortunately though some work has been conducted the psychoanalytic notions lack empirical support. Nevertheless the importance of something like primary process thinking, particularly in the 'incubation phase' (Wallas 1926) cannot be denied. Many of the reports by creative artists and scientists, see for example, Ghiselin (1952) also suggest that this is so.

Of importance to the current discussion is the proposal that creative individuals gain access to and make use of material presented peripherally. The relationship between tests of attention deployment and creativity is clearly interpretable in terms of psychoanalytic theory and people who display wide attention deployment are those who gain access to primary process thought and integrate it into problem-solving activity. The more 'cognitive' analysis of attentinn deployment, discussed extensively earlier on, can also accommodate these suggestions. Of particular importance is the proposal made earlier that when attention is more nearly unitary and focused on dominant aspects of the task the thinking that takes place is analytic as opposed to intuitive; and conversely when attention is wide thinking will be more intuitive and 'creative'. Confirming evidence is found, for example, in the work of Dixon (1971) referred to in Chapter 4. It is both interesting and fruitful to discuss the relationships between attention deployment and creativity and there are a wide variety of interesting issues awaiting investigation; the relationship between attention deployment and humour, subliminal perception and creativity etc. Of most interest in this study is the evidence that attention deployment relates to differences in learning activity.

Discussion of Results concerning Learning, Attention Deployment and other Factors

The results of this study have revealed relationships between the attention deployment, breadth-first learning, cognitive complexity and flexibility during problem solving. Correlations do not indicate causality and any 'explanations' must be viewed with this in mind.

Analysis of the data showed that people with wide attention deployment, according to the particular measuring technique used, tended to adopt a breadth-first approach to the learning material.

The distinctions between people; and the implications of these differences can be seen more clearly by viewing the learning process as the development and elaboration of a (personal) construct system. One of the major aspects of a developing construct system concerns the increasing degree of organisation of the system in terms of superordinacy. Educational growth is not merely the accumulation of more and more pieces of information but the development of an increasingly complex structure for organising and inter-relating ideas, see Salmon (1970) for a more detailed discussion of this. According to Kelly (1955) construct systems are elaborated by the operation of a loosening-tightening cycle. Following Kelly's lead construct theorists emphasise the need for construct systems to first be loosened, so that they can incorporate new information and be reformulated, then tightened. For example, Fransella and Joyston-Bechal (1971) quote a study by Runkel and Damarin (1961) which indicated that teacher-training students progressed through a loosening-tightening cycle as their training progressed.

It is suggested here during learning periods on INTUITION 'depth-first' students maintain close control over their developing construct system only considering information of direct local significance; they appear to concentrate on one clearly defined area of the subject matter (eg 'real world') and elaborate this in a series of highly predictable stages; whereas students adopting a breadth-first approach will choose low probability routes through the material selecting topics from more than one area, transforming and elaborating large inter-related sub-systems. To be effective the breadth-first learner must not merely operate with wide or diffuse attention, he must interrelate the various different elements that he is dealing with. This interrelating can often only be accomplished by developing a higher order, more abstract category that subsumes the elements to be interrelated. The implication of this is that an effective breadth-first learner will develop a more abstract and hierarchically integrated construct system than a depth first learner.

The INTUITION learning situation will, in fact, modify the influence of such differences of approach because the material is presented as a 'learnable' whole and unlike much teaching material the essential relations between topics are made apparent, furthermore as the student works through the material he is <u>forced</u> to recognise analogies and various other correspondences that he may otherwise have ignored.

On the basis of earlier discussions of consistent individual differences in attention deployment and the relationship of such differences to learning it is suggested that a person adopting a 'depth' or 'breadth' first approach when working on INTUITION will adopt an equivalent approach to other learning environments ie the formal aspects of cognition are not situation dependent. The exact nature of the approach will, of course, be influenced by situational factors.

In situations where the constraints operative with INTUITION do not function differences in cognitive structure due to different approaches to learning should be fairly apparent. Development of the inter-personal construct system is an area where there are few constraints on the learning approach used and differences in cognitive structure should be detectable.

The development of a construct system appropriate for dealing with other people is an almost constraint-free learning process and some-one using an approach equivalent to the 'breadth-first' approach observed on INTUITION should engage in consideration of a wide range of sometimes only obliquely related information and develop a complex fluid system probably not very clearly articulated nor rigidly ordered. People adopting a depth-first approach would be inclined to develop a clearly articulated construct system dominated by relatively few superordinate constructs, thus viewing others in a relatively uni-dimensional fashion.

To incorporate the results obtained for the flexibility test into the construct-theory approach the notion of validation-invalidation, Bannister (1966) is useful. Expanding Kelly's experience corrolary, 'A person's construction system varies as he successively construes the replication of events'., Bannister points out that, 'Constructs are not merely ways of labelling our universe, they are ways of trying to understand and anticipate it'. Our constructs experience varying validational fortunes, sometimes anticipations or predictions are correct and we experience validation; at other times or under different circumstances we are invalidated. As this varying validational evidence comes in we tend to modify our construct system so that it can accommodate the new evidence. Bannister (1965) found that people tend to tighten the relationships between constructs when they experience validation and loosen when invalidated. When students participated in the flexibility test they were repreatedly refused validation and presumably encouraged to loosen their construction of the situation, alter their construct system and hence develop an alternative possible solution. Some of the participants, those who exhibited wide attention and breadth-first learning did this relatively quickly; others, even when repeatedly not given validation, continued to attempt to extort validational evidence from the situation and appeared reluctant to change from one possible solution to another.

Students with wide attention deployment tend to be influenced by a wider range of information and react to possible invalidatory evidence more rapidly perhaps because they are more 'aware' of alternative approaches and have a wider range of available, pertinent sources of inspiration. Their counterparts who display narrow attention are not deterred so easily by unsatisfactory evidence and will need to be confronted with relatively large amounts of such evidence; this in turn, may be due to the fact that they are less likely to be distracted or influenced by 'irrelevant' factors and thus they have a more limited awareness of possible alternative routes and will tend to persist with a single approach even when no validating evidence is forthcoming.

This tendency to persist with a single solution attempt can often be observed when a problem solver finds himself in a totally unfamiliar situation, or in a situation of which he has little previous experience. For example someone who knows only a little about motor vehicle repairs and maintenance will, if his car will not start, often examine the same part time after time and each time find no fault. He will continue with the same activity simply because he is unable to generate any ideas about alternative solutions and although he receives no validation he keeps on trying the only possible solution route he can think of.

One frequently used source of inspiration in problem solving situations is when the problem solver can recognise the unfamiliar situation as analagous to one that he is familiar with.

Analogies

Before concluding this discussion some ideas concerning the place of analogy relations in learning will be put forward.

The results concerning attention deployment, learning, problem solving and cognitive complexity are consistent with the suggestion of a stable individual difference dimension concerned with the extent to which cognitive activity is distributed and diffuse as opposed to being constrained and focussed.

It has been shown that a person adopting a breadth first learning style also displays a more complex multidimensional construct system, wider attention deployment and is more flexible when attempting to solve problems. Someone adopting this diffuse and possibly unregulated approach to learning would be likely to make greater use of analogy relations.

It has been suggested by some authors eg Hilgard and Marquis (1964) that learning and problem solving are the same. An alternative position is to say that learning is getting better at problem solving.

The successful solving of problems hinges on the detection of similarity between the problem situation and some other more familiar situation. Often the similarity detected may be an analogy.

An analogy can be seen to have four terms. The first two terms are involved in the initial analogy where, for example, problem 'A' is seen to be analagous to problem 'B'. Next, to make use of the analogy, the problem-solver reasons that if procedure 'x' was the one used to solve problem 'A' then procedure 'x' may be helpful for problem 'B'.

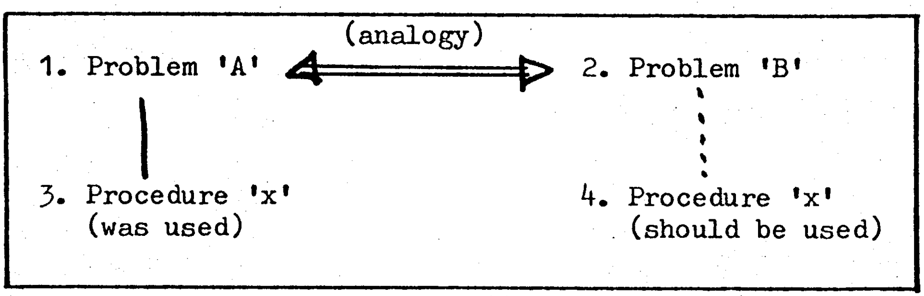

Fig. 8 (The four terms of an analogy)

Thus learning enriches our store of possible similarities that can be used to gain insight into a new problem situation ie learning is getting better at problem-solving.

A learner adopting a breadth-first approach will have access to a much wider range of information at any one time and will thus have greater opportunity for developing analogy relations and as noted earlier, will develop a more complex and abstract construct system.

The results obtained concerning problem solving and learning are fully consistent with these ideas. For instance, in the problem solving test discussed above breadth-first learners display flexible problem solving behaviour due perhaps to the fact that they have a wider range of potential sources of insight into the problem; whereas the depth-first learner will focus his attention on one possible solution route.

As already noted either approach could lead to inefficient problem-solving where either the student 'grass-hops' from one approach to another or 'bashes his head against a brick wall'.

Ability

A feature of the results that has not yet been discussed is the data concerning the test of ability.

The results show a statistically significant relationship between depth/breadth learning and ability, with breadth first learners obtaining higher ability scores. The results concerning ability and the problem solving test are consistent with this finding and show that people who made fewer repeats on the test obtained higher ability scores, though the results are not statistically significant.

Results for the attention deployment test however show a weaker relationship that is, if anything, in the opposite direction ie people with wide attention obtained lower ability scores.

These differences are difficult to explain and a lack of clarity concerning what it is that the ability test measures adds to the problem of understanding the data. Examination of the specific test used reveals that many of the items call for students to make comparisons or to consider analogies of various kinds. It may be that the sort of ability needed for these operations is similar to that required by someone who operates a successful breadth-first approach to learning (on INTUITION) or develops a flexible approach to prŏblem-solving.

This 'competence' dimension could be distinguishable from a 'preference' dimension that is measured by the test of attention deployment; and taken together these two dimensions determine the extent to which an individual adopts a depth or breadth-first approach to learning or is flexible or not when attempting problems (and is given no validation). This line of argument is consistent with the data and has a good deal of explanatory and predictive potential, (eg a large amount of the variance in learning strategy can be 'explained' by combining the relationships between these two measures and depth/breadth learning).

Earlier discussions have covered the possible relationships between creativity and the factors discussed in this thesis.

High scores on creativity tests may be dependent on both the 'preference' and competence factors mentioned above. This would be consistent with the findings of some authors that creativity is related to intelligence and of others that it relates to attention deployment.

Summary

The results reported in this Chapter supported several hypotheses concerning relationships between attention deployment, cognitive complexity, problem solving and learning style.

By using a personal-construct theory approach the influence of differences in attention deployment on cognitive processes and structure was discussed and the experimental findings were shown to be consistent with other related, theoretical viewpoints, experimental results and observations.

The interpretation given to the results is in some ways a re-emergence of an old theme concerning what Freud (1915) described as primary and secondary processes. However the theme is placed on a new, empirically-keyed footing and attempts have been made to measure individual differences. Thus the significant aspect of this section of the thesis is the demonstration of specific relationships between 'personality' and learning coupled with an attempt to provide a comprehensive explanation of individual differences in cognitive processes using attention deployment as an explanatory concept. Further discussion of the implications of the results takes place in Chapter 6.

CHAPTER 6

SUMMARY AND DISCUSSION OF WORK CONDUCTED

1. Introduction

This chapter is intended to give a brief summary of all the work carried out, followed by a short discussion. The details of the work conducted, the findings and more lengthy discussions of results are contained in chapters 2-5.

This chapter is divided into 4 sections

1. Introduction
2. Reporting on chapters 2 and 3
3. Reporting on chapters 4 and 5
4. General Remarks relevant to all of the work reported.

Inevitably in a chapter of this sort, intended as a summary or overview, there will be some repetition of material already presented. This is particularly true in sections 2 and 3; most of section 4, however, is new material not covered earlier.

Examination of Strategies

In most learning situations it is difficult for an observer to form any opinions about the way in which the student conducts his learning; thus little is known about the strategies and tactics that people adopt when learning a new body of subject matter. To some extent the particular strategy adopted will be dependent on the specific subject matter and the way in which material is made available to the learner. For example, when a student is using a programmed text he has little freedom to organise his own learning and his strategy is constrained.

In the experiments described in this thesis students were placed in a situation where they did have considerable freedom to organise their own learning activity. The special feature of the approach adopted is that as well as giving students freedom to organise their own learning it ensures that certain features of their strategies are exteriorised and can be observed by the experimenter.

Indices of Learning

The specific features of student activity that were examined together with a description of what they are thought to indicate are given below.

Appreciation Span : Indicates how far students looked ahead and planned their future learning.

Exploration (Pre- Working): Indicates how much information students collected about the topics to be learned, before they chose which topic they would learn first. ie Before they had begun any formal learning.

Exploration (During Work): Indicates the extent to which students requested outlines of what topics were about, before choosing to learn them.

Depth or Breadth First learning: Indicates the extent to which students either chose a wide range of topics and extended their knowledge on a broad front, or confined their learning to a narrow, 'in-depth', study of one complete area at a time.

Errors : When they felt that they understood a topic students opted to take a test of understanding. A record of the number of times that a student did not pass the test of understanding was also kept; ie a record of errors.

Reliability of indices

With the exception of errors (which were almost non-existent in module 2) the indices of learning proved to be extremely reliable (ie strong positive correlations between scores on module one and module 2), thus it was possible to make a meaningful test of various hypotheses concerning relationships between the indices of learning and measures of personality.

Consistent individual differences

Much past and current work in psychology has been focused on delineating dimensions of difference along which people can be compared and contrasted and where consistent individual differences are exhibited. An aim of such studies is to eventually be able to describe and predict behaviour using as few dimensions as possible. Strategies displayed by learners are, in essence, no different from other forms of behaviour and it should thus be possible to identify relationships between the actual strategies adopted and specific, underlying dimensions of difference, ie personality characteristics. The work conducted in this study was an attempt to examine the existence of such relationships.

2. Reporting on Chapters 2 and 3

The major personality factor investigated in chapters two and three of this study is the extraversion-introversion dimension.

The predictions that can be made after an examination of the empirical and theoretical background to this dimension can be crudely sorted into two categories. In one category are the more biologically-based or genotypic predictions, relating to conditioning, vigilance, reminiscence and so on. In the other category are those mediated by environmental influences, the phenotypic category or behavioural habits such as sociability, impulsiveness etc. The situation is shown diagramatically below.

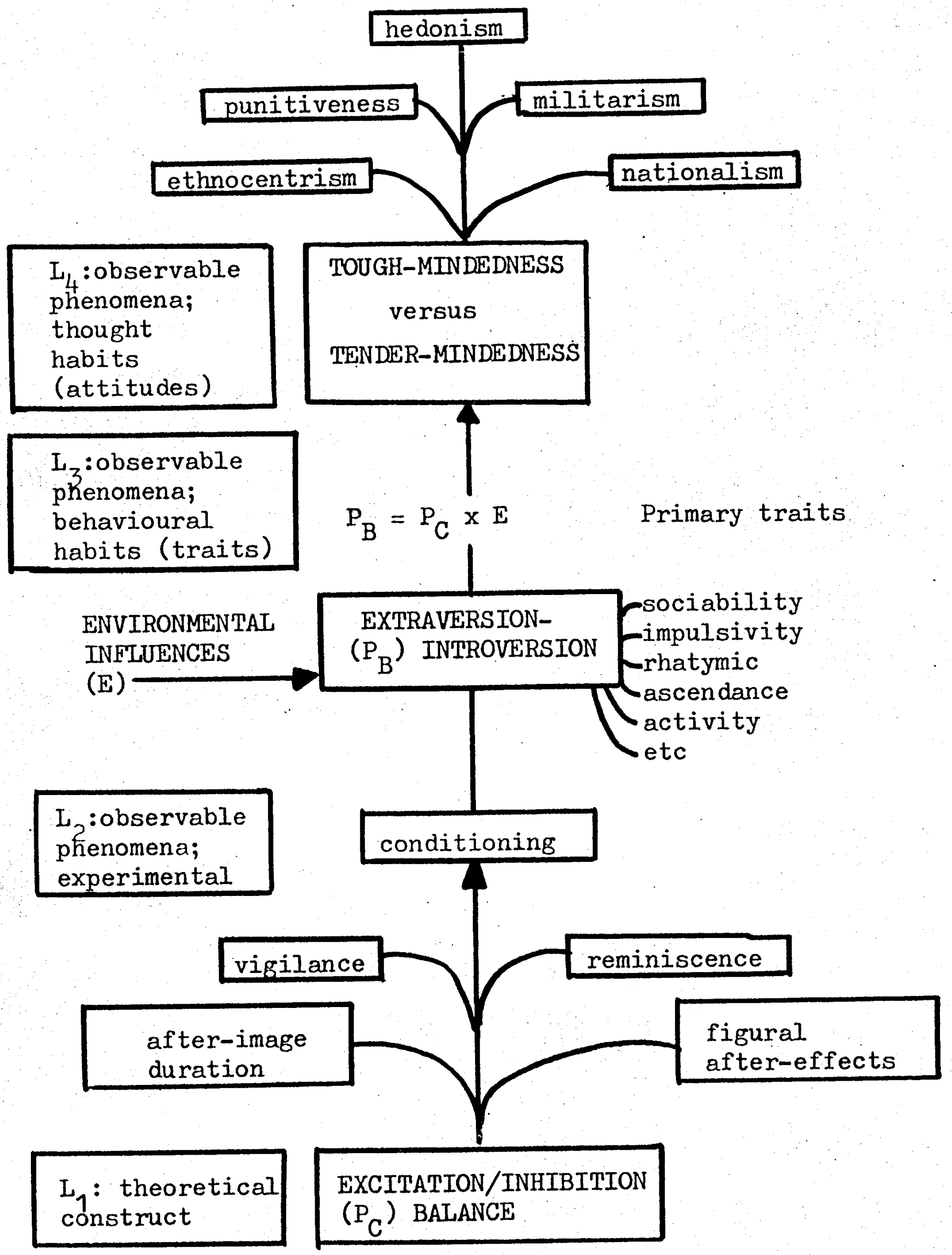

Fig. 1 (Eysenck's diagrammatic representation of his theory of personality. From Eysenbk, 1963, p. 1033)

It is the category concerned with behavioural habits that is most relevant for this study. Unfortunately this is also the category where predictions are both less specific and less accurate.

The predicted differences between extraverts and introverts examined in this study concern the belief that introverts will tend to plan ahead more than extraverts and that they are less impulsive and will 'look before they leap'.

For the purposes of the study these general expectations had to be translated into specific, testable predictions.

i) Planning Ahead - Firstly the expectation that extraverts will plan ahead less than introverts was used as the basis for the prediction that, given the opportunity, introverts will plan a greater distance, ie further ahead than extraverts.

By examining the learning strategies adopted by students it was possible to infer the extent to which they had planned ahead and thus test the accuracy of the prediction.

ii) Looking Ahead - Secondly the expectation that extraverts tend to look before they leap was examined. This was developed into the prediction that extraverts would be less inclined to request a brief outline of a topic before choosing whether or not to work on it.

These two predictions, though probably related, represent different predictions. The two aspects of behaviour are possibly related but can be distinguished as separate characteristics. For example, someone could plan ahead a long way - but do so impulsively and without much attempt to examine the relevant facts.

Again, by examining students' activity it was possible to infer the extent to which they 'looked before they leapt' and thus test the accuracy of the second prediction.

Conflicting Predictions

iii) Errors - It was also possible to make predictions about the relationships between number of errors that students would make and personality dimensions. Consideration of available evidence led, in fact, to two conflicting predictions concerning errors.

A) Tolerance of Ambiguity - Work conducted by Leith and Trown (1968)indicated a relationship between students' tolerance of ambiguity and their success on different types of learning material.

On the basis of their results Leith and Trown suggested that extraverts learned more effectively than introverts from ambiguous and unstructured materials because they have a greater tolerance of ambiguity. When students are learning about a topic on the INTUITION system they are in a non-directive, relatively unstructured, learning situation and it could therefore be predicted that:

i) Extraverts will make less errors than introverts

ii) Students who are tolerant of ambiguity will make less errors than those who are not

Implicit in these predictions is the hypothesis that extraversion and tolerance of ambuguity are related and that extraverts are more tolerant of ambiguity than introverts. This point will be returned to later.

B) Impulsiveness - As they work through the learning material students are allowed to choose for themselves when they are ready to take a test of understanding for a topic. In contrast to the prediction made above it could be anticipated that extraverts will tend to act on impulse and therefore take the test too early; thus making more errors than introverts.

By examining the relationships between errors, tolerance of ambiguity and extraversion-introversion the validity of these predictions was estimated.

Ability

All students participating in the experiments were given the AH5 test of ability. This was done to help ensure that any findings were not simply reflections of chance differences in ability. The test was not included in the hope of finding any significant relationships between ability and the various indices of learning.

Investigation of Predictions

i) 'Planning Ahead' - In addition to investigating the relationship between extraversion and planning ahead the relationship between students' scores on the tolerance of ambiguity scale and planning ahead was examined. It was felt that students who were intolerant of ambiguity could reduce the ambiguity in the situation by planning ahead. Also the previous work of Leith and Trown had indicated a possible relationship between extraversion, tolerance of ambiguity and learning preferences.

Results: The data indicated no consistent statistically significant relationship between the measure of planning ahead (ie appreciation span) and either personality characteristic. [See table (1)]

ii) 'Looking before leaping' - A test specially designed for this study and aimed at measuring the amount of information collected before acting was used in addition to the test of extraversion-introversion (EP1). This test was included in the hope of facilitating the explanation of any relationship discovered between EP1 and the appropriate indices of learning ('pre' and 'during' work exploration).

Results: The data revealed no consistent statistically significant relationships between the personality measures and the indices of exploration.

[See table (2)]

The data did indicate that information collecting behaviour was very stable in a variety of different circumstances, but appeared to be highly situation-dependent and was not a consistent individual characteristic. For example, the reliability of the information collection test was 0.90. The reliability of the 2 indices of learning related to information collection exceeded 0.80; but there was no relationship between scores on the information collection test, either index of information demand during learning and introversion extraversion, indicating the context dependence of information collecting activity.

iii) Errors - The data revealed a relationship between errors, extraversion and tolerance of ambiguity. Extraverts and people who obtained high scores on the tolerance of ambiguity test made less errors than introverts and people who were less tolerant of ambiguity. The relevant relationships were all in the same direction and some were statistically significant.

[See table (1)]

Ability

No statistically significant relationships were found between scores on the AH5 test of ability and any of the indices of learning (including errors). Neither was there any relationship between scores on the EP1 or tolerance of ambiguity scale and AH5.

Thus the following relationships between personality characteristics and indices of learning have been examined.

i) *Extraversion-Introversion
   Tolerance of Ambiguity
   → Appreciation Span) Planning Ahead

ii) *Extraversion-Introversion
   Information Collection
   → (Pre-Working (Exploration; during (Work Exploration) Looking Ahead

iii) *Extraversion-Introversion
   Tolerance of Ambiguity
   → Errors

The relationships between AH5 and all of the above measures were also examined.

Tables 1-4 summarize the findings.

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* A separate impulsiveness score was also calculated and used in the analysis - the intercorrelations for this are provided in the relevant chapters.

	Appreciation Span		Errors	
	Module 1	Module 1+2	Module 1	Module 2
Extraversion-Introversion	+0.33	+0.005	-0.51	+0.05
Tolerance of Ambiguity	+0.05	+0.36	+0.46*	+0.43

Table 1 (correlation matrix : Appreciation Span and Errors vs personality factors)

* $P < .05$

	Pre-Work Exploration		During-Work Exploration	
	Module 1	Module 1+2	Module 1	Module 1+2
Extraversion-Introversion	+0.46	+0.04	-0.02	-0.02
Information Collection	-0.1	-0.49	-0.02	+0.21

Table 2 (correlation matrix : Exploration vs personality factors)

	Appreciation Span		Errors		Pre-Work Exploration		During-Work Exploration	
	Module 1	Module 1+2	Module 1	Module 1+2	Module 1	Module 1+2	Module 1	Module 1+2
AH5	-0.38	-0.44	+.001	-	-0.2	-0.35	+0.07	+0.12

Table 3 (correlation matrix : Ability vs indices of learning style and efficiency)

	EI	TA	IC	AH5
1. Extraversion-Introversion		-0.35	+0.09	-0.06
2. Tolerance of Ambiguity			+0.03	-0.235
3. Information Collection				+0.04
4. AH5				

Table 4 (correlation matrix: interrelationships between personality characteristics and ability)

Indices of Learning

In addition to an examination of the various hypotheses an examination of the interrelationships between the four indices of learning activity was conducted.

The relevant product-moment correlation matrices are given below.

N = 10 Mod. $\frac{1 + 2}{2}$

	App.Span	Pre-Working Explore	During Work Explore
App. Span	X	+0.57*	+0.02
Pre-Working Explore		X	+0.71
During Work Explore			X

Table 5 (correlation matrix : interrelationships between learning indices [Mod 1 + 2])

* $p < 0.1$ two-tail

N = 14 Mod. 1 only

	App.Span	Pre-Working Explore	During Work Explore	Errors
App. Span	X	+0.73**	+0.47	-0.38
Pre-Working Explore		X	+0.42	-0.54
During Work Explore			X	-0.11
Errors				X

Table 6 (correlation matrix : interrelationships between learning indices [Mod. 1])

** $p < .01$ two-tail

Interpretation of Findings

Although most of the relationships examined have failed to reach the 5% level of significance this does not mean that the relationships observed have definitely occurred by chance; merely that they may be due to chance effects. Because of the small numbers involved a large correlation coefficient is needed before the 5% level of significance is reached and some of the relationships observed, though not statistically significant are quite large and may be important if they are 'true' relationships.

The most important features of the data analysis are:

i) the possible relationship between extraversion, tolerance of ambiguity and number of errors made by students working on complex, ambiguous material,

ii) the inconsistency of relationships between extraversion-introversion and the various indices of information demand,

iii) the lack of strong relationships between the indices of information demand,

iv) the inter-relationships between the indices of learning.

The findings of this study can be considered under two main headings:

Educational - concerned with the significance of the findings from an educational point of view and ways in which educational practices might be influenced.

Scientific - concerned with the implications of the specific experimental findings for current or future research work.

Educational

With work of the sort described here it would be extremely valuable if the implications of the results could be examined from an educational point of view and some indication given of how the findings could be put to immediate use. It would, however, not be advisable to develop prescriptions for educators based on the results of this study since most of the results are not sufficiently conclusive. Even for the results that are conclusive the (presumably) complex inter-relationships are not yet well enough understood for the purposes of implementation.

Thus, although this will, hopefully, be an eventual area of 'pay-off' for research of this nature, no specific educational recommendations are forthcoming from this aspect of the study (ie Chapters 2 and 3). Some of the results may be useful to individual educators and with relatively little transformation could form the basis of experimental educational ventures, but the direction of these ventures will depend on the interpretation put on the results.

Future work could concentrate on investigating more fully the relationship between tolerance of ambiguity and extraversion-introversion and the relationship of these characteristics to specific types of learning materials or procedures. It would be important to determine, for instance, whether students who are intolerant of ambiguity perform better than more tolerant students on highly structured and unambiguous material such as linear programmed text books.

Another finding of interest concerns the extent to which information collection behaviour is context-dependent. The results demonstrated that in highly favourable conditions information collecting behaviour was related to impulsiveness ie the correlation between the EP1 impulsiveness scores and scores on the information collection test. However, on INTUITION, information collecting activity was consistent but not related to impulsiveness, extraversion-introversion nor scores on the information collection test.

This has possible implications for anyone involved in preparing teaching materials where it is possible to give learners previews or overviews of the material. It seems unlikely that there will be any universal rules that can be used to determine when to present such information since learners' needs for information on which to base decisions may vary from situation to situation.

The variability of learner requirements and the important situational variables would be interesting topics for experimental study.

Inter-relationships between indices of learning

An ad hoc analysis of inter-relationships between the various indices of learning shows a consistent pattern.

In particular the results show that students who carried out a considerable amount of exploration before beginning any learning tended to exhibit high values for appreciation span. This is an intuitively reasonable finding indicating that people who planned furthest ahead tended also to request an outline of the contents of future topics before working on them (ie distance ahead that students planned and an index of 'looking before leaping' were positively related.)

This finding only holds for the situation studied here and the relationship between these factors in other learning situations will be worth investigating.

Similarly there were indications that the people who made least errors tended to request information about topics before working on them and also planned further ahead. This suggests the conclusion that people who proceeded less impetuously and looked further ahead tended to make less errors. The relationships here are not statistically significant but could probably still be more extensively studied. It would be interesting to collect data that related to the issue of whether planning and information seeking cause fewer errors or whether people only plan further ahead and explore freely when the subject matter is not too difficult for them.

Scientific

The results of this study throw some doubt on the predictive value of current ideas concerning the behaviour of extraverts and introverts. Many workers (see Chapter 1) are investigating the relationships between extraversion/introversion and attainment and are beginning to suggest tentative reasons for the relationships observed. The results of this study suggest that when researchers are considering possible explanations of such inter-relationships they will be ill-advised to assume that extraverts and introverts behave in expected ways. The results obtained indicated that predictions derived from accepted descriptions of how extraverts and introverts behave were not supported when students were placed in a specific learning environment. Discussion of the results obtained (presented in Chapters 2 and 3) will perhaps help to modify and refine ideas concerning the relationships between extraversion-introversion and learning.

The fact that some of the results of this study do not support hypotheses tested does not mean that the results have no scientific value.

Popper (1963) has argued that falsifiability can be seen as the criterion of demarcation between science and non-science. The point being that a scientific theory can never hope to explain everything that can possibly happen; rather it ignores most of what could happen and places itself at risk by making specific predictions about just a few possible happenings. A scientific theory is testable and capable of being refuted (or falsified) by events. It is often only when a theory is falsified in the light of empirical evidence that progress can be made. The results obtained here are useful in various ways. They suggest that it may not be profitable to invoke differences in impulsiveness when examining different attainments of extraverts and introverts. They suggest that it may be profitable to concentrate on differences related to the interaction between type of learning material, tolerance of ambiguity and extraversion. Although not directly suggested by the data the other, more profitable, way to proceed may be to concentrate on differences related to the sociability component of extraversion-introversion and the possible consequences of this for study habits in a wider context than has been studied here. It may be in these areas that an explanation of the correlations between extraversion-introversion and academic attainments is to be found; rather than in the more cognitive aspects of learning studied in this thesis.

The results also indicate the need for a re-assessment of the ideas concerning the characteristics of extraverts and introverts that led to the specific predictions investigated. One way in which these ideas may be revised rests on a consideration of the relationship between extraversion-introversion and tolerance of ambiguity. It is suggested that extraverts are more tolerant of ambiguity than introverts and that from the point of view of certain types of learning activity this is of at least as much relevance as the supposed differences in planning ahead, information collecting and impulsiveness. Thus it is suggested, on the basis of studies carried out, that tolerance of ambiguity may be a component of extraversion-introversion that is important at a theoretical and practical level in relation to learning activity.

Understanding Learning activities

An important original aim of this study was to identify personality correlates of students' learning activities and by doing so a better understanding of the way in which people learn. The work conducted on extraversion-introversion and related personality characteristics (Chapters 2 and 3) has not been particularly successful in identifying personality correlates of learning. This may to some extent be due to the influence of situational factors on student behaviour.

It is worth noting here that because of the numbers involved the studies reported here would only confidently detect very strong relationships. It is possible that some of the relationships examined, though influenced by situational factors, could with a larger sample appear statistically significant, though most were not merely too small, they were also not consistent. It was never the aim of this study to tease out small but statistically significant findings. It was a search for strong relationships, between underlying disposition and learning activity, that were consistent and statistically significant. Clearly any relationships of this sort would be of considerable theoretical and practical significance as well as being statistically significant.

The studies in Chapters 2 and 3 though not particularly successful in identifying personality correlates of learning have provided some important data that can help to improve our understanding of learning. These are the data relating to the indices of learning themselves and the extent to which they are general characteristic of student learning behaviour.

These data will be discussed at the end of the Chapter when results concerning the index of learning studied in Chapters 4 and 5 (Depth/

Breadth learning) have been discussed.

3. Reporting on Chapters 4 and 5

Attention Deployment

The major individual difference dimension considered in Chapters 4 and 5 was that of attention deployment. A summary of previous relevant work and associated theory was given and an attempt was made to clarify the meaning of the main area of interest - width of attention.

To summarize; it was maintained that at any one time people are engaged in a range of information processing activities. Not all of this processing activity is under conscious control, nor is it all immediately relevant to the main task at hand. People displaying narrow attention will, under normal conditions of arousal etc be more likely to confine their attention (ie processing activity) to factors perceived as task relevant. Or, at least their behaviour will be less influenced by factors that are peripheral to their prevailing mental-set.

A person displaying wide attention will tend to process and be influenced by peripheral cues as well as those of immediate relevance to his current mental set or focus of attention.

The essential points are:

i) Attention is divisible (ie processing is not entirely serial)

ii) Attention can vary from wide to narrow. When attention is narrow it is more nearly unitary and processing capacity is allocated almost exclusively to the task at hand. When attention is wide processing activity is more distributed, and cues less related to ongoing activity are more likely to initiate processing activity.

iii) Some processing may take place without conscious control or awareness - but may still influence behaviour and conscious thought.

It is also suggested that when attention is more nearly unitary and focussed on the dominant aspects of the task the thinking that takes place is 'analytic' as opposed to 'intuitive', Bruner (1960) whereas when attention is wide thinking is more likely to be intuitive.

Consistent Individual Differences

A person's width of attention can vary from being highly selective and focussed through more diffuse attention to the other extreme when, during REM sleep, attention appears to be at its least selective and stimuli applied during or before sleep will elicit complex imagery and associations. Although, for example, as arousal changes, peoples' position on this width of attention dimension will also change; it is maintained that there are stable individual differences in width of attention; ie some people will tend to operate with consistently narrower attention than others. Operationally this means that they will be relatively insensitive to the influence of peripheral information sources. It is suggested that width of attention is a consistent aspect of an individual's cognitive style (ie that it is useful to use this particular dimension as a way of describing and comprehending differences in cognition).

People differing on an underlying dimension of this type would be expected to exhibit differences in their learning and problem solving activities and also in cognitive structure.

Differences in Learning

The major areas of interest in this thesis are the individual differences in learning strategy displayed by students when working on the INTUITION system. As noted above it was expected . .

that differences in width of attention would be associated with differences in learning activity. Briefly a person with wide attention should behave in an 'holistic' fashion, processing and integrating a wide range of information, developing his understanding in a global fashion whereas a person with narrower attention would operate in a more 'serialist' fashion and would severely restrict the range of information used, building up his understanding in an orderly step by step localised process. These differences in learning activity should in turn relate to differences in cognitive structure and the person with a more holistic learning strategy would develop a more multidimensional, construct system.

On the basis of these expected relationships various hypotheses were developed and tested. To test the hypotheses the theoretical constructs of width of attention, cognitive complexity, learning strategy etc. were operationalised by examining student performance on various measuring instruments and observing their behaviour on the INTUITION system. The specific hypotheses examined are given below.

Hypotheses

1) Attention Deployment and Depth/Breadth First Learning

The first hypothesis concerns the relationship discussed above between width of attention and learning activity.

The hypothesis was that learners with wide attention deployment would adopt a more holistic or global approach to learning whereas learners with narrower attention deployment would follow a more localised, serialist approach.

It was possible to estimate the extent to which a student adopted a local or global approach by examining the route taken through the topics in a localised, depth-first fashion, building up their understanding of one area at a time in a compartmentalised way; at the other were students who approached the material on a breadth-first more global basis moving through the material on a broader front and extending their understanding of a number of areas more or less simultaneously. A test for measuring width of attention was also developed. Essentially the test examined the extent to which students made use of peripherally and centrally presented cues in a problem-solving situation. (The method for estimating depth/breadth learning and the test of attention deployment are fully described in Chapter 5.

The specific hypothesis tested was that people who display a breadth/first approach to learning (on INTUITION) will exhibit wider attention deployment (measured by the test mentioned above) than those who follow a depth-first approach.

2) Cognitive Complexity and Depth/Breadth First Learning

As noted above it was anticipated that people who adopted a breadth-first approach to learning would develop more complex, multi-dimensional construct systems. It was hypothesised that the approach to learning displayed on INTUITION was not simply a response to that particular situation but represented a consistent feature of an individual learning style; ie a person adopting a depth or breadth first approach on INTUITION will adopt a similar approach to other situations (eg when learning informally about other people and thus should develop a relatively more multi-dimensional system for construing others).

The Bieri test of cognitive complexity was used to assess the extent to which students construed other people in a multi-dimensional or more nearly unidimensional fashion.

The specific hypothesis tested was that, "People who display a breadth-first approach to learning (on INTUITION) will be more cognitively complex (as measured by the Bieri test) than those who follow a depth-first approach".

(It could, of course, also be hypothesised that students who adopted a breadth-first approach would develop a more complex and multi-dimensional construct system concerning the subject-matter of INTUITION (probability in this experiment). Due to time constraints and lack of suitable measuring techniques this hypothesis was not tested in the current study.

3) Problem Solving and Depth/Breadth First Learning

It was hypothesised that, when attempting to solve problems, students with wide attention deployment would be more susceptible to the influence of 'peripheral' cues as well as those related to their current mental set and would be more inclined to try alternative approaches to the one currently being attempted.

Students with narrower attention deployment would, by contrast tend to persist with one particular approach. (Incidentally it was noted that neither approach was necessarily more efficient). A test was developed that enabled the experimenter to observe the degree of persistence (ie tendency not to change from a potential solution route) or flexibility (ie the tendency to shift from route to route) shown by students.

During the test participants played the role of personnel manager attempting to solve some labour problems. Participants were given feedback after every solution attempt, (the situation was 'fixed' so that this feedback was alwayd negative - ie it was impossible for participants to suggest a correct solution). The sequence of attempts was recorded. On each trial it was possible for participants to repeat solution attempts or to suggest new solutions. The extent to which participants repeated or not was taken as an index of persistence/flexibility. The test environment and procedures are quite complicated and cannot be fully explained here. Full details are given in Chapter 5.

As already noted it was anticipated that scores on this test would relate to differences in attention deployment; however the main area of interest in this thesis concerns the relationship between learning activity and other characteristics. Thus the specific hypothesis tested concerned the relationship between scores on the problem-solving exercise and depth/breadth first learning, with another hypothesis (see below) concerning the relationship between performance on this exercise and attention deployment. Consistencies in attention deployment are, of course, seen as part the 'reason' for any relationships between depth/breadth learning and persistence/flexibility in problem-solving.

The specific hypothesis tested was that, "People who display a breadth-first approach to learning (on INTUITION) will display less persistent behaviour (ie make fewer repeats on the problem-solving exercise) than those who follow a depth-first approach".

4) Self-Conistency and Depth/Breadth First Learning

The fourth hypothesis concerned the relationship between a measure of self-consistency (ie the extent to which people see their own characteristics as compatible or as incompatible and contradictory) and depth/breadth-first learning. The test of self-consistency used was the Gergen-Morse (1967) test. The specific hypothesis tested was that "People who display a breadth-first approach to learning (on INTUITION) will exhibit less self-consistency (as measured by the Gergen-Morse test) than those who follow a depth-first approach".

In addition to the investigation of the hypotheses above the results were examined to determine the relationships between the various measures used.

It was anticipated that the tests would be strongly related with attention deployment acting as the underlying common factor. The predicted direction for the various inter-relationships is given in parentheses in table (8).

Finally the relationships between the AH5 test of general ability and the other measures was also examined. No specific hypotheses were generated concerning relationships between ability and other factors. The test of ability was included to assess the degree of 'overlap' between ability and other factors, a factor of importance when evaluating the predictive and explanatory significance of any relationships revealed.

Investigation of predictions

The hypotheses were examined by observing student performance on the INTUITION equipment and on the measuring instruments outlined above.

Hypothesis One (Attention Deployment)

The analysis revealed that there were significant differences between learners who adopted a breadth-first approach and those who adopted a depth-first approach. As predicted, breadth-first learners displayed wider attention deployment, ie the ratio of peripheral cues used to central cues used was significantly larger for breadth-first than depth-first learners. See table (7).

Hypothesis Two (Cognitive Complexity

The analysis revealed significant differences between depth and breadth-first learners (results for module one alone were in the predicted direction but were not statistically significant). As predicted breadth-first learners displayed a more multi-dimensional construct system than depth-first learners; ie they obtained significantly lower scores on the Bieri test of cognitive complexity. See table (1).

Hypothesis Three (Problem Solving)

The analysis revealed significant differences between depth and breadth-first learners. As predicted breadth-first learners were more flexible in their approach to problem-solving when faced with lack of validation; ie they offered fewer repeat attempts on the problem-solving exercise. See table (7).

Hypothesis Four (Self-Consistency)

The analysis did not reveal any significant differences and the hypothesis was not supported. An explanation of this result is given in Chapter 4 and proposes that the hypothesis tested was based on poor theoretical grounds. See table (7).

The results are shown in table (7).

	Measures on which Depth/Breadth learners show significant differences	
	Module 1	Module 2
Attention Deployment	*	*
Cognitive Complexity	+	**
Problem-Solving	**	**
Self-Consistency	+	+

Table 7 (measures on which depth/breadth learners show significant differences)

** $p < .025$ * $p < .05$ (one tail) + no statistically significant difference

Inter-relationships Between Other Measures

As noted earlier it was predicted that the various measures taken would all be positively related with attention deployment acting as the common factor. A correlation matrix is given below. The predicted direction for the coefficient in each cell is given in parenthesis.

	1 AD	2 CC	3 PS	4 SC
1. Attention Deployment (Narrow = Low Score)	X	(-ve)** -0.62	(-ve)* -0.54	(+ve) +0.13
2. Cognitive Complexity (Complex = Low Score)	X	X	(+ve) +0.43	(-ve) -0.29
3. Problem-Solving (Flexible = Low Score)	X	X	X	(-ve) -0.32
4. Self-Consistency (Consistent = Low Score)	X	X	X	X

Table 8 (correlations between personality measures)

** $p < .01$, one-tailed
* $p < .025$, one tailed

Ability

The analysis revealed differences between depth and breadth-first learners. Breadth-first learners obtained significantly higher scores on the test of ability than depth-first learners.

The relationships between ability and the other measures are shown in the table of correlation coefficients given below.

	Attention Deployment	Cognitive Complexity	Problem Solving	Self Consistency
Ability	-0.345	+0.0131	-0.452	-0.022

Table 9 (correlation matrix : ability vs other personality measures).

Interpretation of Findings

The main findings given above show that the predicted interrelationships between attention deployment learning activity, cognitive complexity and problem solving are, for the most part, supported by the data. The most important features of these results and their implications will depend on the reader's viewpoint. In an attempt to ensure that most issues of general interest are covered the central findings and their implications will be examined (as were the results for Chapters 2 + 3) under 2 headings; Educational and Scientific.

Educational

It would be premature to develop firm educational prescriptions from the work reported in Chapters 4 + 5 of this thesis; however there are a number of issues that are important from an educational point of view.

The most significant feature of the results is that they support the suggestion that there are consistent individual differences in learning style related to differences in attention deployment and cognitive complexity.

The results support the conclusion that people who learn using a depth-first approach will develop a relatively simple and less multi-dimensional construct system. An interesting consideration here is the effect that differences in learning activity will have on cognitive structure. What would be the effect of controlling people's learning activity and forcing them into a depth or breadth-first mode, ie would it be possible to influence the organisational complexity of a construct system by controlling a person's learning environment or would fundamental differences in attention deployment counteract any such attempts? The answers to these questions can be discovered in the context of controlled educational experiments and will have important implications for teaching education and possibly remedial education. There is an increasing tendency for teachers/trainers to be more specific about goals of learning exercise. The movement began with statements of behavioural objectives and is continuing as attempts are made to develop 'knowledge structures', 'topic maps' etc. A knowledge structure acts as a partial map of the cognitive structure that the teacher wants the student to develop. The work reported here raises the possibility that different teaching techniques will be appropriate for the development of different types of structures (differing in terms of how they are organised and interrelated - not in terms of subject-matter) eg a breadth-first approach sproduces a more complex structure. It also seems that different types of students will find certain structures easy to learn and others more difficult. The work reported suggests correspondences between learning procedure, cognitive structure and individual differences in students; that adds to our understanding of important learning-related variables and is a further step towards the goal of having enough knowledge about the learning process for instruction to be both effective and individualised.

Another interesting area concerns the relationship between the test of ability and depth/breadth learning. Possible explanations of this relationship are discussed more fully in the next section. For the moment it is sufficient to note that although there is a statistically significant relationship between the conventional test of ability and depth/breadth learning there is no relationship between attention deployment and ability. Thus the introduction of the idea that differences in attention deployment are related to differences in learning is valuable, since attention deployment is independent of ability and thus improves explanatory power; these two independent factors taken together must 'explain' a considerable amount of the total variance associated with depth-breadth learning.

The results concerning problem-solving have implications from an educational viewpoint. There were clear cut differences in terms of the number of solution attempts made by students when faced with continual lack of validation. It seems that there may be some people (those with narrow attention deployment who tend to adopt a depth-first approach to learning) who will persist for long periods with a limited number of solution attempts - whereas other people will be more inclined to try a variety of possible solutions. Clearly the success of each type of approach will depend on many factors. The simple fact that students and teachers can be made aware of the different styles and can be encouraged to consider their value in various situations, rather than unconsciously adopt a single approach is a useful step forward.

Perhaps even more important is the possibility that students could be trained to adopt different approaches on different occasions. For example, what would be the effect of giving students exercises similar to the attention deployment test described earlier and encouraging them to concentrate on both sets of cues?

Exercises of this type could have possible repercussions in both problem-solving styles and (bearing in mind the discussion in Chapter 4 on creativity).

To summarize, as with the results of work described in Chapter 3, no firm educational recommendations can be made, but work of an experimental nature to investigate some of the ideas raised could be profitably pursued.

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Scientific

The finding of importance from a scientific point of view is the demonstration of the possible existence of differences in cognitive style observable as individual differences in attention deployment, learning activity, problem-solving and cognitive structure. The experimental findings have been backed up by theoretical discussion that provided a workable and somewhat novel way of looking at the learning process. An attempt has been made to ensure that the theoretical ideas are consistent and have some explanatory and predictive power. The work and theoretical analyses have built on previous relevant work and attempted to clarify the concept of width of attention as the distribution of available processing capacity. The concept has been made explicit and operationalised in a test of attention deployment. The same has been done for dimensions of difference relating to learning, cognitive complexity and problem-solving and inter-relationships between the various measures have been examined.

The experimental findings in Chapter 5 have, by and large, supported the predictions made and the important scientific implications cannot be separated from the more general ideas put forward. These ideas concern the inter-relationships between attention deployment and several factors including learning strategy. The relationships are summarized below.

Figure 2 shows the inter-relationships supported by data collected in this study.

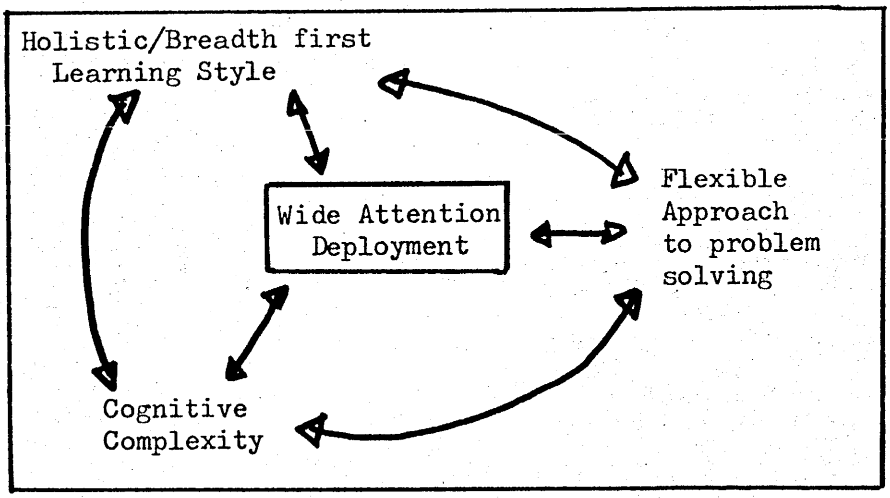

Figure 2 (Summary of inter-relationships indicated by the data)

As the figure indicates attention deployment is seen as the central and most fundamental concept. A more detailed examination of these inter-relationships and the causal chains involved is given in Chapters 4 and 5.

Further predictions made in Chapters 4 and 5 concern the relationships of subliminal perception and creativity to the factors shown above. Essentially it is suggested that creativity and subliminal perception may be positively related to wide attention deployment and some available supporting evidence is quoted. The main features of the inter-relationships (observed and predicted) are shown in Figure 3.

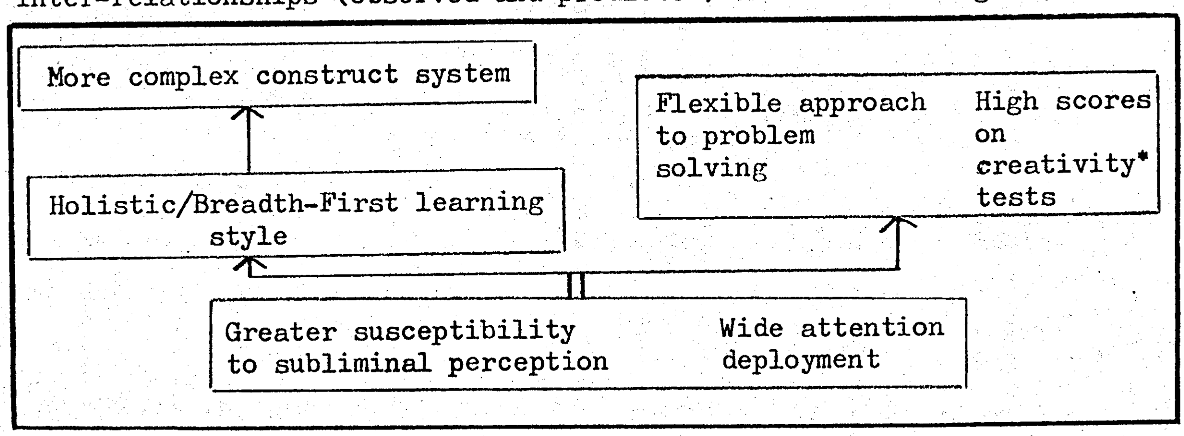

Figure 3 (Diagram showing main features of observed and predicted relationships)

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* Footnote The relationships should be most apparent on tests of creativity concerned with the production of novel situations or uses etc. Where suitability or relevance are not evaluated.

This diagram represents a partly validated statement concerning individual differences in cognitive style.

There are some implications for further research

i) Cross-validation of the initial findings reported in this study

ii) Validation of the other hypothesised relationships

The theoretical ideas that have been raised briefly here are covered more fully in Chapters 4 and 5.

4. General Remarks

i) Cognitive versus traditional personality factors

One of the main aims of the work reported in this thesis was to attempt to uncover relationships between personality factors and learning. The work reported in Chapter 5 has been most successful in this aim. A possible reason for this is the nature of the personality factors considered.

Ignoring psychodynamic and phenomenological theories, which although stimulating and often very comprehensive, present little opportunity for adequate formalisation and seem to have limited application outside the realms of psychotherapy and counselling, three major schools of personality theory may be identified.

1. Trait/typological
2. Social Learning Theory
3. Cognitive Theory

1. Trait/typological theories

This approach is founded on the assumption that differences in behaviour are caused by differences within individuals. Trait theorists believe that it is valuable to attempt to conceptualise individual differences in behaviour as being determined, at least in part by a person's position on an underlying disposition or dimension of difference. These dimensions of difference are described as traits and are seen as being responsible for cross-situational consistencies in behaviour.

Social Learning Theory

Contemporary exponents of this approach, such as Bandura and Walters (1963) and Mischel (1968) (1969), have improved on the typical neo Hullian learning theory approach of Dollard and Miller (1950) by ceasing to attempt a rapprochement between Freudian theory and learning theory and also by carrying out their studies using human subjects. They have emphasised the importance of models and imitation and noted that individuals are affected not only by rewards and punishment that they receive but also by the rewards and punishments that they observe others receiving.

Cronbach (1957) has pointed to the 'two disciplines' of scienctific psychology. Clearly the trait theorist approach, outlined above is allied to the individual differences viewpoint and as such minimises the importance of situational variables. By contrast the learning theory approach, where there is a distinction between stimulus and response and the latter can be explained in terms of the former, emphasises the primacy of situational variables.

A number of studies have attempted to assess the relative contribution of situations and persons eg Endler and Hunt (1966, 1968, 1969), Moos (1968, 1969). Bowers (1973) reviews a group of 11 studies and concludes that the data "......Clearly indicates that neither the trait nor situationist predictions are borne out. Far too little of the total variance (12.7%) is due to the person....on the other hand the percentage of variance due to situations is also meagre.

Argyle and Little (1972) also review a number of studies and provide

4 possible models that clarify various points of view.

The models are:

i) Total person variability

This represents the extreme trait theory view that intro-individual differences are totally responsible for differences in behaviour; and differences in behaviour will be consistent from situation to situation.

ii) Total situation variance

This represents the extreme situationist view that behaviour is totally determined by situational factors.

iii) Dispositional

According to this point of view both person and situational variables contribute, so that although individuals differ according to the situation the rank order of different people will remain the same.

iv) Interaction

Here the point of view is that both personality and situations contribute to outcome but in such a way that each person changes his score in each situation and rank order is not necessarily maintained.

Argyle and Little reviewed a collection of studies designed to assess the relative contribution of person and situation. They concluded that the idea of personality as consistent patterns of behaviour received very little support and emphasised the importance of interaction variance. Most of the studies reviewed by both Bowers and Argyle and Little were concerned with traditional descriptions of personality such as leadership, persuasibility, and anxiety. Mischel has also summarized a considerable body of evidence and concluded that cross-situational generality did not hold for variables such as dependence, attitudes to authority, rigidity and moral behaviour -

ie the same sort of conclusion as Bowers and Argyle and Little; however Mischel also found that cross-situational generality did hold for more cognitive factors such as intelligence and field dependence.

Cognitive Theory

Traditionally personality theorists have emphasised the motivational emotive and biological characteristics of individuals and only in the last 15-20 years has a consideration of thought processes been important.

Cognitive theorists such as Bieri et al (1966), Harvey Hunt and Schroeder(1961,)Schroeder, Driver and Streufort(1967), Rokeach(1960), Witkin et al(1962)have some features in common, in that individual styles of thinking have tended to be conceptualised in much the same way that the trait theorists have conceptualised traits and there has been an emphasis on the way in which a person processes information and constructs his view of the world.

This approach in psychology (it is not, of course, a new point of view for philosophers) owes much to the work of Piaget (1954) who suggested that reality is virtually constructed by an individual and that this construction is a function of his methods and means of knowing it - also Kelly (1955) and Neisser (1967).

Demonstrations of the invariance of cognitive styles have been somewhat more impressive than have the attempts to demonstrate the invariance of some of the traditional personality traits eg Mischel (op cit), Witkin et al (1962).

The greater situational independence of cognitive factors may, in part, explain the results obtained in this thesis.

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The factors studied in Chapters 2 and 3 were more traditional personality factors, whereas cognitive factors more concerned with information processing and structure, were the focus of attention in Chapters 4 and 5.

It is undoubtedly true that the situation is an important determinant of behaviour - it is also true that there are certain consistencies in behaviour across situations. Our perception (or construction) of a situation is to some extent a subjective and personal one. Thus a consideration of man's means of 'construing' his environment and the consistencies that exist in our methods and styles of cognition may provide a possible basis for examining individual differences that are consistent from situation to situation and may improve on the existing conventional trait conception of personality which appears to offer little consistency across situations.

ii) Stability and generality of the learning indices studied

A matter of some importance from the educational viewpoint concerns the stability of the various learning indices studied and the extent to which they indicate 'situation-free' learner characteristics.

All of the indices examined with the exception of errors were found to be extremely reliable measures. Not only were the measures reliable but the balance of evidence suggests that some were indicators of 'real' generalisable student characteristics and not merely specific indicators of how learners behaved on a particular piece of equipment. The evidence concerning the learning indices as valid measures of general characteristics is summarized below.

Feedback from Students

When students had completed all of their sessions on the INTUITION equipment the experimenter discussed, in detail, their reactions to the equipment. During the course of the discussion the student was referred to his own learning records and the extent to which he had chosen near or distant topics as aims was made clear to him (ie he was told whether he had displayed a high or low 'appreciation span').

The student was then asked to comment on his reasons for choosing nearby or distant aim topics.

The experimenter continued the discussion and with as little prompting as possible tried to assess whether or not, for this particular student, appreciation span was an indicator of how far ahead he had planned.

The same procedure was followed for depth/breadth learning and for the indices of exploratory behaviour. Discussion also took place on whether or not each of the indices were descriptive of the general learning procedures that the student adopted.

Feedback from Teachers

Four members of the teaching staff at Henley, who between them had taught all of the students used in the experiment were also informally presented with information about the ways in which students had behaved on the INTUITION equipment and asked to comment on the validity of the findings from their experience of the particular students involved.

The evidence obtained from these sources pointed to the following conclusions.

1 a) Appreciation Span does indicate the distance ahead that students planned when working on INTUITION.

b) The value for Appreciation Span obtained from INTUITION is descriptive of the extent to which a student looks ahead in any learning situation.

2 a) The value obtained for Depth/Breadth learning does indicate the extent to which a student extended his knowledge in a number of areas more or less simultaneously when working on INTUITION.

b) The extent to which a student adopted a Depth/Breadth-first approach when working on INTUITION is indicative of the extent to which he adopts this approach in any learning situation.

It was not possible to establish such a consistent picture of what the two measures of exploration (pre and during work) were indicating.

In general terms it seems that pre-working exploration was indicative of the extent to which a student had gathered information before deciding where to begin learning, ie the extent to which a student made use of what Ausubel (1960) has described as "advance organisers".

However, during work exploration seems to have been influenced by many factors including for instance whether students thought the information slides were interesting or not. One student claimed to have explored extensively at one particular point just to see if the equipment would go wrong and show the wrong slide!

Thus it was difficult to identify any consistent reasons for observed differences in exploration. Furthermore, it did not seem that students' exploratory behaviour on INTUITION bore any relationship to behaviour in other situations. This is confirmed by the lack of relationship between exploration conducted on INTUITION and the results of the information demand test, and by students' comments.

These conclusions are somewhat subjective and must be viewed with caution. They are presented mainly for the sake of completeness since it was felt worthwhile to record the best available conclusions concerning the generality of the learning indices studied.

The extent to which these conclusions are valid will be an interesting topic for further study.

iii) <u>Some Methodological Implications</u>

These experiments have shown that it is feasible and informative to examine certain aspects of students' learning strategies using the techniques described. Two of the drawbacks of the research were the length of time taken to gather the data and the unavoidable smallness of the sample.

It would be of considerable value to researchers if a method was available for collecting data from large numbers of students. The experience gained in this study makes it possible for a description of the essentials of such a method to be given, they are:

1) <u>a topic map</u>, showing how a collection of topics are related
2) <u>a task structure</u>, or set of behavioural objectives for investigating and learning about each topic
3) <u>a set of instructional material</u> for each topic
4) <u>a procedure</u> for testing students' understanding of individual topics.
5) <u>a procedure</u> for recording the order of topics worked on

This basic prescription specifies the essential features of a learning environment. These essential features could be embodied in various ways depending on the interests, ingenuity and financial resources of the researchers but it is by no means essential to develop sophisticated equipment.

The basic prescription can be supplemented by various features depending on the aims of the research so that, for example, a facility for recording the extent and intensity of students' planning activity could be added.

The main point is that it would be possible to develop a learning environment that could be used to collect data fairly quickly from large numbers of students and could be adapted to study a variety of indices of learning strategy, or to conduct studies of various situational factors.

A few possibilities are given below:

- students could be offered alternative types of instruction for the topics involved, eg rule followed by example or example followed by rule
- students could be given access to 'summary' and 'review' topics
- the effect of material of varying degrees of difficulty could be studied
- extensive studies of personality-learning relationships could be undertaken.

Thus the description offered above could be used profitably as a basis for the design of methods for studying learning, situational variables, and personality characteristics.

A final statement

In the first few paragraphs of Chapter 1 it was noted that the writer's interest in learning and personality was sparked by a desire to be able to provide a more comprehensive picture of learning than ability tests would allow. The experiments conducted in this thesis have examined personality factors that are, for the most part, unrelated to ability and in some cases relationships between those factors and indices of learning style and efficiency have been established. Some of the other investigations have revealed little in the way of relationships between learning and personality but have still been valuable in clarifying and refining areas of interest.

It is hoped that the products of this research, ie the results and the theoretical ideas discussed will be of as much value to other workers as the actual process of conducting and writing up the work has been to the writer.

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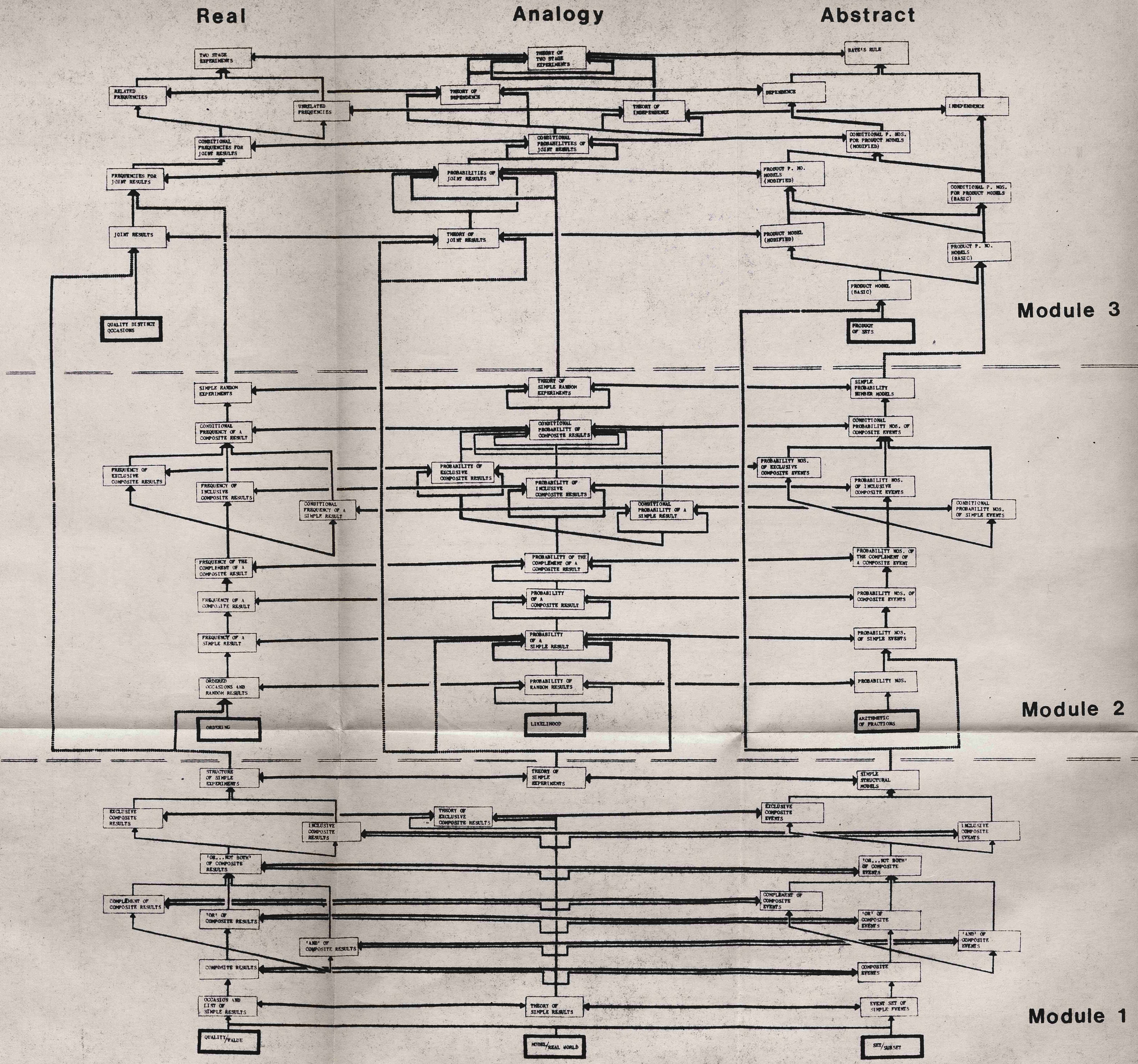
APPENDIX 1

Topic Map for 3 Modules of Probability Theory



Key : dotted lines are entailments not shown on mini-structures
thick bordered boxes are primitives

Fig 4. Entailment structure showing relations between the mini-entailment structures of modules 1, 2, and 3.

APPENDIX 2

The Written Introduction Given to Students

Appendix 2

The Written Introduction Given to Students

In practice, and perhaps not surprisingly to the reader, these written instructions proved to be rather difficult for students to understand and invariably needed supplementing by considerable verbal explanation. This verbal explanation covered the main topics mentioned in the written material but in much simpler language. In fact, introducing the equipment to the subjects and ensuring that they understood it was not a very difficult task; this was probably due more to the interest and abilities of the students than the clarity of the written instructions presented here.

The writer did not participate in the preparation of these instructions and they are presented because they were actually given to students as part of the introduction - although, as noted above, they were quickly supplemented by verbal explanation.

These instructions have since been re-written and are now far easier to read.

System Research Ltd: SSRC Project: "Application and Development of a Theory of Learning and Teaching"

Introductory Notes: For students using the INTUITION system.

Aims of the Study:

1. To evaluate the equipment, materials and procedures which are designed to individualise instruction.

2. To gather detailed information about how people learn.

Methods:

We wish you to go through a course of instruction, using the equipment and materials. The equipment is designed so that we can observe how you learn and how you explain topics once you understand them.

Subject Matter:

The subject matter is probability theory, presented in an essentially non-technical way which tries to make clear the basic concepts.

Probability theory is concerned with constructing abstract models for the results of experiments carried out in the real world.

The models represent the chance or likelihood of occurrence of results. For example, an abstract model might be constructed to represent the likelihood of occurrence of the result even number for a dice throw.

The basic notions in probability theory are important in all sciences and in all activities involving risk-taking, and decision-making. Theoretical discussion of the nature of chance is an important topic in philosophy.

The subject matter has, for convenience, been broken down into three modules.

Module 1 is concerned with modelling the structure of a single experiment.

Module 2 is concerned with modelling the random results from a series of repeated experiments.

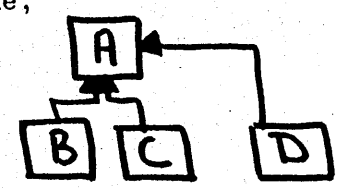
Module 3 is concerned with modelling the random results from a series of experiments, where each experiment has two distinct parts or stages and where the results from one stage may or may not influence the results from the second stage.

How the subject matter is presented:

Each module is broken down into topics. Each topic is explained by written text and by demonstration. The equipment called STATLAB is for simulating experiments and constructing abstract models.

For each module, there is a large chart called an entailment structure which represents how topics are related. The entailment structure shows what other topics you need to have understood (called pre-requisites), before you can work on any particular topic.

For example,



You may work on topic A only when you have understood topic D OR topics B AND C.

The lower most topics are called primitives: you are required to have an understanding of these before using the system.

The uppermost topics are the head topics, you will have completed a module when you understand the three head topics. You will have completed the course when you come to understand the head topics on module 3.

The entailment structure shows the many permissible ways there are of progressing through the subject matter.

On each chart topics are organised into three main groups:

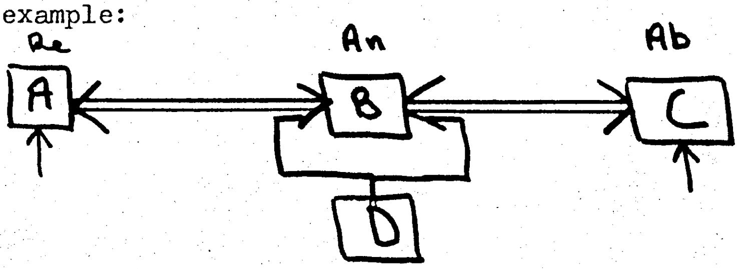
(1) topics concerned with experiments carried out in the real world (these are headed, "Re").

(2) topics concerned with constructing and manipulating abstract models (these are headed "ab")

(3) topics that show how models are set up to correspond to real world experiments. These topics state the form of the analogies that relate the real world and the abstract world. (These are headed "An").

The analogies are shown by the thick lines with arrow heads at each end.

For example:



This shows that, having understood topic D, you may learn A, B and C in several different ways:

A then B then C

C then B then A

A then C then B

C then A then B

ALSO

There is an important extra rule for topics in the An column which allows you to work on an An topic without having understood the corresponding RE and AB topics, provided you work on one or both of the Re and Ab topics, at the same time. So that in the example you could work on A and B, B and C or A and B and C.

Procedure

The basic rule of the system is that before learning about a topic, you must understand sufficient pre-requisite topics.

Your understanding of a topic will be tested by asking you to carry out practical exercices on STATLAB.

To help you in deciding what to do, lights are provided on the chart that show:

(1) for each topic, what other topics lie on possible routes to it (yellow lights).

(2) at each stage in learning, what topics you are permitted to learn (red lights).

In addition, you can bring on descriptive slides which briefly say what a particular topic is about.

The procedure is as follows:

(1) You may explore the subject matter by bringing on descriptive slides. The instruction card shows how.

(2) You choose a topic to aim for. This may or may not be a topic you are permitted to work on at this stage, but it may be a topic which you are working towards. The instruction card tells you how to indicate your aim topic.

(3) Having chosen an aim you may choose one or more topics to work on.

Any "work on" topic must have a yellow light on, showing that it is on a route to the aimed for topic or the aim topic itself, AND a red light on, showing that you have understood the pre-requisite topics.

To start work on a topic the flap must be opened. INSERT A "GOAL PLUG" AS SHOWN ON THE INSTRUCTION CARD. If the work on topic is "Illegal" a warning tone will sound and the plug must be removed.

On the reverse side of the flap are the numbers of the main text folder (large number) and of the demonstration text for the topic. (The instruction card shows how to locate the text for those topics which have four red lights).

(4) When the topic(s) has been established as a legal "work on" you may study the main text and carry out the demonstrations using STATLAB. Demonstrations can be omitted if you think they are unnecessary.

(5) When you think you are ready you should ask to have your understanding of the topic(s) tested. You will be asked to carry out exercises using STATLAB.

(6) If the test(s) for understanding are satisfactory, the work on topics are marked understood and the procedure returns to step 1. If the test(s) are failed, you must continue to work on the topics(s) in question: reading the text and setting up demonstrations on STATLAB, until you are again ready for testing.

NOTE

In all cases, the demonstration of your understanding must not be just a copy of the demonstration given in the tutorial materials.

Having shown that you understand the topic(s) mark it (them), as understood by inserting an "understood plug(s)" (see instruction card). This will bring on the red lights of further topics that are now available as possible "work on" topics.

The Form of Tutorial Materials

The tutorial materials are organised as follows:

For each topic there is a set of written materials that constitutes the "Main Text". The large index number on the node flap refers you to the appropriate file.

For "Abstract" topics (nodes on the right hand side of the entailment structure) just one set of demonstrations are provided. For "real world" and "analogical" topics, three sets of demonstration materials are provided. These give examples from different fields of application of probability theory; those chosen are "games of chance", "behavioural science" and "plant breeding". You may, if you wish, examine just one set or any two sets or all three. The relevant sets for a given topic carry the same index number but are filed in different boxes.

You may, if you wish omit demonstrations if you feel that you understand the topic. You will still be required, of course, to carry out practical exercises to demonstrate this understanding and so must be familiar with the relevant parts of STATLAB.

STATLAB

STATLAB is the facility for carrying out demonstrations and giving explanations, in the form of practical test exercises.

The details of its operation are explained in the demonstration materials. Initially the practical exercises may seem very simple, as you progress through the subject matter they become more complex and more of STATLAB becomes relevant for use.

The left hand panels (A and B) are for carrying out exercises simulating practical experiments to which probability theory is applicable.

The right hand panels (C and D) are for constructing abstract models and carrying out calculations. Topics from the left hand side of the entailment structure ("Re") require only Panels A and B. Topics from the right hand side of the entailment structure ("Ab") require only panels C and D. Topics from the centre part ("An") require all 4 panels.

APPENDIX 3

Graphical Representation of Students' aiming and Exploratory Behaviour

Appendix 3

Graphical representation of students' aiming and exploratory behaviour.

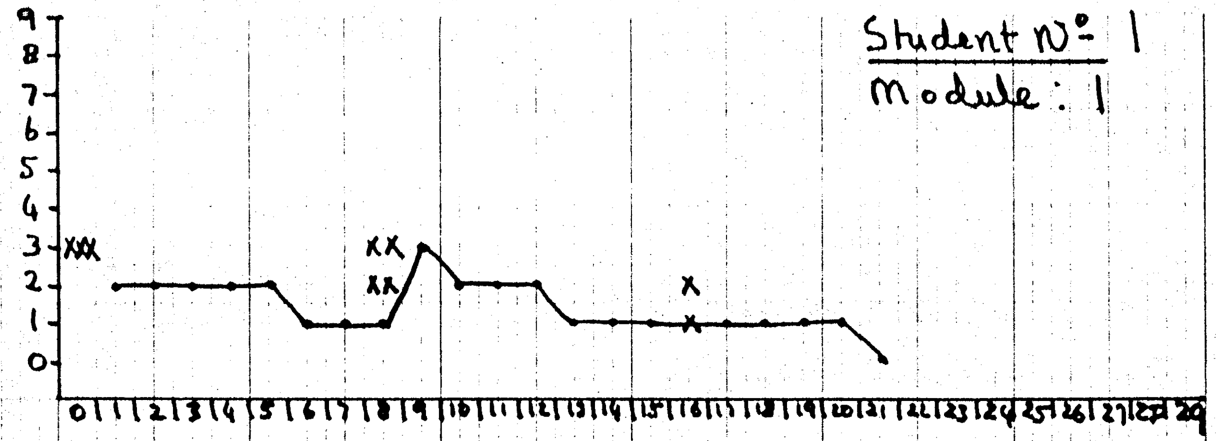
i) Aiming

The ordinate represents the distance (calculated as shown in Chapter 2) between the current topic being worked on and the topic being aimed at. The line of the graph plots each student's measured appreciation span as he/she progressed through the material.

ii) Exploration

Each cross (x) signifies an explored topic. The ordinate represents the distance (calculated as shown in Chapter 2) between the current topic being worked on (or just completed) and the topic explored.

Thus the number of crosses above occasion 'o' indicate the amount of pre-working exploration that each student conducted The crosses above occasion '1' indicate the number and position of topics explored between the first and second topic worked on etc.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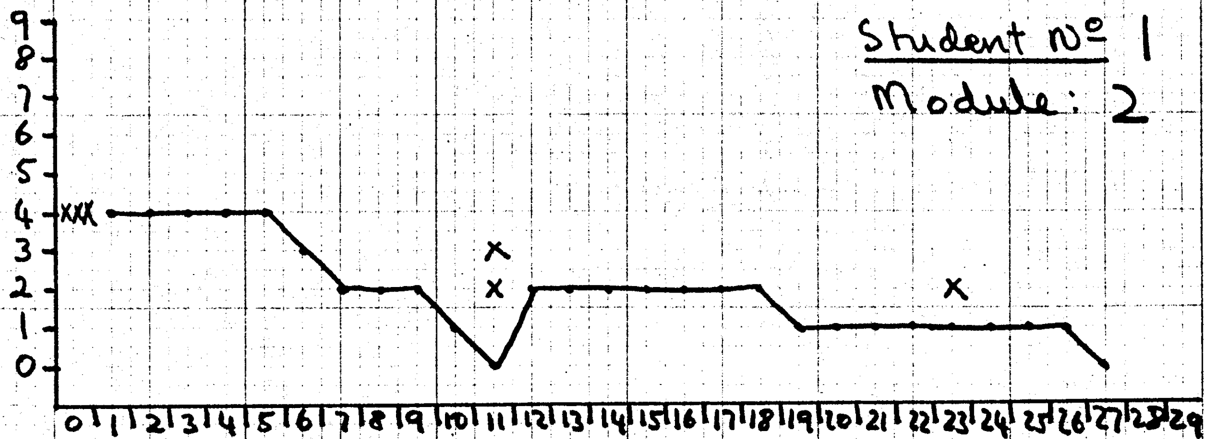
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Student No 2
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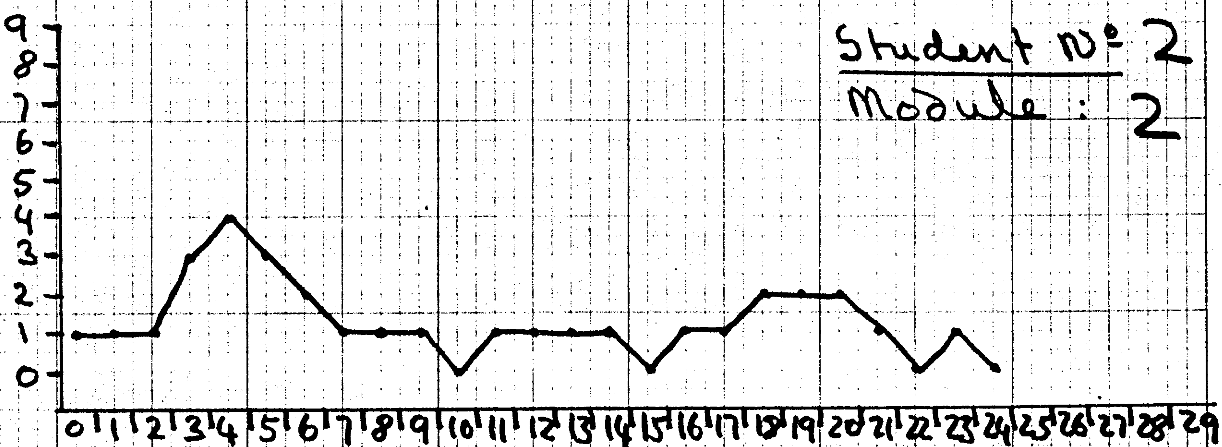
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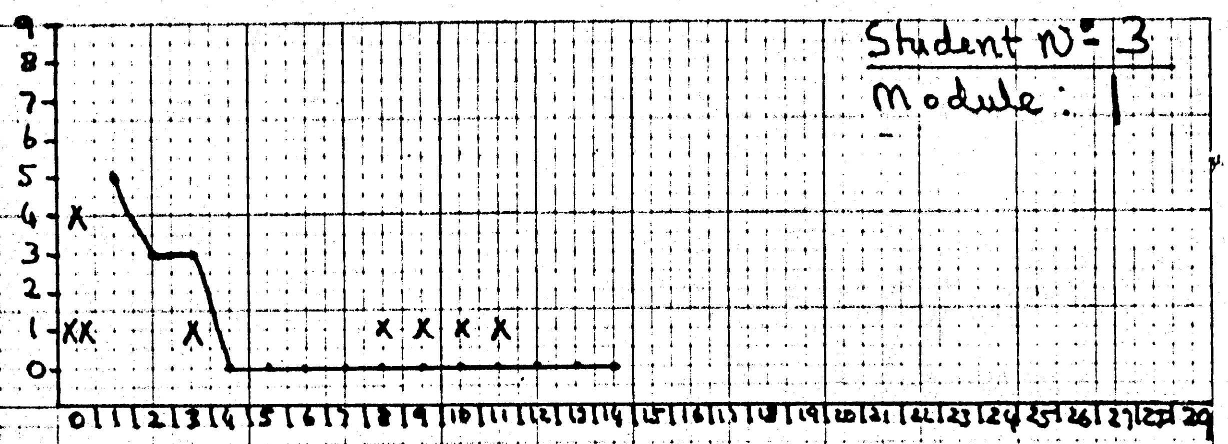
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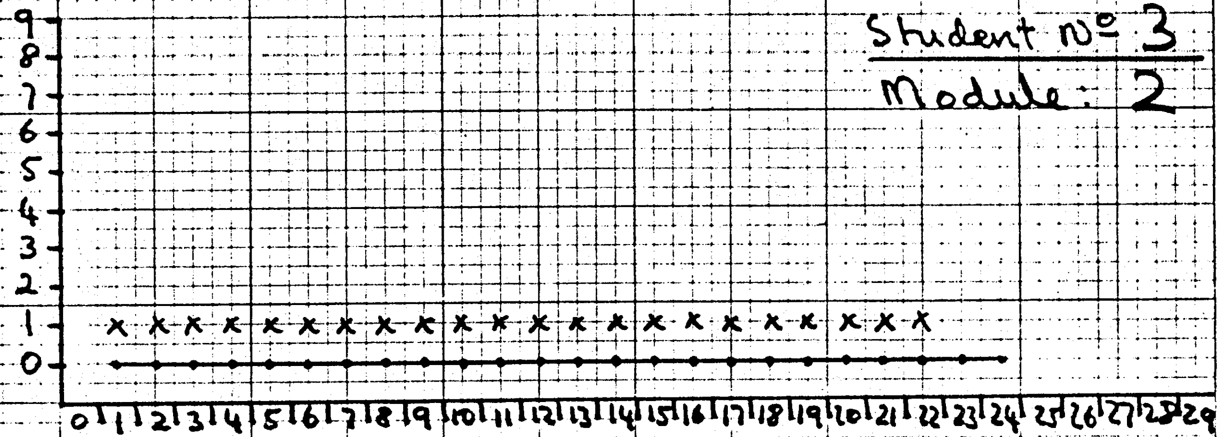
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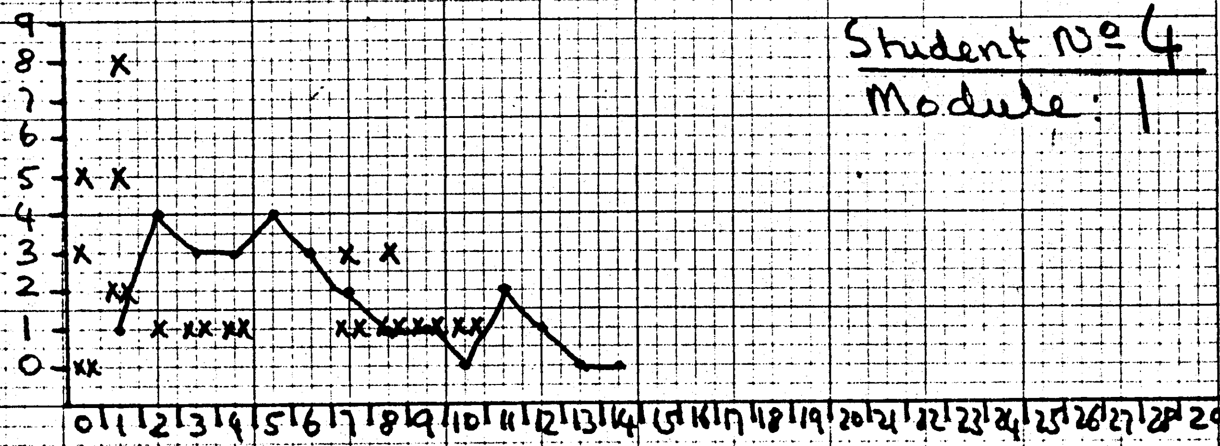
Module: 2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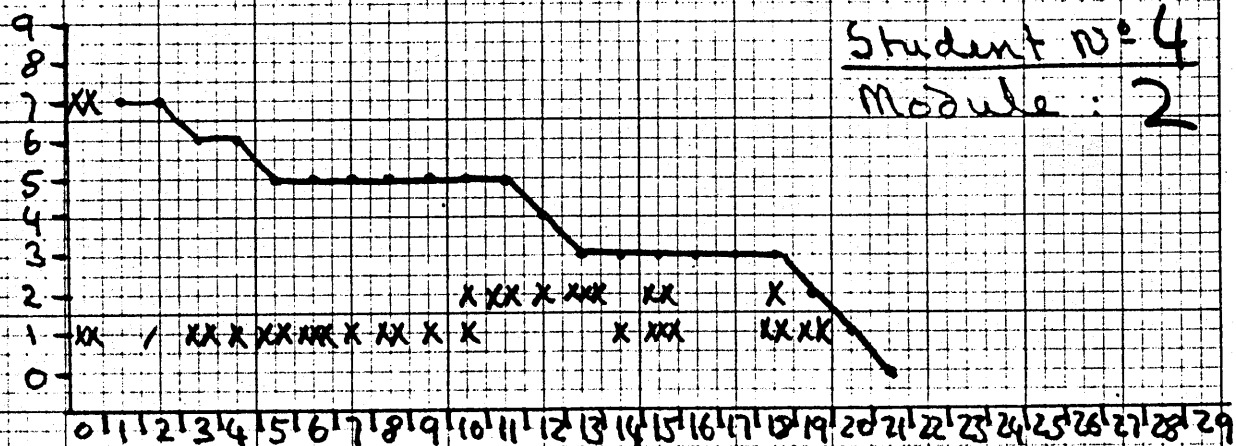
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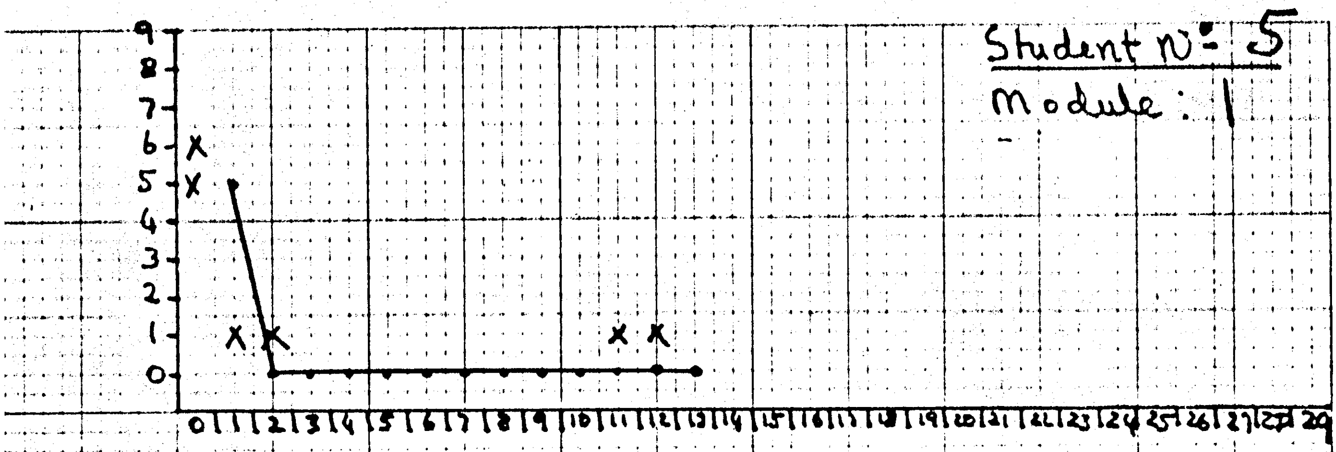
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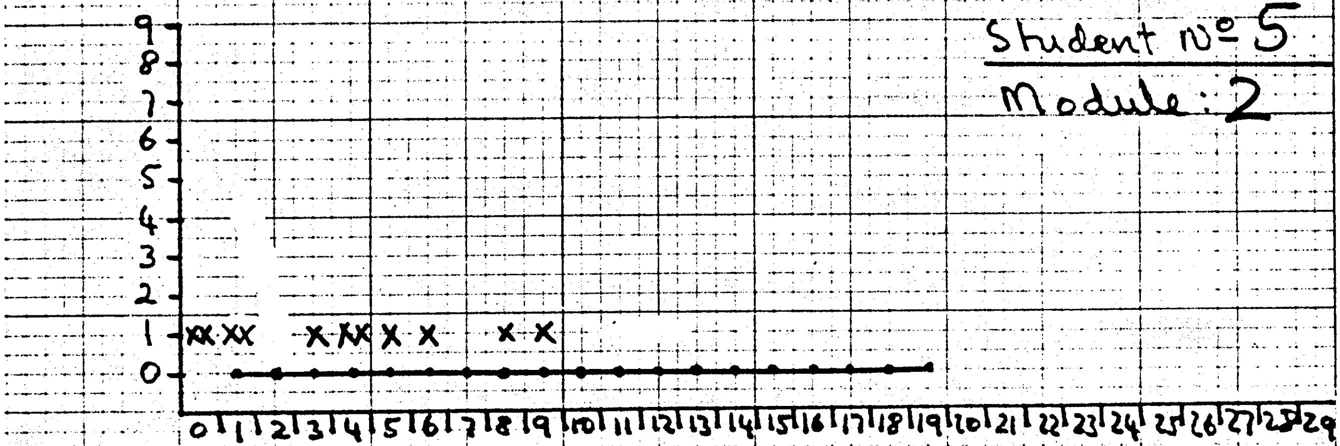
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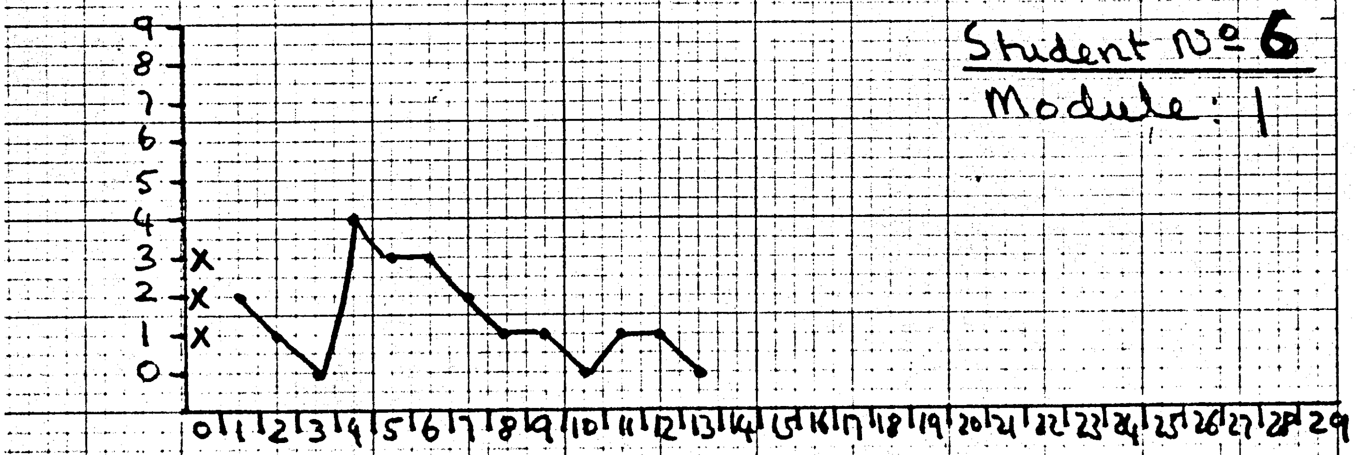
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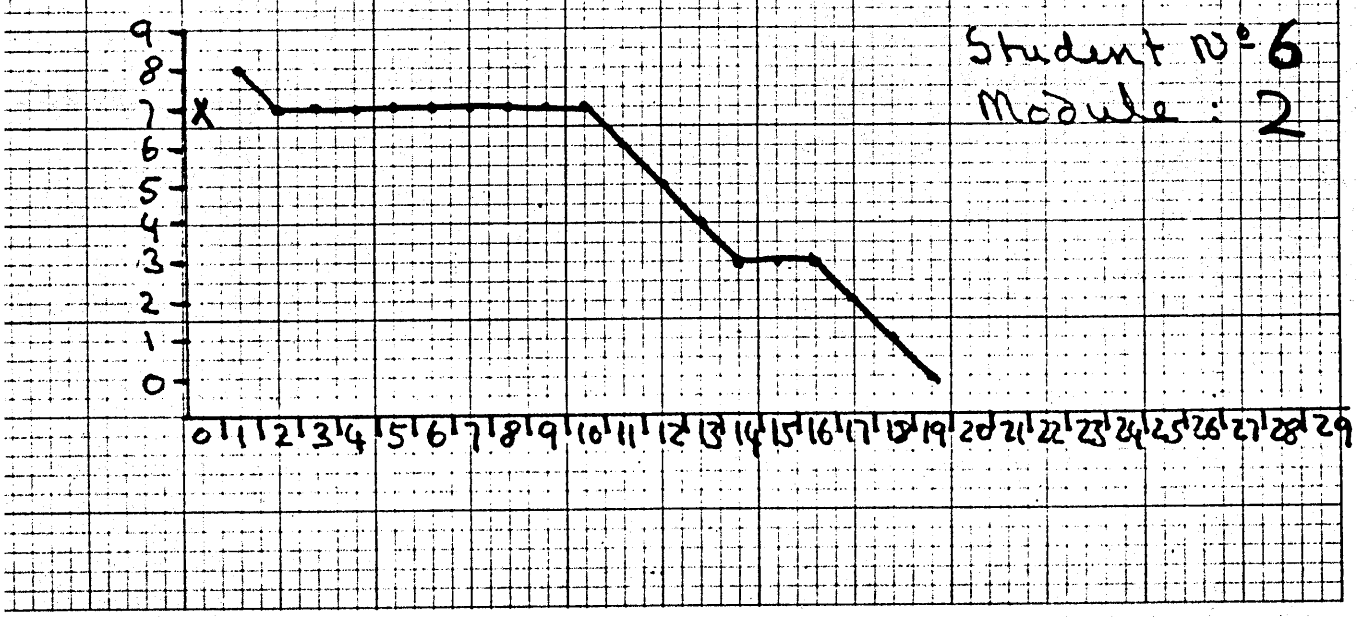
Student Nº 6
Module : 2


Student Nº 7
Module: 1
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0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29


Student Nº 7
Module: 2
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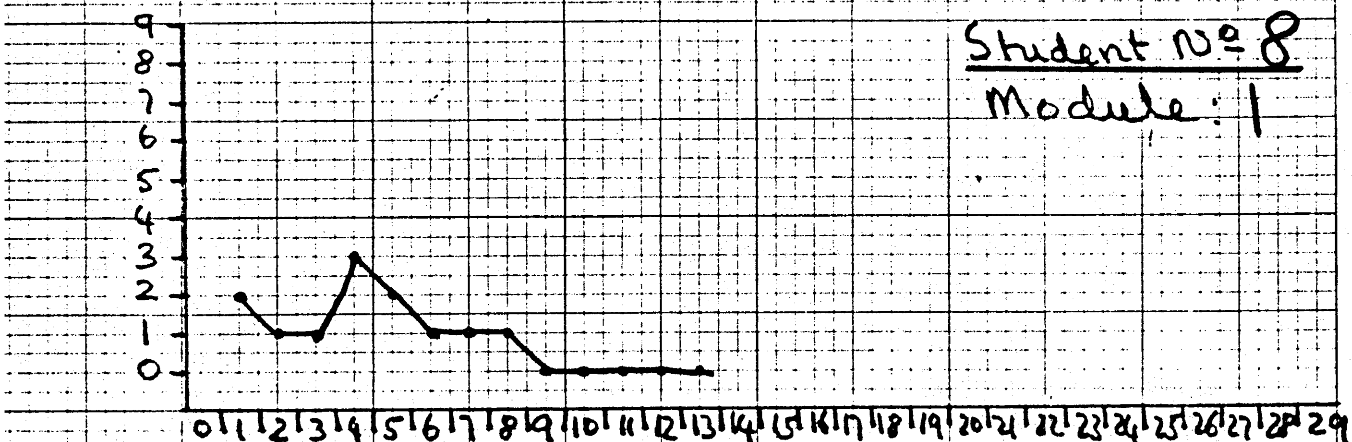
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29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0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29


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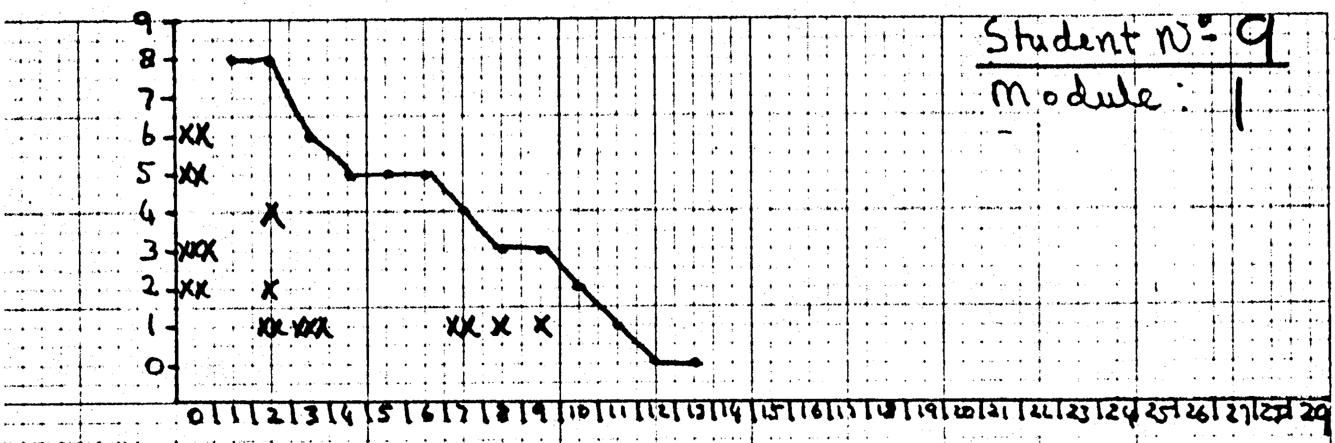
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29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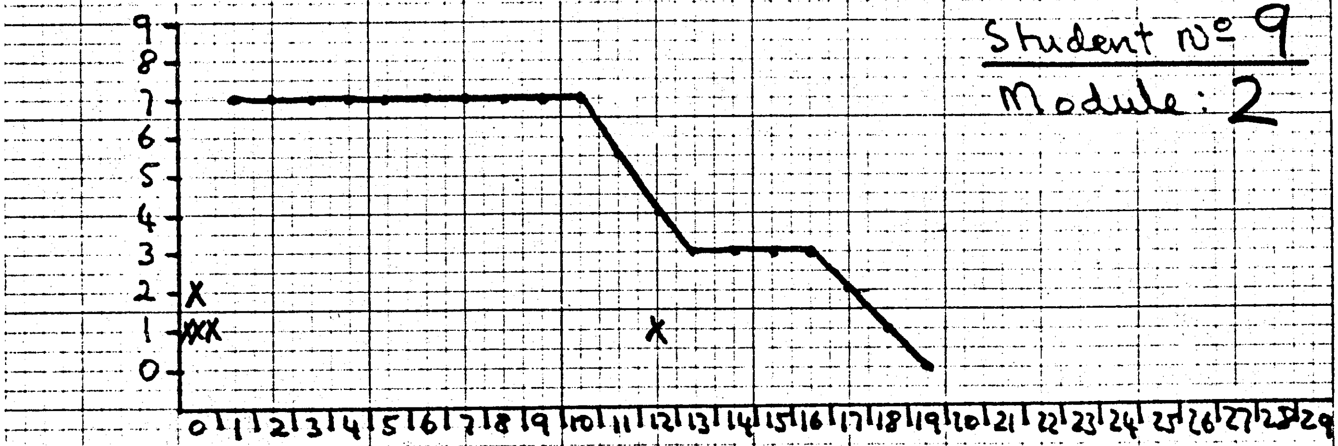
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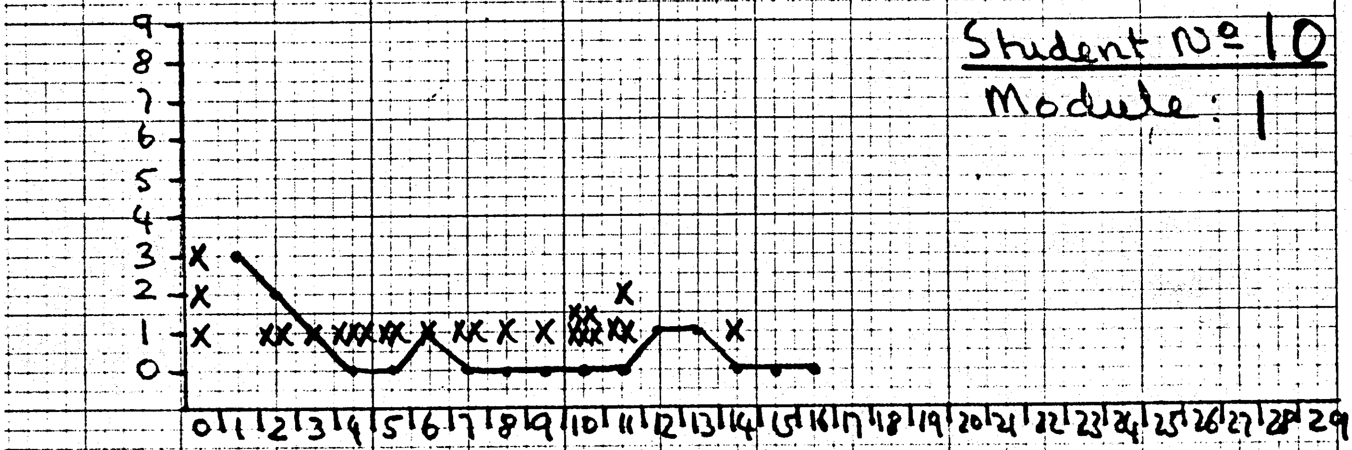
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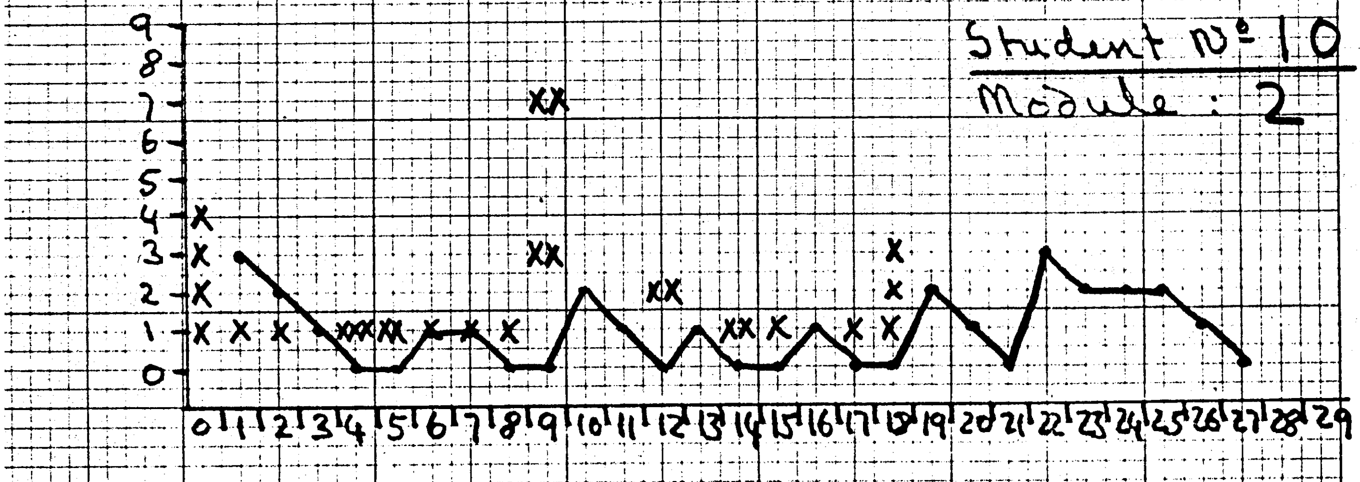
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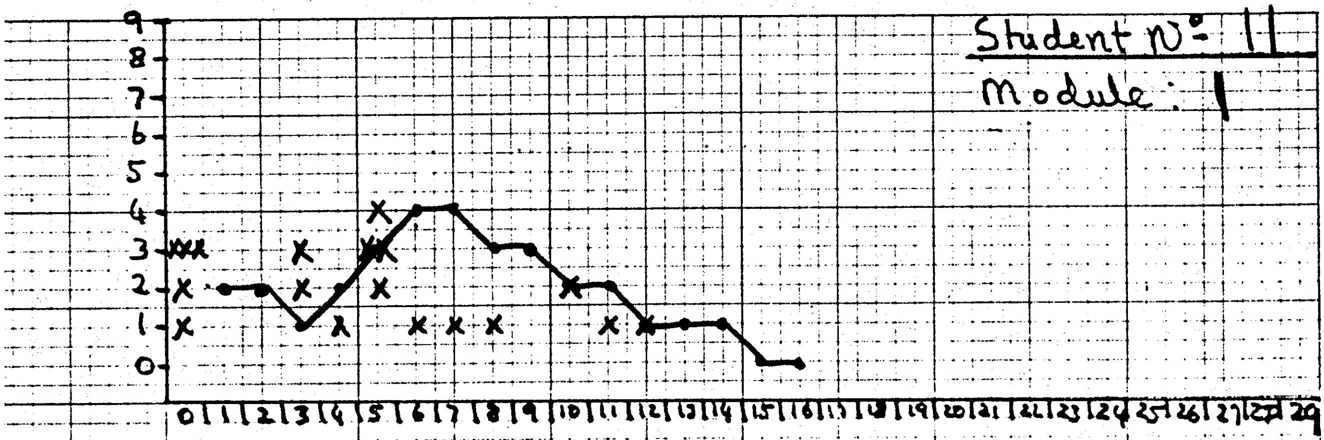
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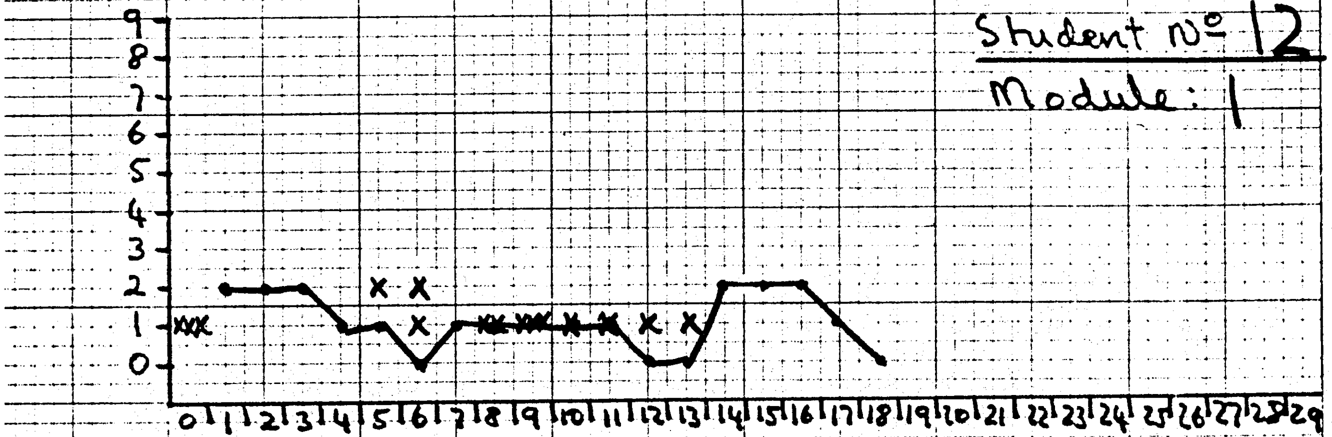
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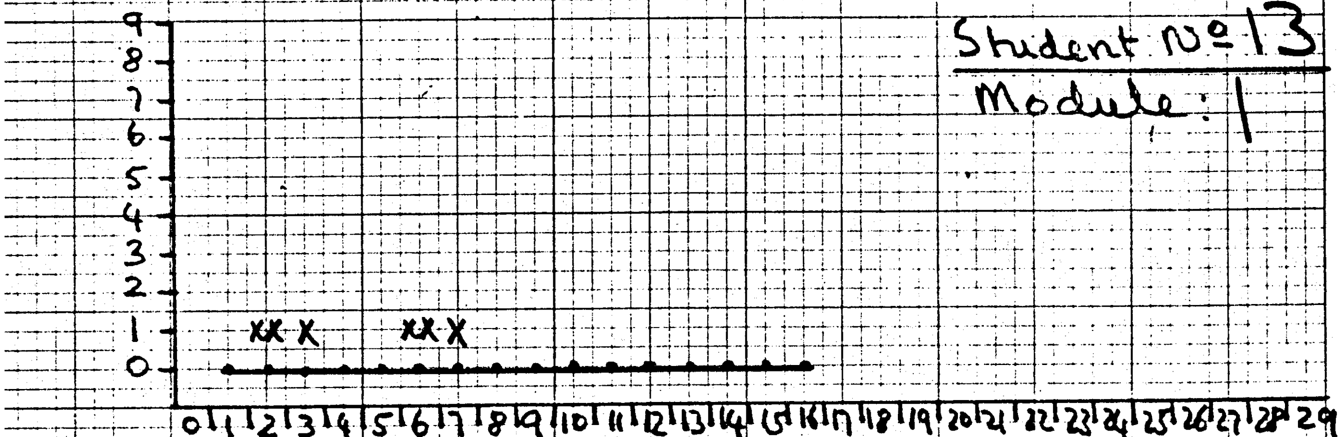
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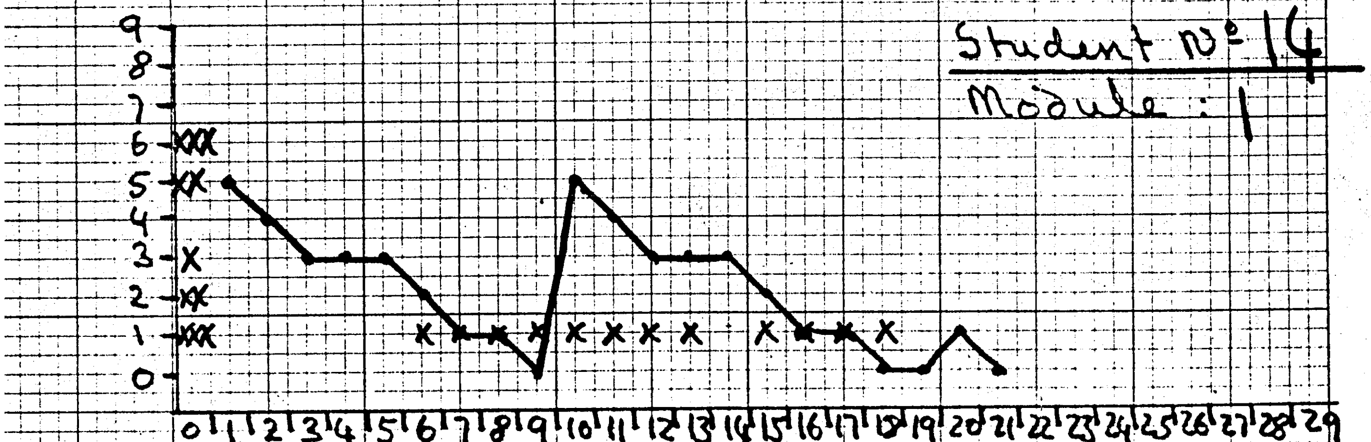
Module: 1


Student Nº 14
Module: 1

APPENDIX 4

Record Sheets

Appendix 4

Record Sheets

These sheets were used to record details of student progress by the experimenter/observer.

To simplify the records each topic on the topic map for each module was given a code. The topic map for module 1 is given below as an illustration.

Real	Analogical	Abstract
Re 1	An 1	Ab 1
Re 2a Re 2c	An 2	Ab 2a Ab 2
Re 3		Ab 3
Re 4a Re 4b Re 4c		Ab 4a Ab 4b Ab 4c
Re 5		Ab 5
Re 6	An 6	Ab 6

Module 1 Student No 1

Topic Aimed For	Topic Worked-On	Accuracy of first Explanation	Topics Explored
			Re4a, Re4b, Re4c
1 Re4a	Re6	✓	
2 Rera	An6	✓	
3 Re4a	Ab6	✓	
4 Re4a	Ab5	✓	
5 Re4a	Ab4a	✓	
6 Re4a	Re5	✓	
7 Re3	Re4a	✓	
8 Re3	Re4b	✓	Re2c, Re2a, Ab2c Ab2a
9 Ab2a	Re4c	✓	
10 Ab2a	Ab4b	✓	
11 Ab2a	Ab4c	✓	
12 Ab2a	Re3	✓	
13 Ab2a	Ab3	✓	
14 Ab2a	Re2a	✓	
15 Ab2a	An2a	✓	
16 Ab2a	Ab2a	✓	Abl, Rel
17 Rel	Re2c	✓	
18 Rel	Ab2c	✓	
19 Anl	Rel	✓	
20 Anl	Abl	✓	
21 Anl	Anl	✓	
			An4, Ab4, Re4
1 An4	Re7	✓	
2 An4	Re6	✓	
3 An4	Re5	✓	
4 An4	Re4	✓	
5 An4	Ab7	✓	
6 An4	An7	✓	
7 An4	An6	✓	
8 An4	Ab6	✓	
9 An4	Ab5	✓	
10 An4	An5	✓	
11 An4	An4	✓	Re2, An2
12 An2	Re3a	✓	
13 An2	Ab4	✓	
14 An2	Ab3a	✓	
15 An2	Re3b	✓	
16 An2	Re3c	✓	
17 An2	Ab3b	✓	
18 An2	Ab3c	✓	
19 An2	An3a	✓	
20 An2	An3b	✓	
21 An2	An3c	✓	
22 An2	Re2	✓	
23 An2	Ab2	✓	Anl
24 Anl	An2	✓	
25 Anl	Rel	✓	
26 Anl	Abl	✓	
27 Anl	Anl	✓	

Module 1 Student No 2

	Topic Aimed For	Topic Worked-On	Accuracy of first Explanation	Topics Explored
1	Ab4b	Ab6	✗	
2	Ab4b	Ab5	✓	
3	Ab3	Ab4c	✓	
4	Ab3	Ab4b	✓	
5	Ab3	Ab4a	✓	
6	Ab2a	Ab3	✓	
7	Abl	Ab2c	✓	
8	Abl	Ab2a	✗	
9	Abl	Abl	✓	
10	An2	An6	✓	An2, Re2c
11	Anl	An2	✗	
12	Anl	Re2a	✓	
13	Anl	Anl	✓	
14	Rel	Rel	✓	
	Module 2			
1	Re6	Re7	✓	
2	Re5	Re6	✓	
3	An5	Re5	✓	
4	An4	Re4	✓	
5	An4	An7	✓	
6	An4	An6	✓	
7	An4	An5	✓	
8	An4	Ab5	✓	
9	An4	Ab4	✓	
10	An4	An4	✓	
11	Re2	Re3c	✓	
12	Re2	Re3b	✓	
13	Re2	Re3a	✓	
14	Rel	Re2	✓	
15	Rel	Rel	✓	
16	An2	An3a	✓	
17	An2	An3b	✓	
18	An2	Ab3b	✓	
19	An2	Ab3c	✓	
20	Anl	An3c	✓	
21	Anl	An2	✓	
22	Anl	Anl	✓	
23	Abl	Ab2	✓	
24	Abl	Abl	✓	

Module 1 Student No 3

	Topic Aimed For	Topic Worked-On	Accuracy of First Explanation	Topics Explored
1	Ab3	Re6	✓	Ab3,Reb,Ab6 An6
2	Ab3	An6	✓	
3	Ab3	Ab6	✓	Re5
4	Re5	Re5	✓	
5	Re4c	Re4c	✗	
6	Re4b	Re4b	✓	
7	Re4a	Re4a	✓	
8	R3	Re3	✓	Re2c
9	Re2c	Re2c	✓	Re2a
10	Re2a	Re2a	✓	Re1
11	Re1	Re1	✗	An2
12	An2	An2	✓	
13	An1	An1	✓	
14	Ab1	Ab1	✓	
	Module 2			
1	Re7	Re7	✓	Re6
2	Re6	Re6	✓	Re5
3	Re5	Re5	✓	Re4
4	Re4	Re4	✓	An7
5	An7	An7	✓	An6
6	An6	An6	✓	An5
7	An5	An5	✓	Ab5
8	Ab5	Ab5	✓	Ab4
9	Ab4	Ab4	✓	Ab3c
10	Ab3c	Ab3c	✗	Ab3b
11	Ab3b	Ab3b	✓	Ab3a
12	Ab3a	Ab3a	✓	Ab2
13	Ab2	Ab2	✓	Ab1
14	Ab1	Ab1	✓	Re3a
15	Re3a	Re3a	✓	Re3b
16	Re3b	Re3b	✓	Re3c
17	Re3c	Re3c	✓	Re2
18	Re2	Re2	✗	Re1
19	Re1	Re1	✓	An3b
20	An3b	An3b	✓	An3a
21	An3a	An3a	✓	An3c
22	An3c	An3c	✓	An2
23	An2	An2	✓	
24	An1	An1	✓	

Module 1 Student No 4

Topic Aimed For		Topic Worked-On	Accuracy of first Explanation	Topics Explored
				Ab2c, Ab6, Re4b, Re6
1	Re5	Re6	✓	Re4a, Re4b, An1, Re1
2	Re1	Re5	✓	Re4a
3	Re1	Re4a	✓	Re4b, Re4c
4	Re1	Re4c	✓	An6, Ab6
5	Re1	Ab6	✓	
6	Re1	Re4b	✓	
7	Re1	Re3	✗	Ab3, Re2b, Re2a
8	Re1	Re2c	✗	An2, Re2, Ab1
9	Re1	Re2a	✓	Re1, An2
10	Re1	Re1	✓	An2, Ab2
11	An1	An6	✓	
12	An1	An2	✓	
13	An1	An1	✓	
14	Ab1	Ab1	✓	
Module 2				
				Ab7, Re7, Ab1, Re1
1	Ab1	Re7	✓	
2	Ab1	An7	✓	
3	Ab1	Re6	✓	An6, Re5
4	Ab1	An6	✓	Ab6, Ab1
5	Ab1	Re5	✓	Re4, An5
6	Ab1	Re4	✓	Re3c, Re3b, Re3a
7	Ab1	Re3a	✓	Re3b
8	Ab1	Re3b	✓	Re3c, An5
9	Ab1	Re3c	✓	Re2
10	Ab1	Re2	✓	Re1, An1
11	Ab1	Re1	✓	Ab5, An5
12	Ab1	Ab6	✓	Ab4
13	Ab1	Ab5	✓	Ab3c, Ab3c, Ab3a
14	Ab1	An5	✓	An4
15	Ab1	An4	✓	An3a, An3b, An3c, An2, Ab3
16	Ab1	An3b	✓	
17	Ab1	An3a	✓	
18	Ab1	An3c	✓	An2, Ab2, Ab3a
19	Ab1	An2	✓	Ab2, An1
20	Ab1	An1	✓	
21	Ab1	Ab1	✓	

Module 1 Student No 5

Topic Aimed For	Topic Worked-On	Accuracy of first Explanation	Topics Explored
			Rel, Re2c
1 Re2c	Ab6	✓	Ab5
2 Ab5	Ab5	✓	Ab4a
3 Ab4a	Ab4a	✓	
4 Ab4b	Ab4b	✓	
5 Ab4c	Ab4c	✓	
6 Ab3	Ab3	✓	
7 Ab2c	Ab2c	✓	
8 Ab2a	Ab2a	✓	
9 Abl	Abl	✓	
10 An6	An6	✓	
11 An2	An2	✓	Anl
12 Anl	Anl	✓	Rel
13 Rel	Rel	✓	
Module 2			
			Re7, Ab7
1 Ab7	Ab7	✓	Ab6, An7
2 Ab6	Ab6	✓	
3 An7	An7	✓	An6
4 An6	An6	✓	An5, Ab5
5 Ab5	Ab5	✓	Ab4
6 Ab4	Ab4	✓	An5
7 An5	An5	✓	
8 An4	An4	✓	Ab3c
9 Ab3c	Ab3c	✓	Ab3b
10 Ab3b	Ab3b	✓	
11 Ab3a	Ab3a	✓	
12 Ab2	Ab2	✓	
13 Abl	Abl	✓	
14 An3a	An3a	✓	
15 An3b	An3b	✓	
16 An3c	An3c	✓	
17 An2	An2	✓	
18 Anl	Anl	✓	
19 Rel	Rel	✓	

Module 1 Student No 6

Topic Aimed For	Topic Worked-On	Accuracy of first Explanation	Topics Explored
1 Re4c	Re6	✓	Re4a, Re6, An6
2 Re4c	Re5	✓	
3 Re4c	Re4c	✓	
4 Re1	An6	✓	
5 Re1	Re4b	✓	
6 Re1	Re4a	✓	
7 Re1	Re3	✓	
8 Re1	Re2c	✓	
9 Re1	Re2a	✓	
10 Re1	Re1	✓	
11 Ab1	Ab2	✓	
12 An1	Ab1	✓	
13 An1	An1	✓	
Module 2			Ab1
1 Ab1	Re7	✓	
2 Ab1	An7	✓	
3 Ab1	Re6	✓	
4 Ab1	Re5	✓	
5 Ab1	Re4	✓	
6 Ab1	Re3c	✓	
7 Ab1	Re3b	✓	
8 Ab1	Re3a	✓	
9 Ab1	Re2	✓	
10 Ab1	Re1	✓	
11 Ab1	An6	✓	
12 Ab1	An5	✓	
13 Ab1	An4	✓	
14 Ab1	An3c	✓	
15 Ab1	An3b	✓	
16 Ab1	An3a	✓	
17 Ab1	An2	✓	
18 Ab1	An1	✓	
19 Ab1	Ab1	✓	

Module 1 Student No 7

Topic Aimed For	Topic Worked-On	Accuracy of first Explanation	Topics Explored
1 Re1	Re6	✓	
2 Re1	Re5	✓	
3 Re1	Re4c	✓	
4 Re1	Re4a	✓	
5 Re1	Re4b	✓	
6 Re1	Re3	✓	
7 Re1	Re2c	✓	
8 Re1	Re2a	✓	
9 Re1	Re1	✓	An1
10 An1	An6	✓	
11 An1	An2	✓	
12 An1	An1	✓	
13 Ab1	Ab1	✓	
Module 2			
1 Re1	Re7	✓	
2 Re1	Re6	✓	
3 Re1	Re5	✓	
4 Re1	Re4	✓	
5 Re1	Re3a	✓	
6 Re1	Re3b	✓	
7 Re1	Re3c	✓	
8 Re1	Re2	✗	
9 Re1	Re1	✗	
10 An1	An7	✓	
11 An1	An6	✓	
12 An1	An5	✓	
13 An1	An4	✓	
14 An1	An3a	✗	
15 An1	An3c	✓	
16 An1	An3b	✓	
17 An1	An2	✓	
18 An1	An1	✓	
19 Ab1	Ab1	✓	

Module 1 Student No 8

Topic Aimed For	Topic Worked-On	Accuracy of first Explanation	Topics Explored
1 Re4b	Re6	✓	
2 Re4b	Re5	✓	
3 Re3	Re4b	✓	
4 Re1	Re4c	✓	
5 Re2a	Re4a	✓	
6 Re2a	Re3	✓	
7 Re1	Re2c	✓	
8 Re1	Re2a	✓	
9 Re1	Re1	✓	
10 An6	An6	✗	
11 An2	An2	✓	
12 An1	An1	✓	
13 Ab1	Ab1	✓	
Module 2			
1 Re5	Re7	✓	
2 Re5	Re6	✓	
3 Re4	Re5	✓	
4 Re2	Re4	✓	
5 Re2	Re3c	✓	
6 Re2	Re3b	✓	
7 Re2	Re3a	✓	
8 Re1	Re2	✓	
9 An1	Re1	✓	
10 An1	An7	✓	
11 An1	An6	✓	
12 An1	An5	✓	
13 An1	An4	✓	
14 An1	An3b	✓	
15 An1	An3c	✓	
16 An1	An3a	✓	
17 An1	An2	✓	
18 Ab1	An1	✓	
19 Ab1	Ab1	✓	

Module 1 Student No 9

Topic Aimed For		Topic Worked-On	Accuracy of first Explanation	Topics Explored
				An1, Re5, Re2a, Re1 Ab1, Ab2b, Re4c, Ab4a, Ab4c, Ab5
1	An1	An6	✓	
2	An1	Re6	✓	Re6, Re5, Re3, An6
3	An1	Re5	✓	Re4a, Re4c, Re4b
4	An1	Re4c	✓	
5	An1	Re4b	✓	
6	An1	Re4a	✓	
7	An1	Re3	✓	Re2a, Re2c
8	An1	Re2c	✓	Re2a
9	An1	Re2a	✓	Re1
10	An1	Re1	✓	
11	An1	An2	✓	
12	Ab1	An1	✓	
13	Ab1	Ab1	✓	
Module 2				
				Re7, Re6, Ab7, An7
1	Ab1	Re7	✓	
2	Ab1	Re6	✓	
3	Ab1	Re5	✓	
4	Ab1	Re4	✓	
5	Ab1	Re3b	✓	
6	Ab1	Re3a	✓	
7	Ab1	Re3c	✓	
8	Ab1	Re2	✗	
9	Ab1	Re1	✗	
10	Ab1	An7	✓	
11	Ab1	An6	✓	
12	Ab1	An5	✓	An4
13	Ab1	An4	✓	
14	Ab1	An3a	✓	
15	Ab1	An3b	✓	
16	Ab1	An3c	✓	
17	Ab1	An2	✓	
18	Ab1	An1	✓	
19	Ab1	Ab1	✓	

Module 1 Student No 10

Topic Aimed For		Topic Worked-On	Accuracy of first Explanation	Topics Explored
				Re4a, Re5, An6
1	Re4a	An6	✓	
2	Re4a	Re6	✓	Ab6, Re5
3	Re4a	Re5	✓	Re4a
4	Re4a	Re4a	✗	Ab5, Re4c, Re4b
5	Re4c	Re4c	✓	Re4b, Re3
6	Re3	Re4b	✓	Re4b
7	Re3	Re3	✗	Re2a, Re2c
8	Re2c	Re2c	✓	Re2a
9	Re2a	Re2a	✓	Re1
10	Re1	Re1	✓	Ab4a, Ab4b, Ab4c,
				Ab3, Ab2c
11	Ab3	Ab3	✓	Ab2a, Ab2b, Ab1
12	Ab1	Ab2a	✓	
13	Ab1	Ab2c	✓	
14	Ab1	Ab1	✓	An2
15	An2	An2	✓	
16	An1	An1	✓	
Module 2				
				Re7, Re6, Re5, Re4
1	Re4	Re7	✓	Re6
2	Re4	Re6	✗	Re5
3	Re4	Re5	✓	
4	Re4	Re4	✗	Re3a, Re3b, Re3c
5	Re3b	Re3b	✓	Re3a, Re2
6	Re2	Re3a	✓	Re3c
7	Re2	Re3c	✓	Re2
8	Re2	Re2	✓	Re1
9	Re1	Re1	✗	An1, Ab1, Ab5, An5
10	Ab5	Ab7	✓	
11	Ab5	Ab6	✓	
12	Ab5	Ab5	✓	Ab3b, Ab3c
13	Ab3c	Ab4	✓	
14	Ab3c	Ab3c	✗	Ab3a, Ab3b
15	Ab3a	Ab3a	✓	Ab2
16	Ab2	Ab3b	✓	
17	Ab2	Ab2	✓	Ab1
18	Ab1	Ab1	✓	An7, An6, An5
19	An5	An7	✓	
20	An5	An6	✓	
21	An5	An5	✓	
22	An1	An4	✓	
23	An1	An3c	✓	
24	An1	An3b	✓	
25	An1	An3a	✓	
26	An1	An2	✓	
27	An1	An1	✓	

Module 1 Student No 11

Topic Aimed For	Topic Worked-On	Accuracy of first Explanation	Topics Explored
1 Ab4b	Ab6	✓	Ab4a, Ab5, Ab4c, Re4c Ab4b
2 Ab4b	An6	✓	
3 Ab4b	Ab5	✓	Ab3, Ab2c
4 Ab2b	Ab4b	✓	Re4b
5 Ab2b	Re4b	✓	An2, Ab2a, Re2b, An1
6 An1	Ab4a	✓	Ab4c
7 An1	Ab4c	✓	Ab3
8 An1	Ab3	✓	Re3
9 An1	Re3	✓	
10 An1	Re2a	✓	Ab2a
11 An1	Ab2a	✓	An2
12 An1	An2	✓	Re2a
13 An1	Re2c	✗	
14 An1	Re1	✓	
15 An1	An1	✓	
16 Ab1	Ab1	✓	

Module 1 Student No 12

	Topic Aimed For	Topic Worked-On	Accuracy of first Explanation	Topics Explored
1	Ab4b	Ab6	✓	Ab6, An6, Re6
2	Ab4b	An6	✓	
3	Ab4b	Re6	✓	
4	Ab4b	Ab5	✓	
5	Ab4b	Re5	✓	Ab4b
6	Ab4b	Ab4b	✓	Re3, Re4c
7	Re3	Re4b	✓	Re4c
8	Re3	Re4c	✓	Re4a, Ab4a
9	Re3	Re4a	✓	Re3, Ab4a, Ab4c
10	Re3	Ab4c	✓	
11	Re3	Ab4a	✓	Re3
12	Re3	Re3	✓	Re2c
13	Re2a	Re2a	✓	An2
14	Ab1	An2	✓	
15	Ab1	Re2b	✓	
16	Ab1	Re1	✓	
17	Ab1	An1	✓	
18	Ab1	Ab1	✓	

Module 1 Student No 13

Topic Aimed For		Topic Worked-On	Accuracy of first Explanation	Topics Explored
1	Re6	Re6	✗	
2	Re5	Re5	✓	Re4c, Re4b Re4a
3	Re4c	Re4c	✓	
4	Re4a	Re4a	✓	
5	Re4b	Re4b	✓	
6	Re3	Re3	✗	Re2c, Re2a Re2a
7	Re2c	Re2c	✓	
8	Re2a	Re2a	✓	
9	Re1	Re1	✓	
10	An6	An6	✓	
11	An2	An2	✗	
12	An1	An1	✓	
13	Ab3	Ab3	✓	
14	Ab2a	Ab2a	✗	
15	Ab2c	Ab2c	✓	
16	Ab1	Ab1	✓	

Module 1 Student No 14

Topic Aimed For	Topic Worked-On	Accuracy of first Explanation	Topics Explored
			Re6, Re5, Re2a, Ab5, Ab4b, Ab2a, Abl, Anl, Rel, Ab6, An6
1 Abl	Ab6	✓	
2 Abl	Ab5	✓	
3 Abl	Ab4a	✓	
4 Abl	Ab4b	✓	
5 Abl	Ab4c	✓	
6 Abl	Ab3	✓	Ab2c
7 Abl	Ab2c	✓	Ab2a
8 Abl	Ab2a	✓	Abl
9 Abl	Abl	✓	Re6
10 Rel	Re6	✓	Re5
11 Rel	Re5	✓	Re4a
12 Rel	Re4a	✓	Re4c
13 Rel	Re4c	✓	Re4b
14 Rel	Re4b	✓	
15 Rel	Re3	✓	Re2c
16 Rel	Re2c	✓	Re2a
17 Rel	Re2a	✓	Rel
18 Rel	Rel	✓	An6
19 An6	An6	✓	
20 Anl	An2	✓	
21 Anl	Anl	✓	

APPENDIX 5

Illustrative Command Sheet and Check List

Appendix 5

Illustrative command sheet and check list, for use when students are using STATLAB to give explanations (see section on 'errors' in Chapter 2).

"OR ... NOT BOTH" of Composite Events

Commands

1 Distinguish an event set, α , and its members (a_i).

2 Mark the empty set, $\emptyset$.

3 Distinguish composite events, A_1 and A_2, with at least one member in common.

4 Given (A_1 or A_2 not both) is the case, switch on those simple events that might be the case.

5 Given (A_1 and A_2) is the case, switch on those members of (A_1or A_2 not both) that might be the case.

6 Distinguish composite events, A_3 and A_4, with no members in common.

7 Given (A_3 or A_4) is the case, switch on those simple events that are not the case.

8 Given (A_3 or A_4 not both) is the case, switch on those simple events that are not the case.

Checklist

1 Event set circled and lights of members switched on.

2 Outside of event set circle marked $\emptyset$.

3 A_1 and A_2 are circled subsets of α, with at least one member in common.

4 Simple events in A_1 or A_2 but not both, are switched on.

5 No members of (A_1 or A_2 not both) are switched on.

6 A_3 and A_4 are circled subsets of α with <u>no</u> members in common.

7 All simple events not in A_3 or A_4 are switched on.

8 All simple events not in A_3 or A_4 are switched on.

APPENDIX 6

Information Collection Test

Appendix 6

Information Collection Test

Written Introduction

You will be presented with a list of 32 different types of people. This will represent all the possible combinations that can be made up from the following set of variables.

1	Sober Dress	6	Bright, Fashionable Clothes
2	Unmarried	7	Married
3	Drives slowly	8	Drives fast
4	Under 40 years old	9	Over 40 years old
5	Does not smoke	10	Smokes

You will be given four items of information from the list above that relate to a particular person.

You will be given these items of information one by one and at any point in the sequence you can stop me and elect to say which one of the 32 different possible combinations you think will describe the person in question.

You should be aware of the following:-

1. When I give you the first item about any particular person (ie I may say that he drives slowly) this will obviously enable you to cut down the number of possible groups that may be the one that describes him from 32 to 16.
2. When I give you the second item it will cut down the number from 16 to 8 - and so on. Until I give you the 4th item by which time you will be able to narrow down the field to 2.
3. When I give you the second item I will also tell you this particular person's occupation*.

*Footnote. This was an extra item of information introduced to give participants some basis for deciding on a particular combination of characteristics.

4. I will never give you any more than 4 items for any person. (In other words you will always have to, at least, choose one from two possible groups).
5. You may stop me at any time from the first item onwards and tell me which group will describe the person in question.

Once you have done this we will not consider that person any more and will move on to the next one.

I will not tell you whether or not you were correct until we reach the end. You will be expected to base your judgement on the interrelationships that exist between the items of information that you are supplied with and on your knowledge of people and their characteristics.

The scoring system is operated by awarding points according to when you make your choice.

The earlier you decide the more points you will be awarded, but if you choose wrongly you will have points deducted*.

After reading the written introduction students were asked if they had any questions concerning the test. They were then given two practice sequences to ensure that they did grasp what was required of them. The practice sequences took the following form:-

> Students were <u>given</u> the list of 32 possible combinations (see overleaf)
>
> Students were <u>told</u> "I will give you one item of information about the first person. You should remember that it is a real person - not someone made up specially for the test.

* <u>Footnote</u>: In practice, no such scoring system existed, scores were computed (as described in Chapter 3) to indicate how much information students collected before guessing.

They are either people I know personally or descriptions of people pieced together from newspaper reports and such like.

1) This person 'drives fast'.

By supplying this information I have cut down the possible number of groupings that may be used to describe this person from 32 to 16 - since only 16 of the group contain 'Drives Fast' as a member.

2) He is also an army officer.

This information does not directly help you to cut down the list of possibilities but you may feel that certain things are now less likely to occur than others.

3) If you wish to do so you may state which group (1-32) is likely to describe the person in question - or you may ask for another item of information.

4) (Assuming that the subject does not make a choice).

This person is under 40.

If you wish you may now state which group will describe this person.

5) (Assuming he does not make a choice).

This person is unmarried.

You should realise that the only possible groups that could describe this person are numbers 3, 10, 11 and 20. Check that you agree that this is so. If you wish you may now state which groups will describe this person.

6) (Assuming he does not make a choice).

This person does not smoke.

The only possible alternative choices now available are numbers 11 or 20. I will not give you any more information -

you must now make a choice between these two alternatives.

This same procedure was followed for a second practice sequence so that the student was completely familiar with the procedure.

After a short pause the test was conducted. The sequence of ten test items given is shown below:

Test Items

1. 4; (Policeman), 2, 5, 1.
2. 9; (Actor), 10, 2, 6.
3. 2; (Doctor), 4, 8, 5.
4. 5; (Professional Footballer) 7, 3, 4.
5. 2; (Sales Representative (Insurance)), 6, 5, 3.
6. 7; (Vicar), 6, 4, 8.
7. 10; (Pop Singer), 4, 6, 2.
8. 1; (Burglar), 2, 9, 3.
9. 9; (Politician), 2, 3, 5.
10. 5; (Bank Manager), 9, 7, 1.

THE 32 POSSIBLE COMBINATIONS

Bright Clothes Unmarried Drives Fast Over 40 Smokes	1	Bright Clothes Unmarried Drives Slowly Over 40 Smokes	2
Sober Dress Unmarried Drives Fast Under 40 Smokes	3	Bright Clothes Married Drives Fast Over 40 Smokes	4
Sober Dress Unmarried Drives Slowly Over 40 Does not smoke	5	Sober Dress Married Drives Fast Over 40 Smokes	6
Bright Clothes Married Drives Slowly Under 40 Smokes	7	Sober Dress Married Drives Fast Under 40 Smokes	8
Sober Dress Unmarried Drives Slowly Under 40 Does not smoke	9	Bright Clothes Unmarried Drives Fast Under 40 Smokes	10
Bright Clothes Unmarried Drives Fast Under 40 Does not smoke	11	Sober Dress Married Drives Slowly Over 40 Does not smoke	12
Bright Clothes Unmarried Drives Fast Over 40 Does not smoke	13	Sober Dress Married Drives Slowly Over 40 Does not smoke	14
Bright Clothes Unmarried Drives Slowly Over 40 Does not smoke	15	Bright Clothes Married Drives Fast Under 40 Smokes	16

Bright Clothes
Married
Drives Slowly
Over 40
Smokes 17

Bright Clothes
Married
Drives Fast
Over 40
Does not smoke 18

Sober Dress
Unmarried
Drives Fast
Over 40
Smokes 19

Sober Dress
Unmarried
Drives Fast
Under 40
Does not smoke 20

Sober Dress
Married
Drives Slowly
Over 40
Smokes 21

Bright Clothes
Unmarried
Drives Slowly
Under 40
Smokes 22

Sober Dress
Unmarried
Drives Slowly
Over 40
Smokes 23

Bright Clothes
Unmarried
Drives Slowly
Under 40
Does not smoke 24

Sober Dress
Married
Drives Slowly
Under 40
Smokes 25

Bright Clothes
Married
Drives Slowly
Over 40
Does not smoke 26

Sober Dress
Unmarried
Drives Slowly
Under 40
Smokes 27

Sober Dress
Married
Drives Fast
Under 40
Does not smoke 28

Sober Dress
Unmarried
Drives Fast
Over 40
Does not Smoke 29

Sober Dress
Married
Drives Fast
Over 40
Does not smoke 30

Bright Clothes
Married
Drives Fast
Over 40
Does not smoke 31

Bright Clothes
Married
Drives Slowly
Under 40
Does not smoke 32

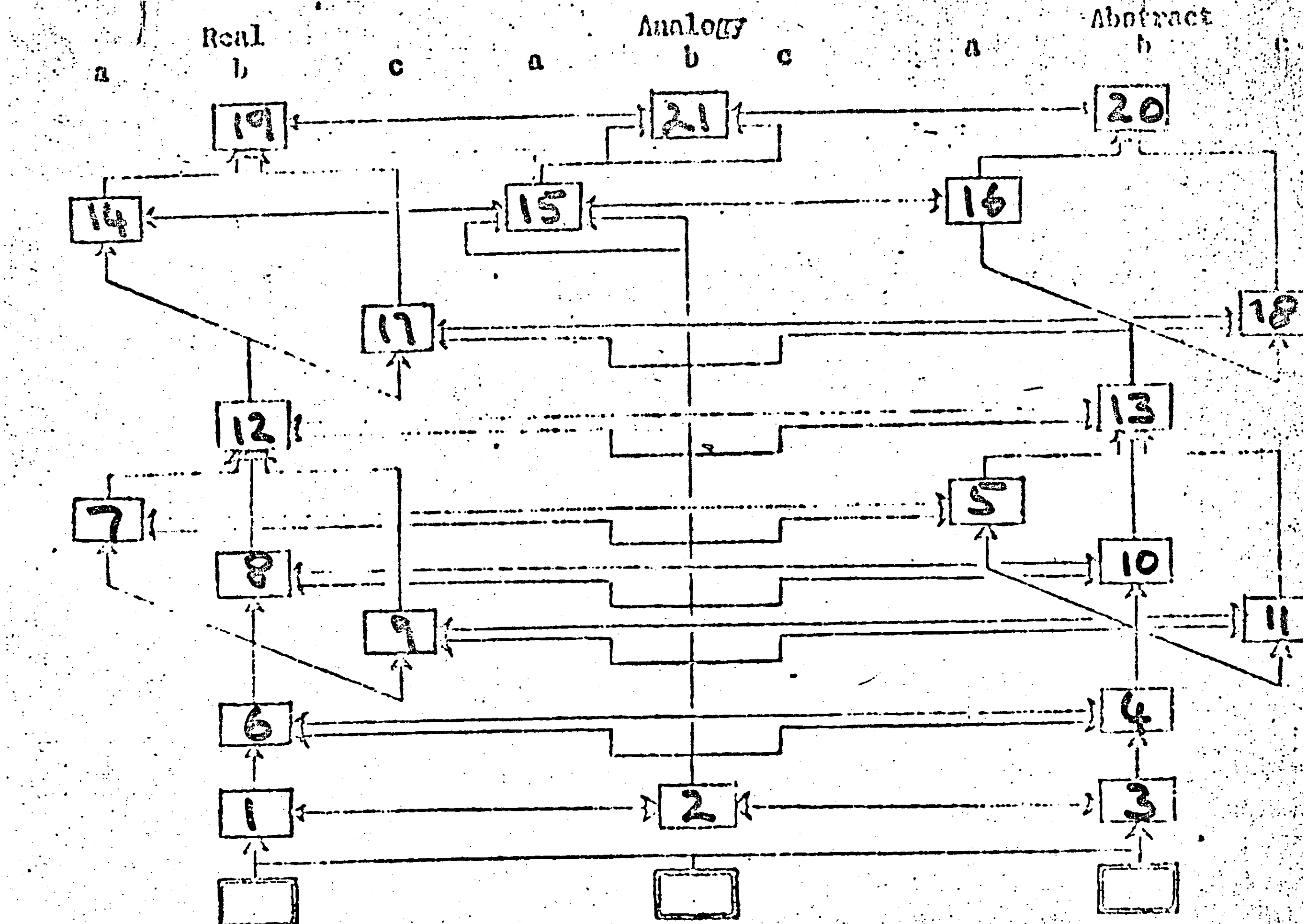
Appendix 7

Students' routes through the modules

The charts in this appendix show the routes that students took through modules 1 and 2.

Student No: 1

Module 1



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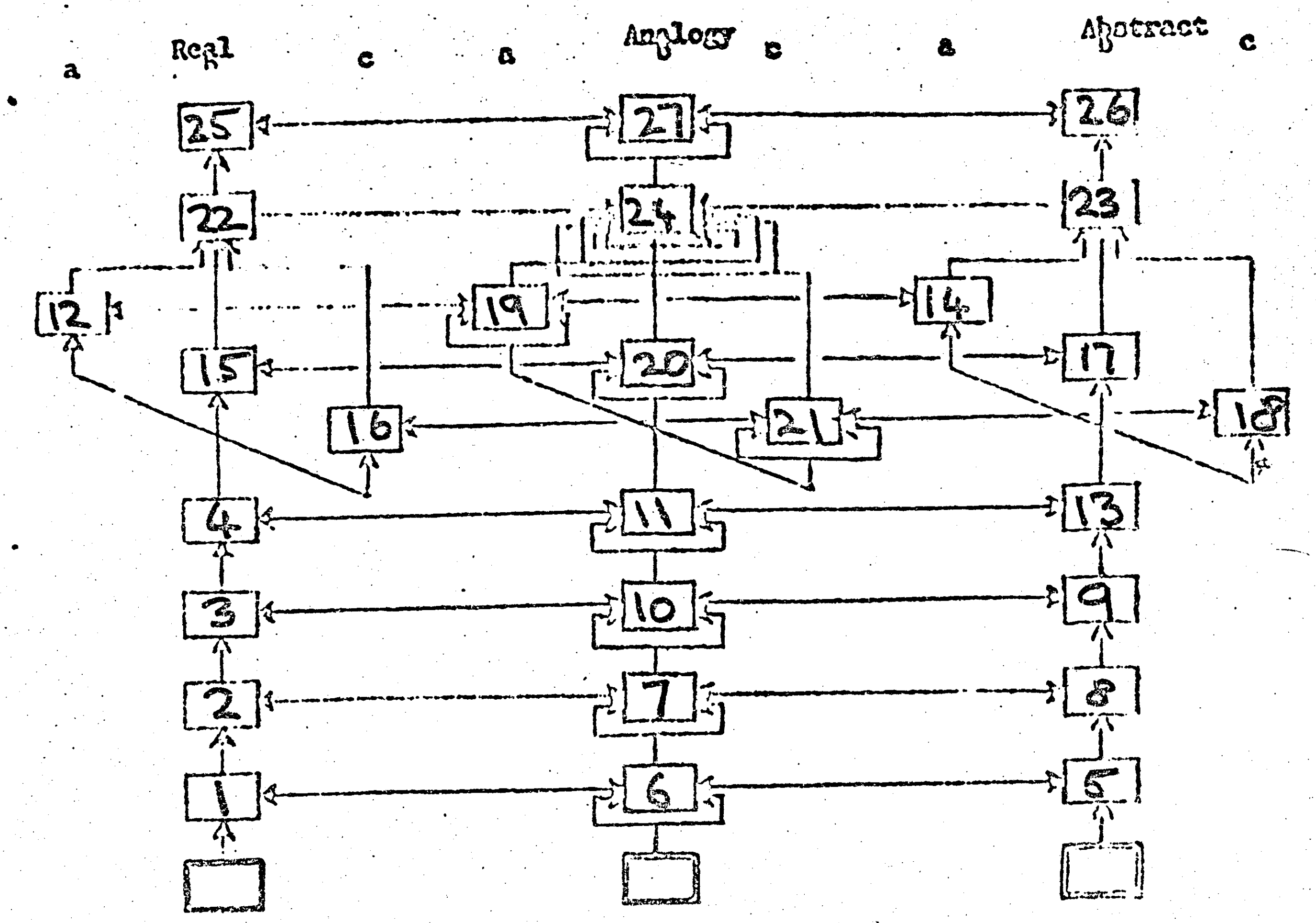
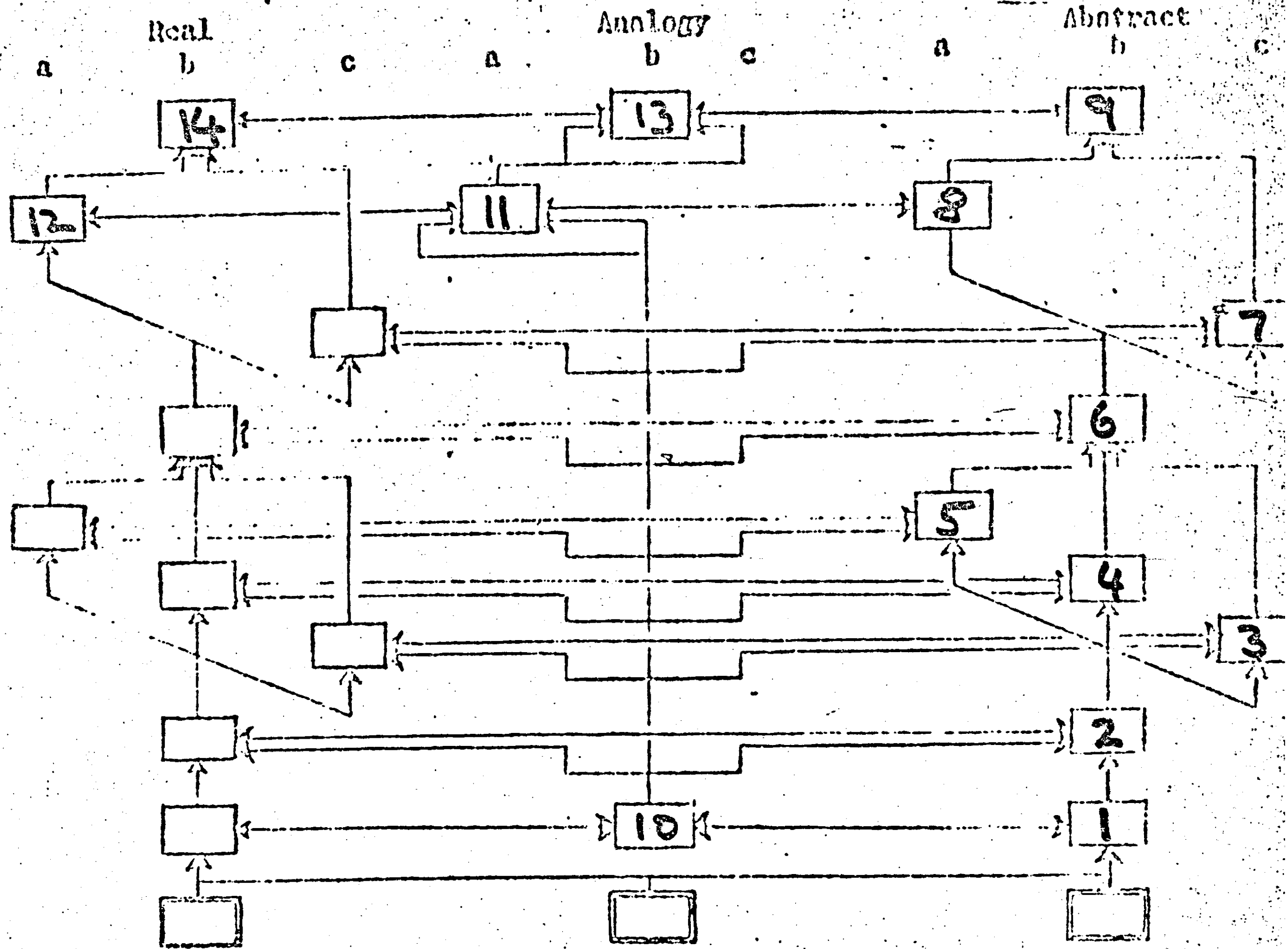


STUDENT ID - 2

Module 1



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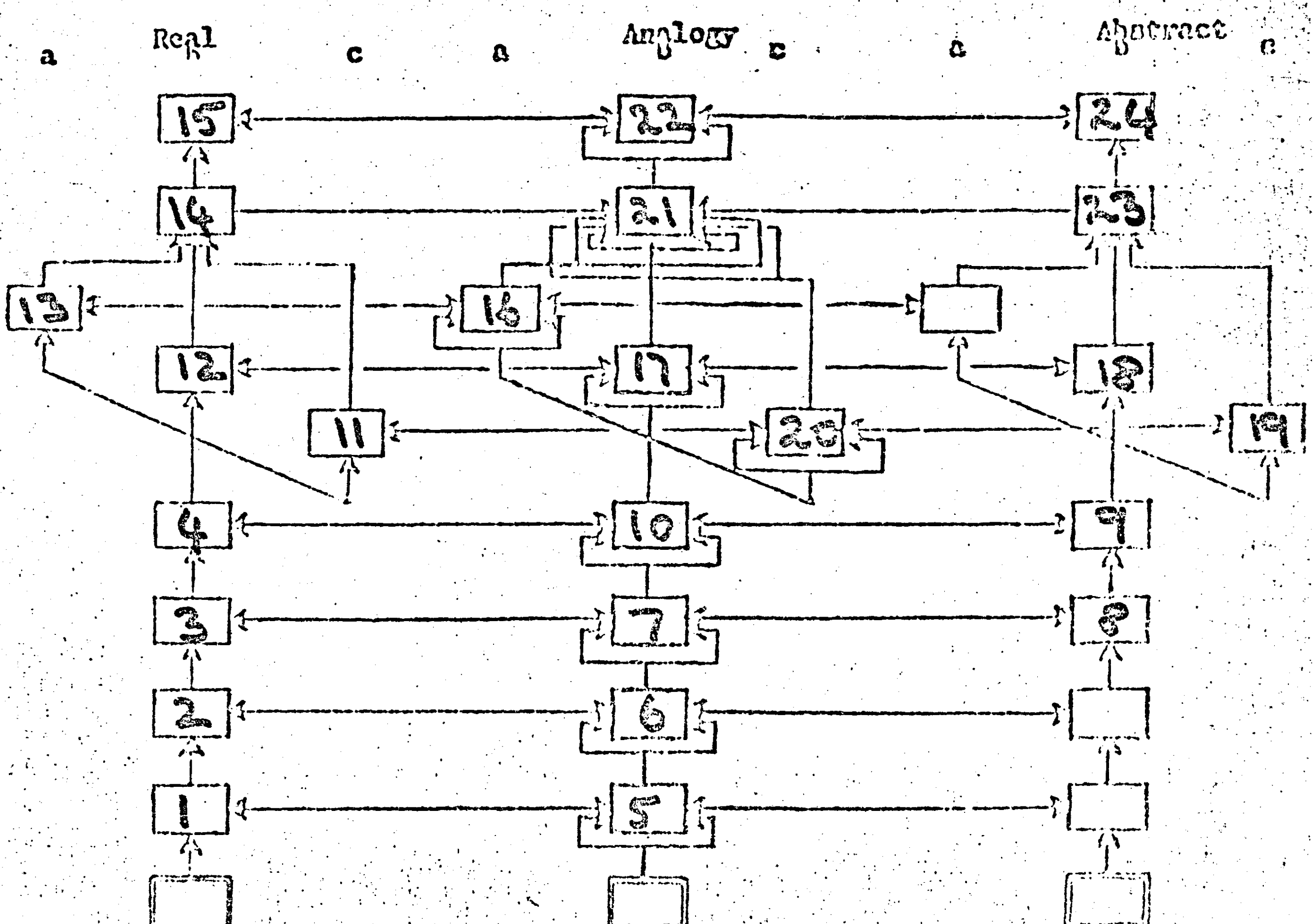
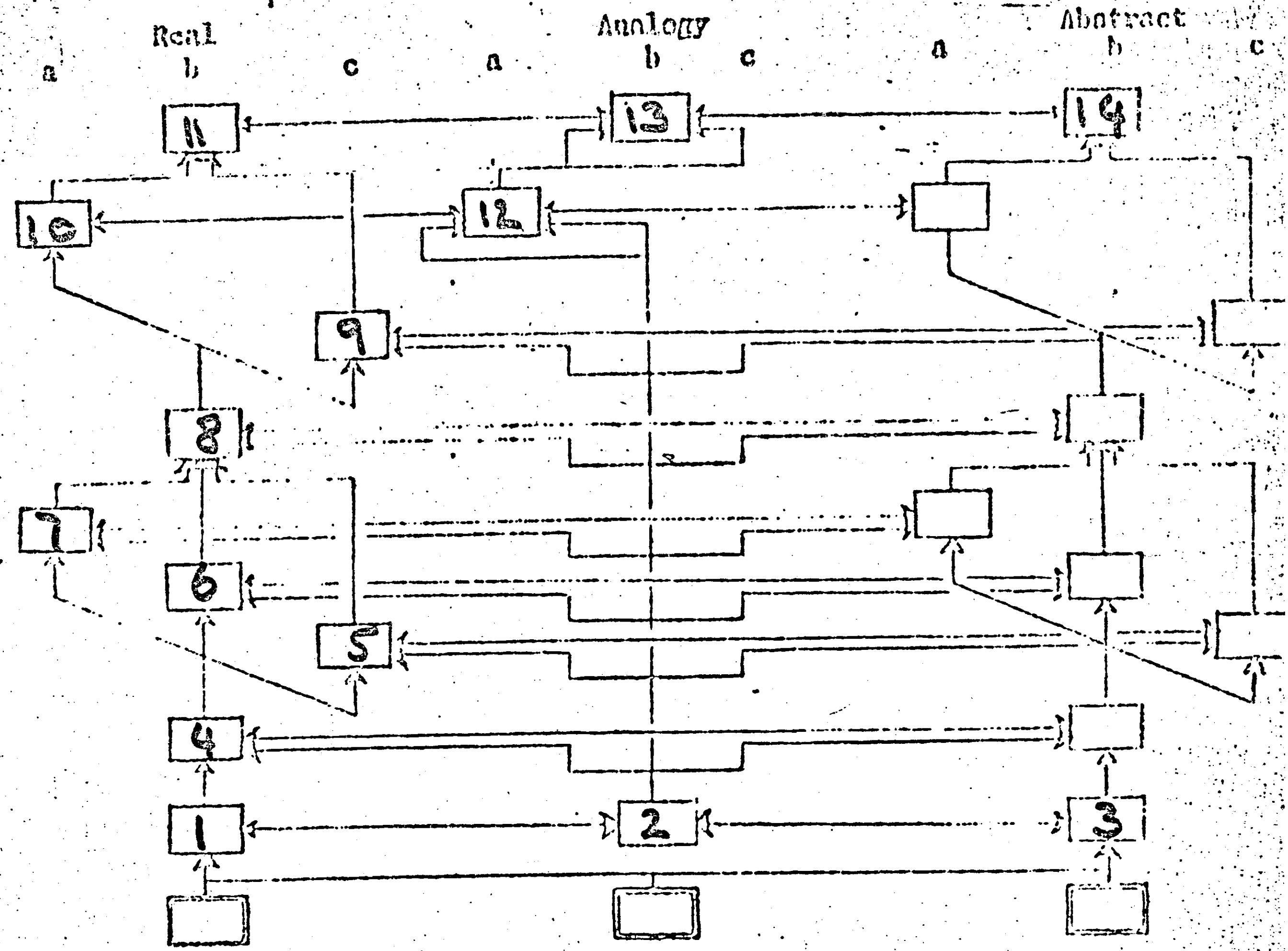
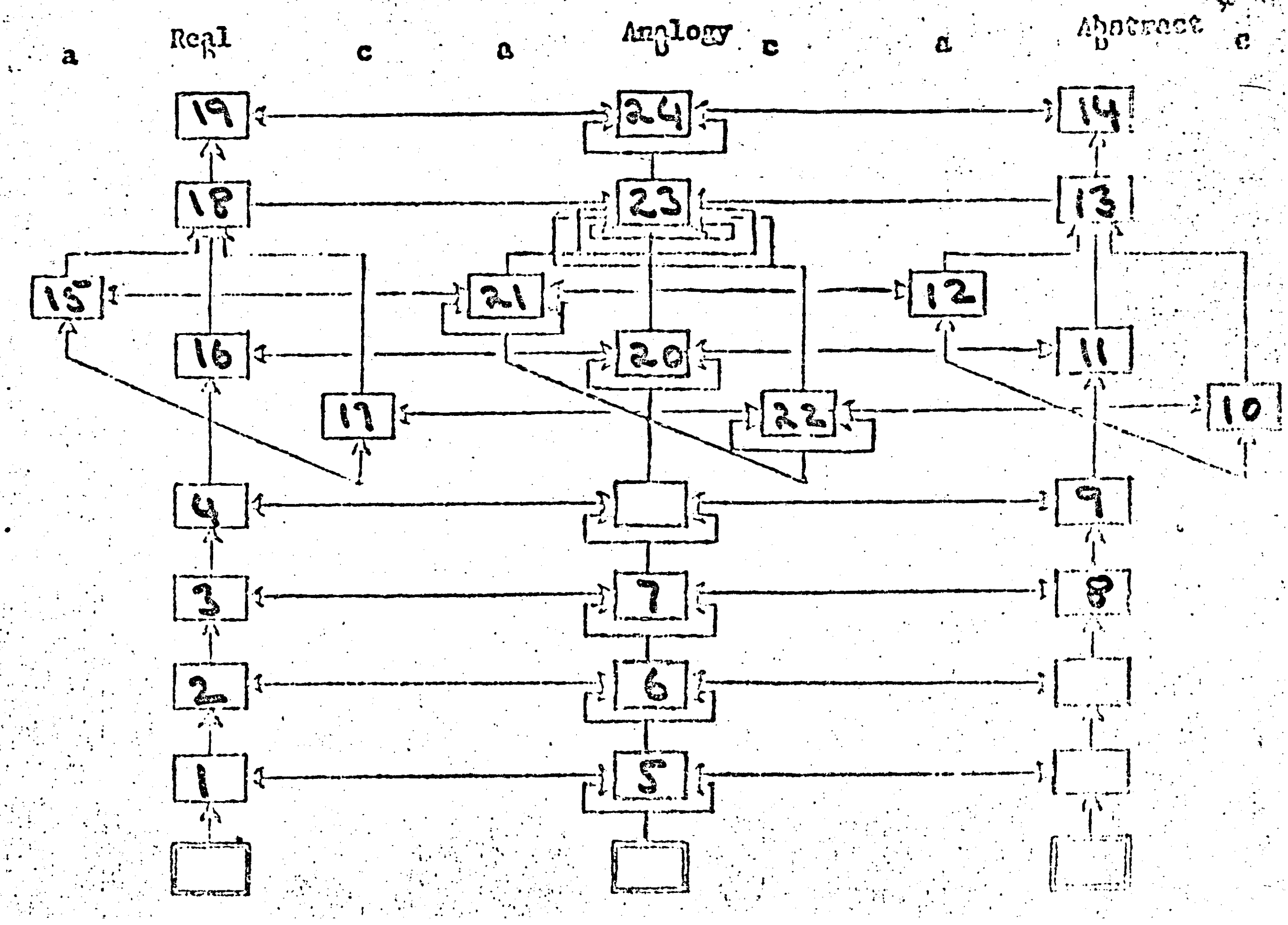


Student ID: 3

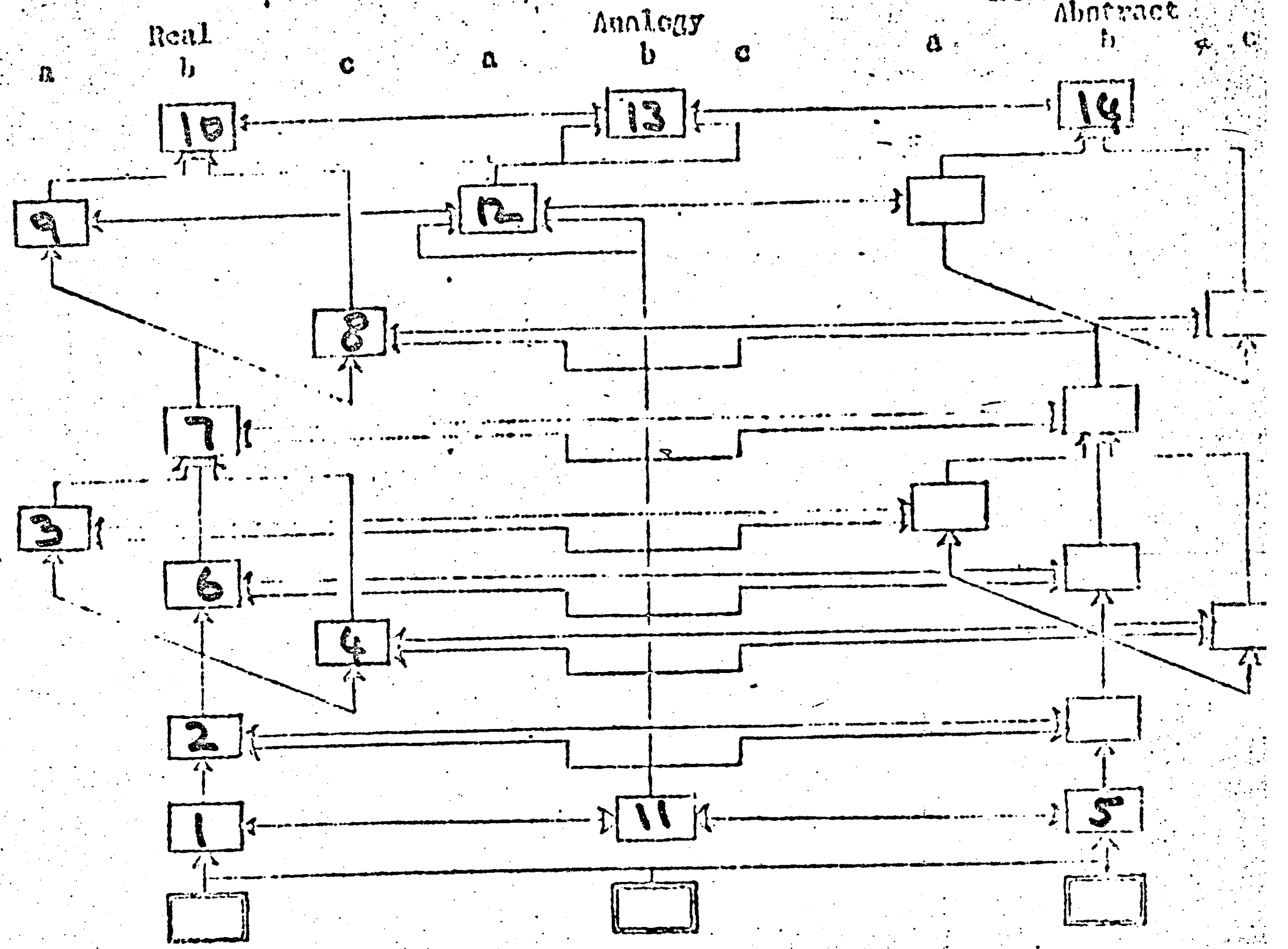
Module 1



Module 2



Module 1



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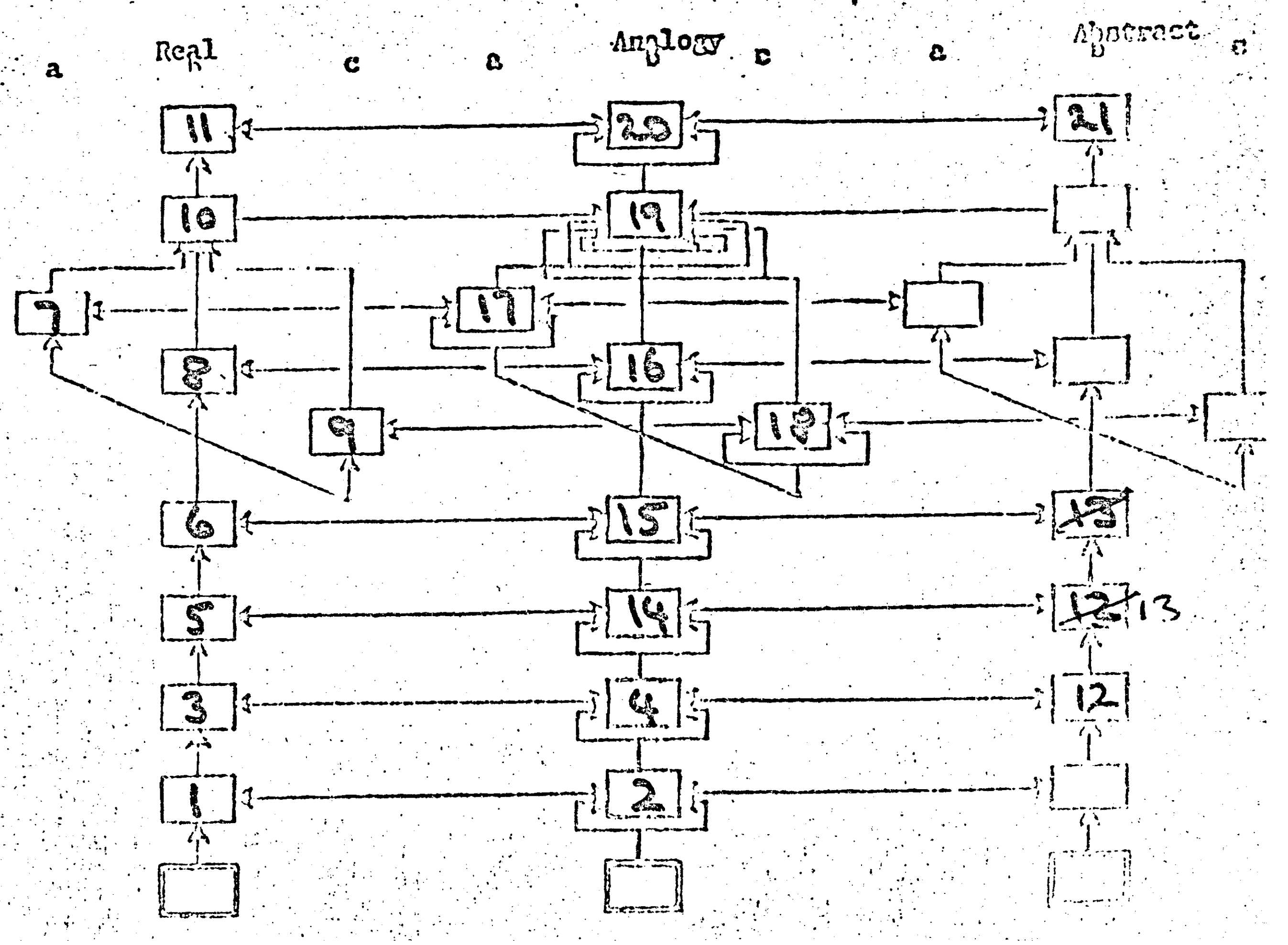

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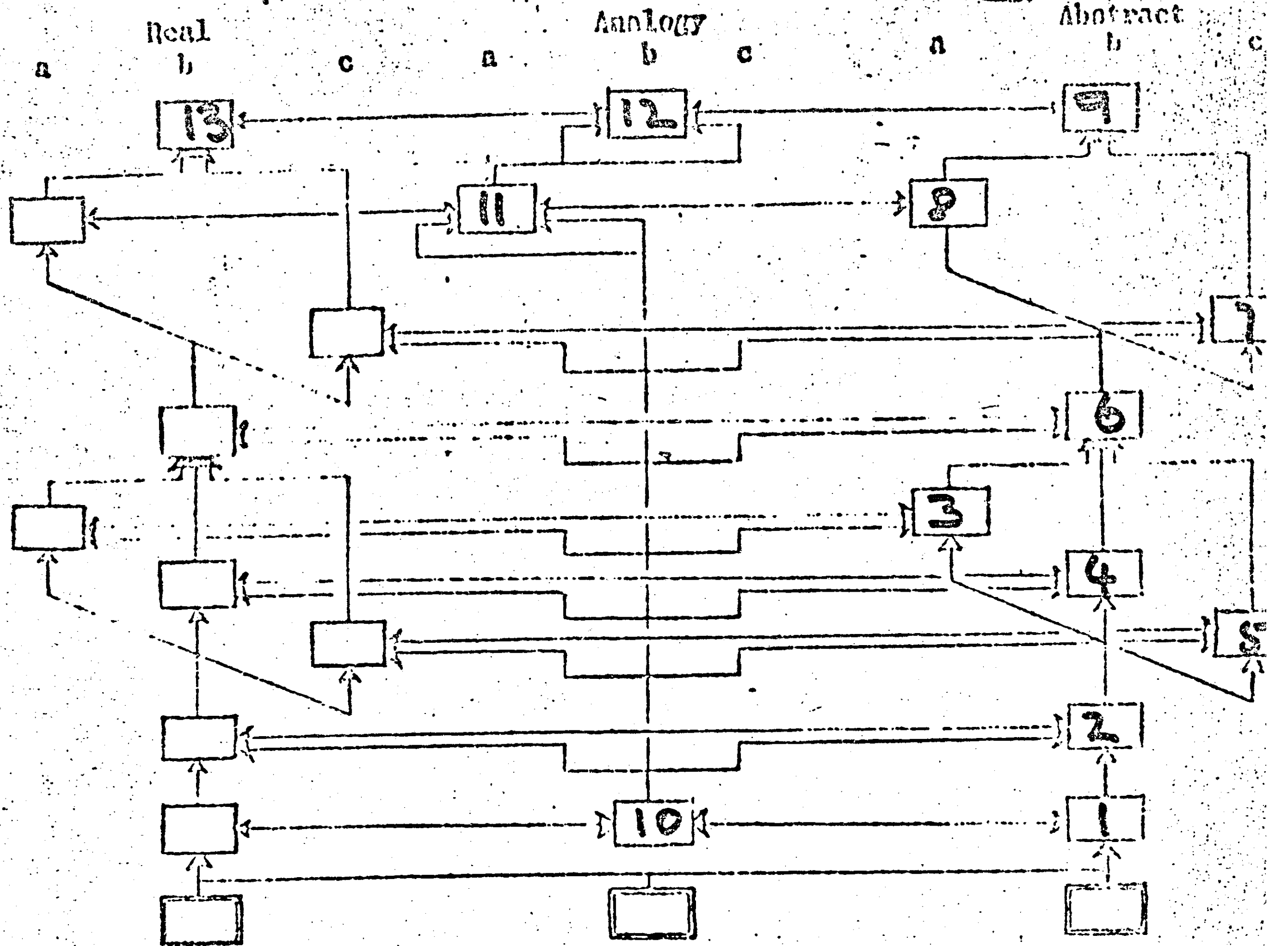

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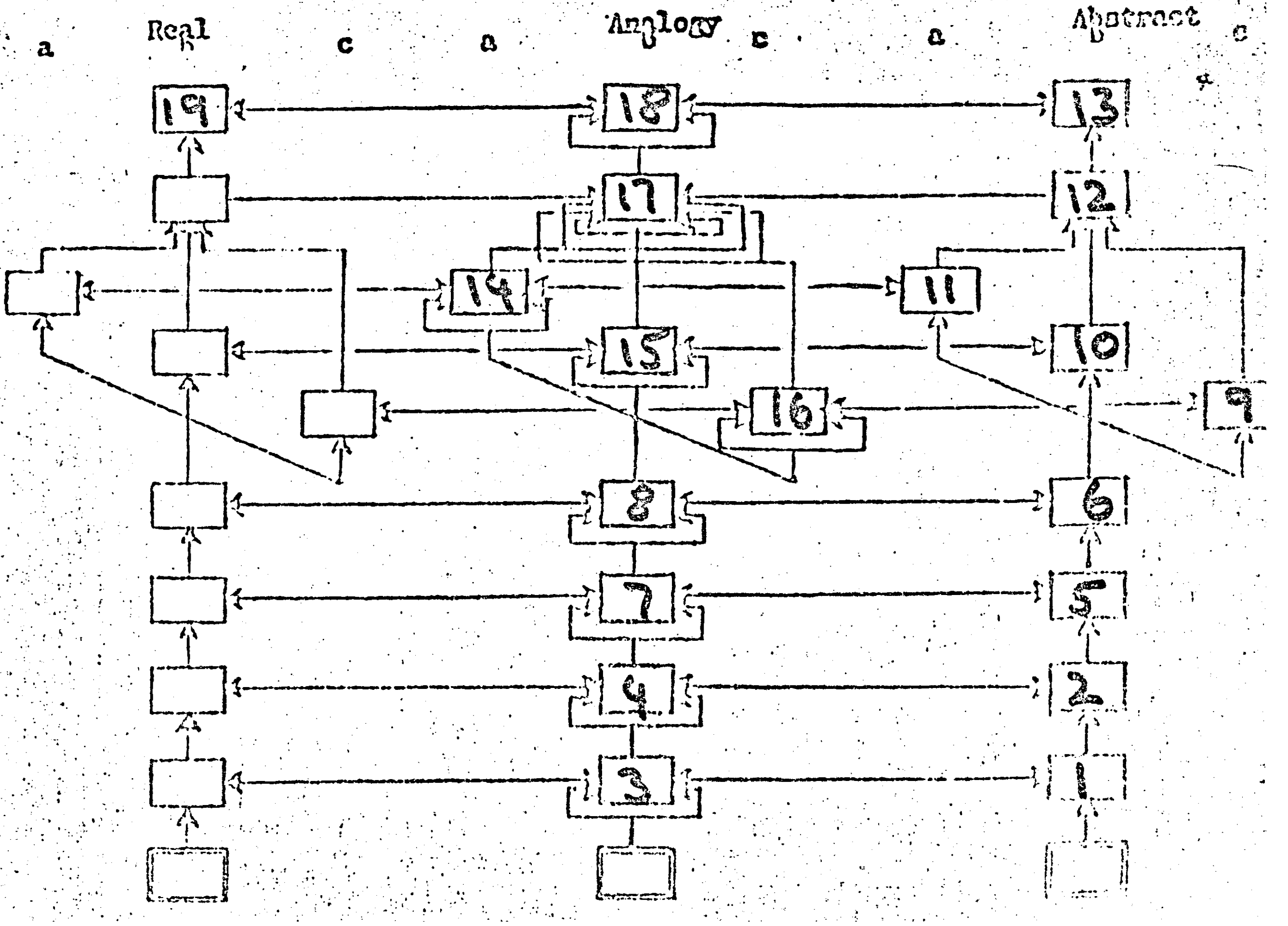
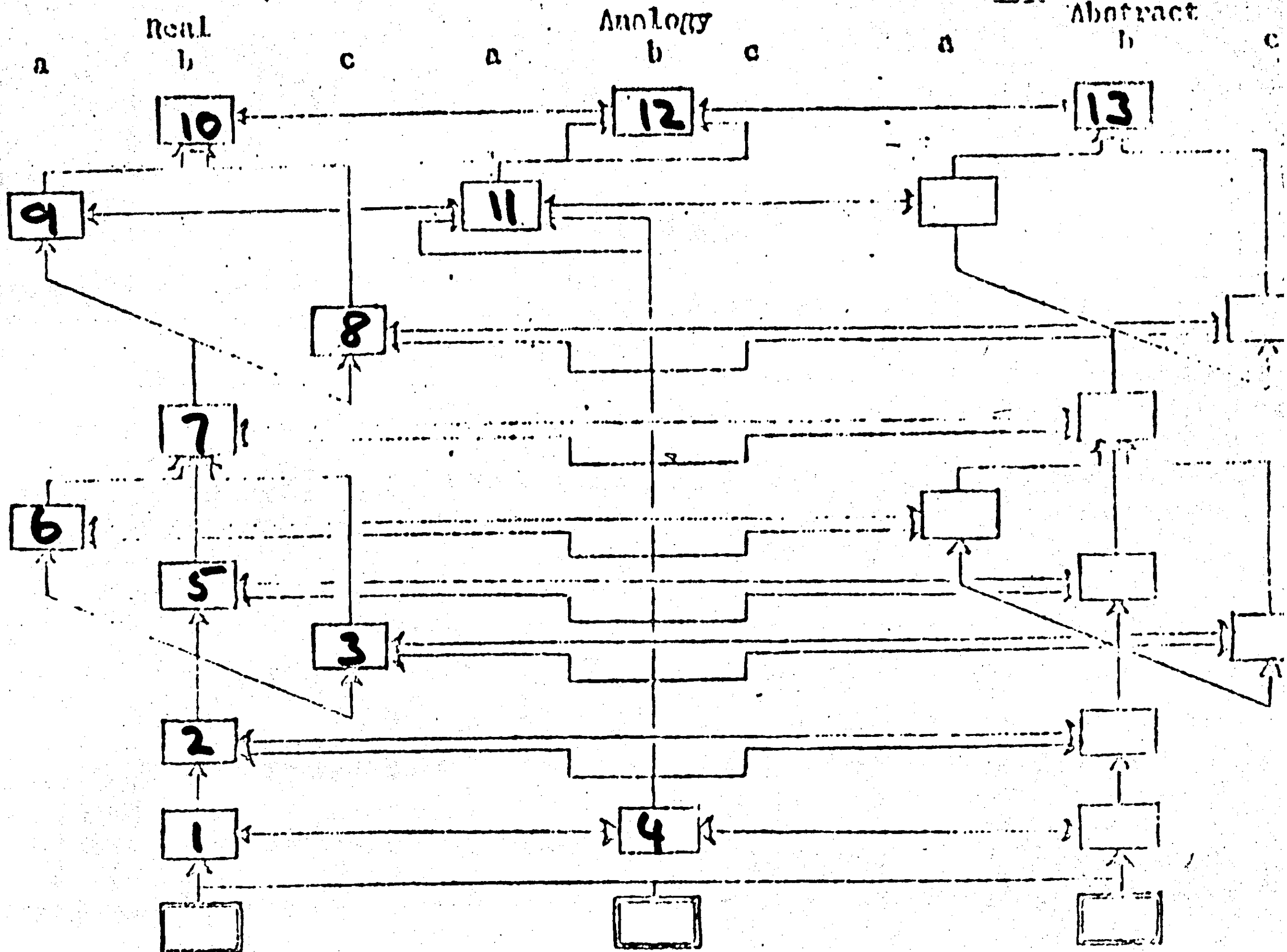


STUDENT NO= 6

Module 1



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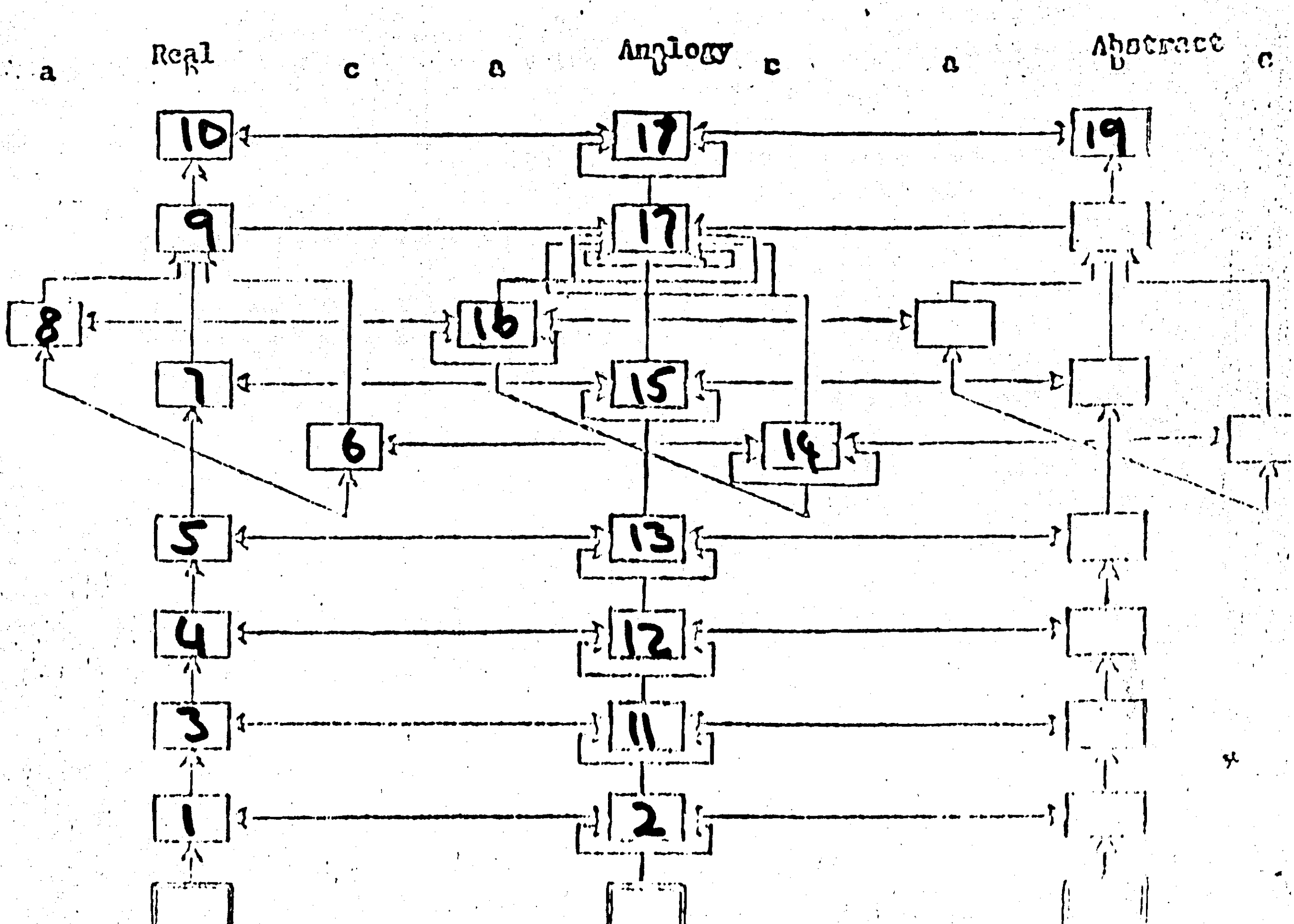
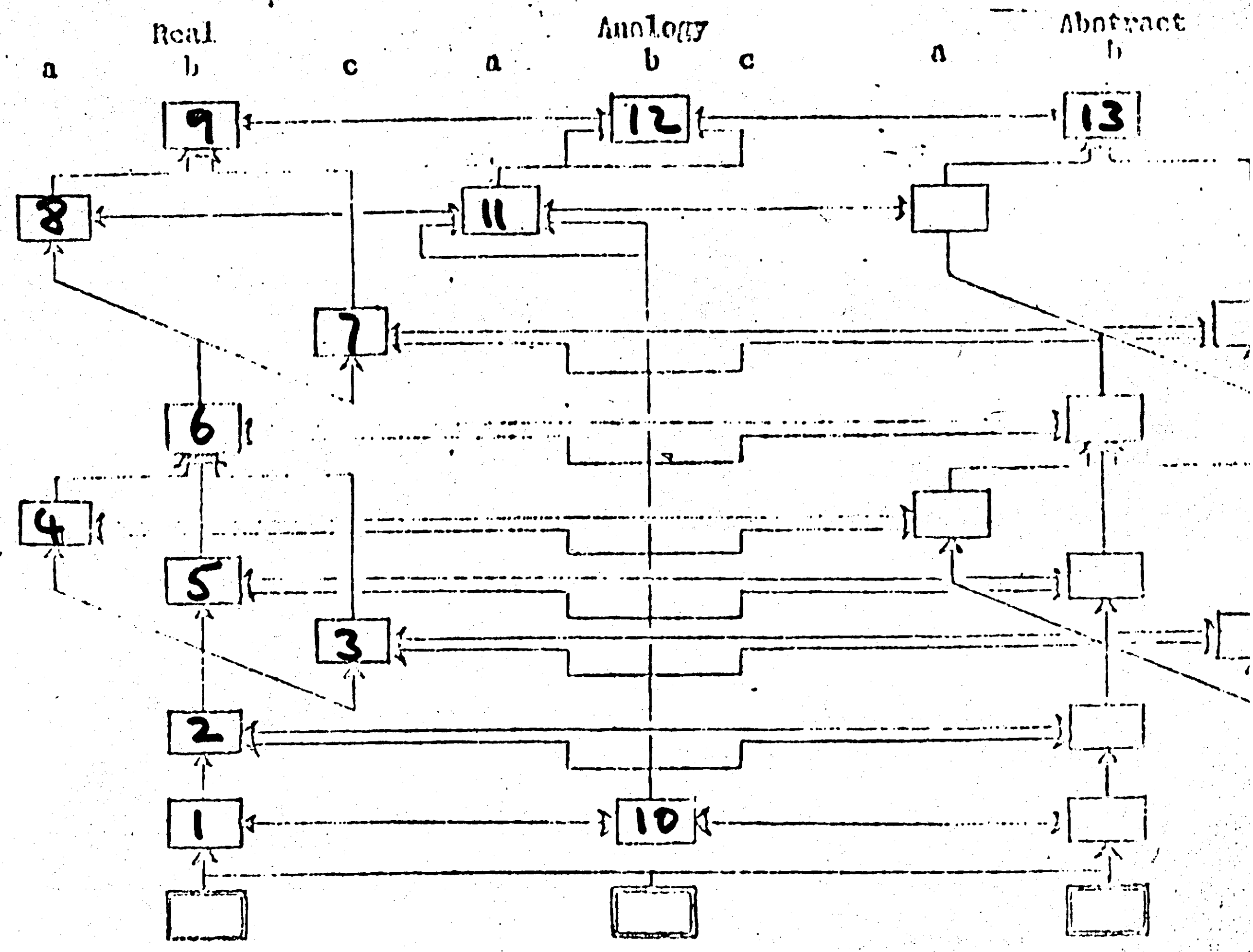


Student No 7

Module 1



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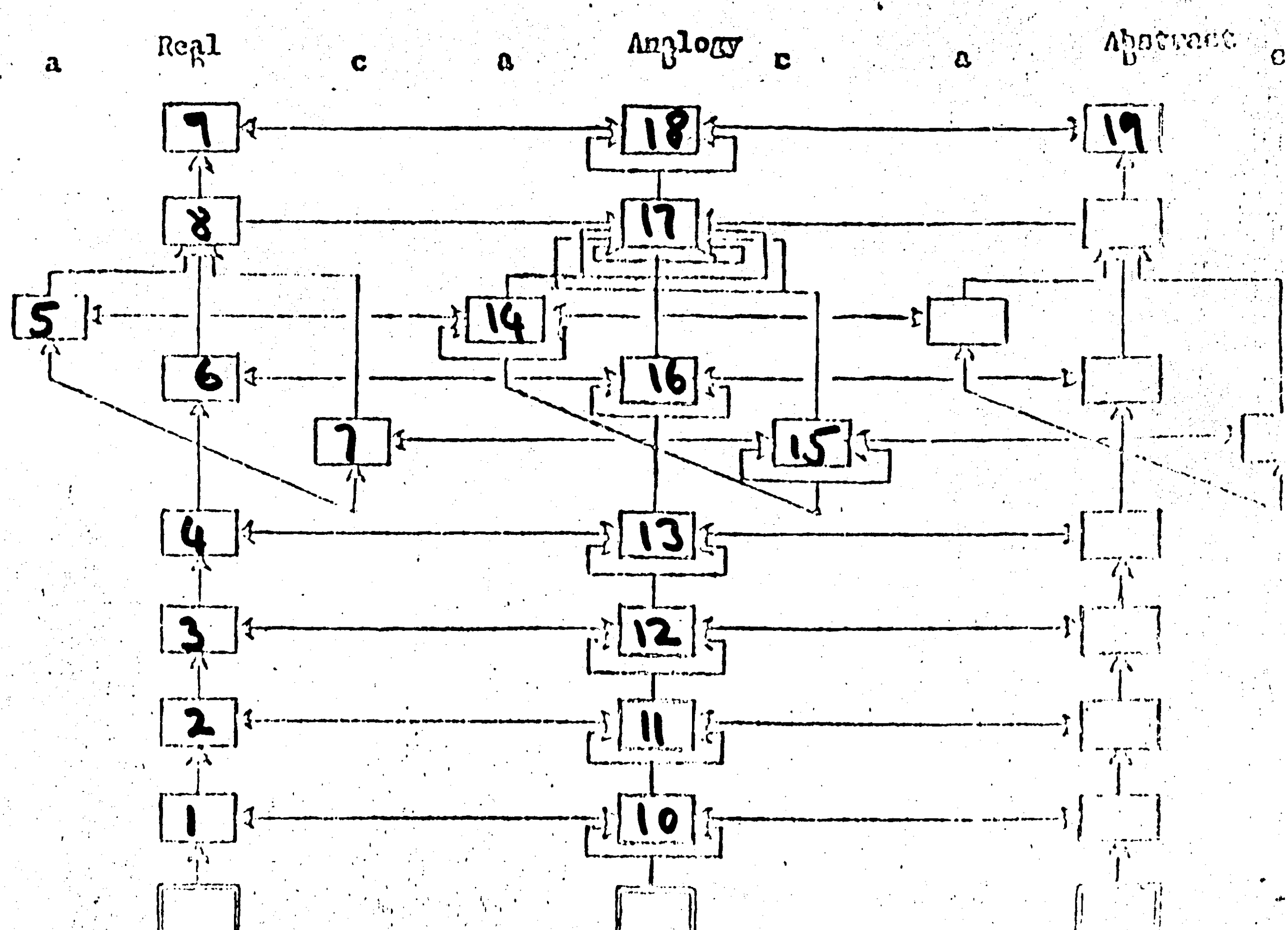
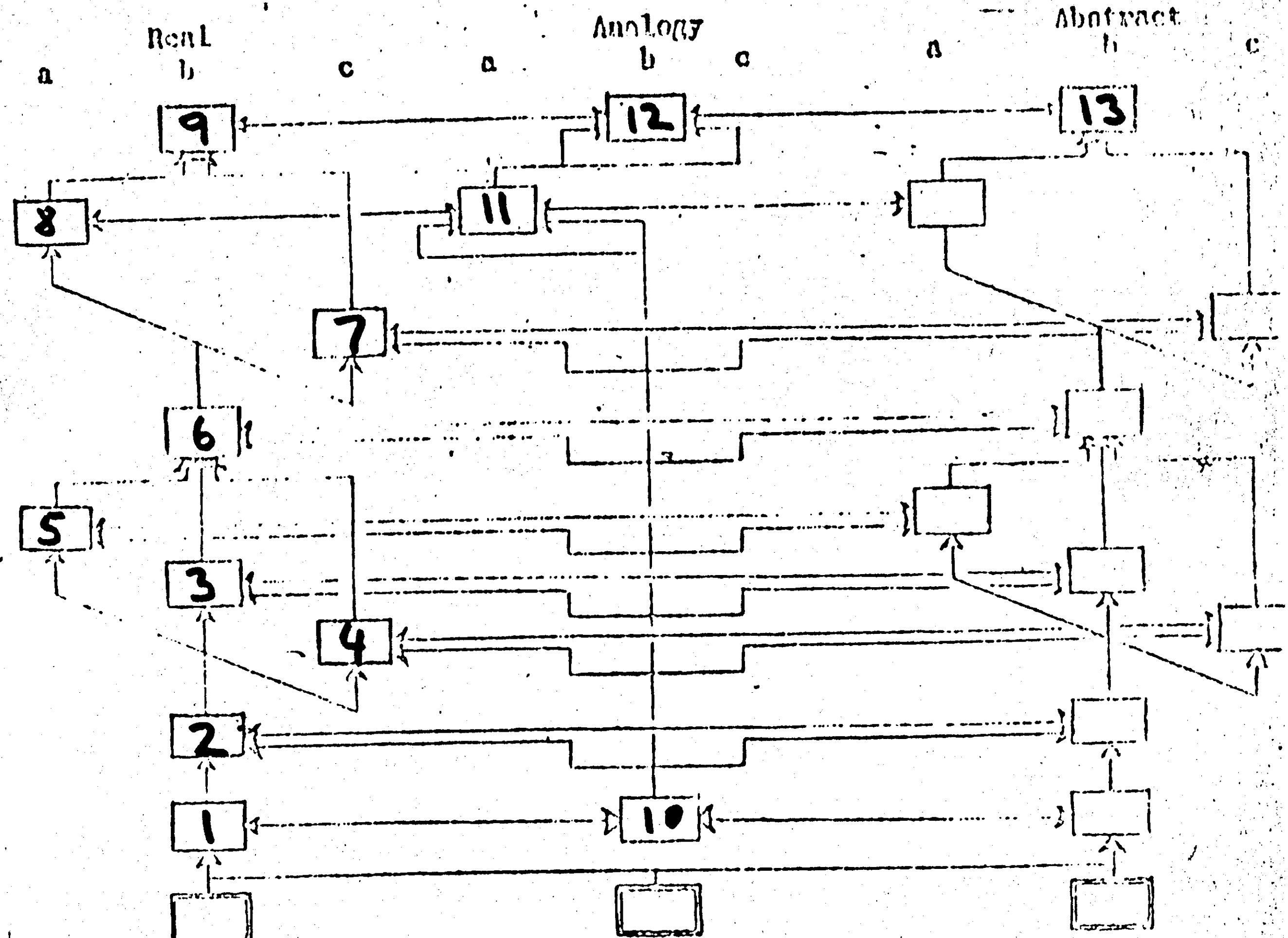


Student Nº 8

Module 1



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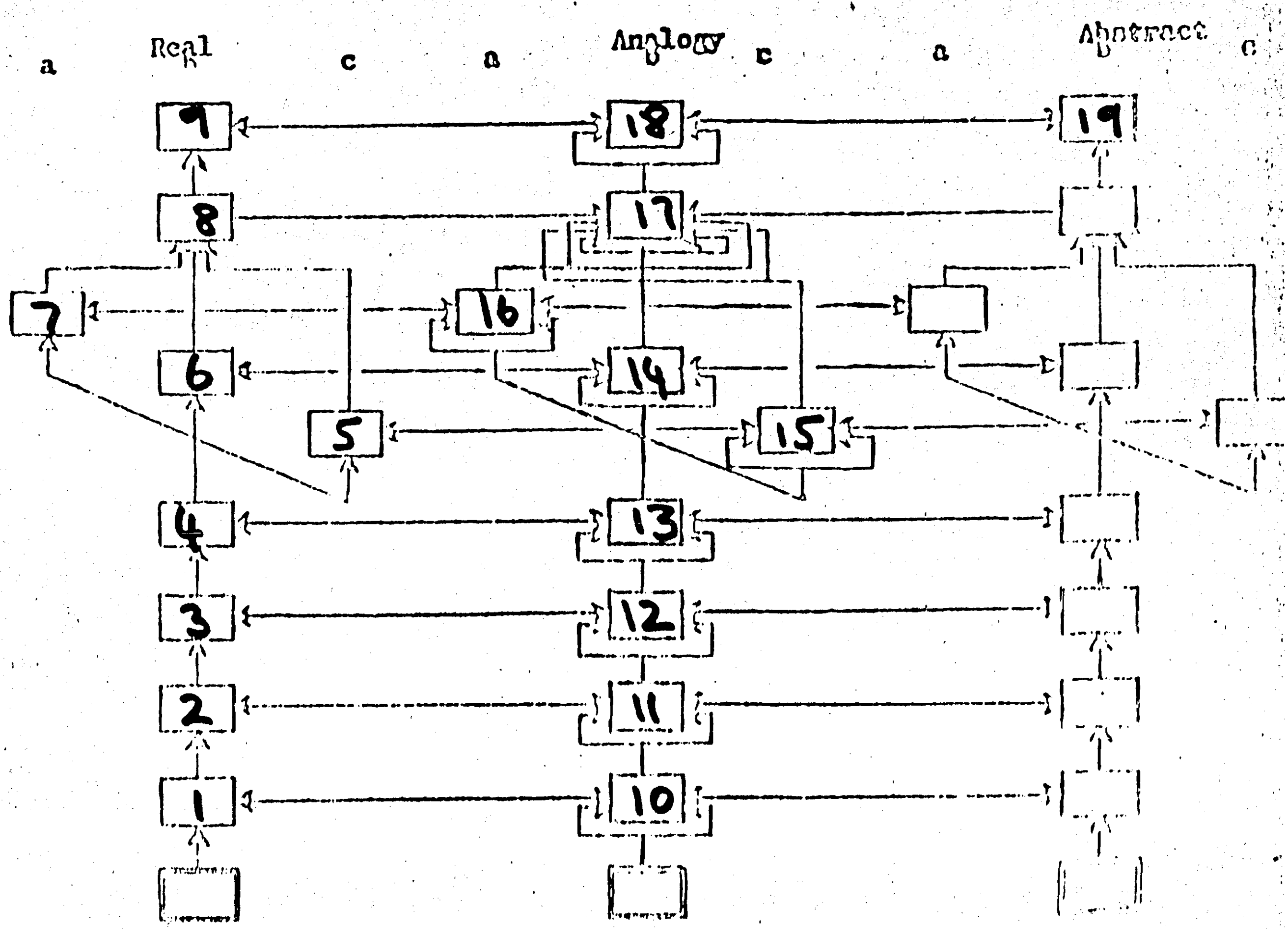
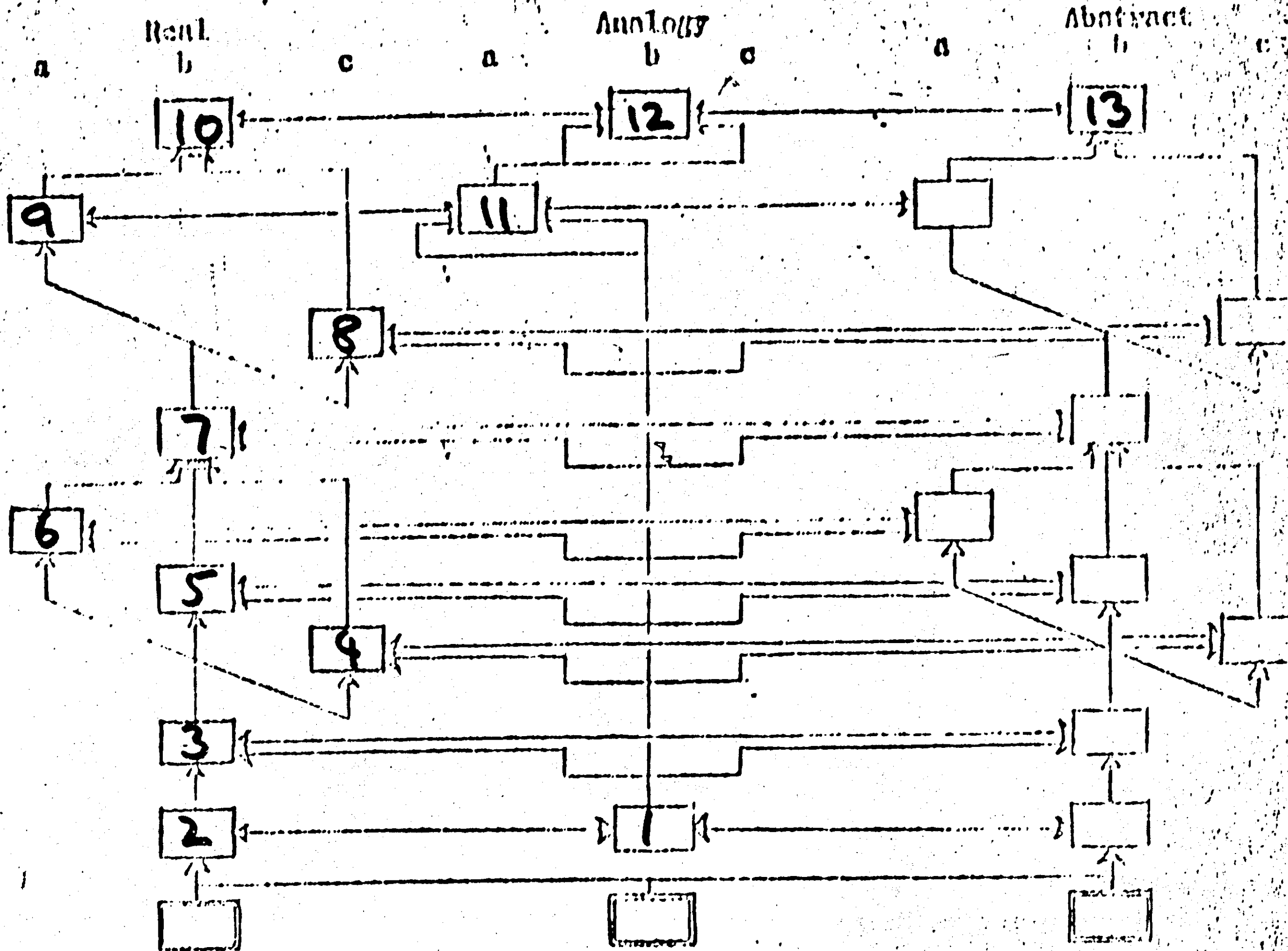
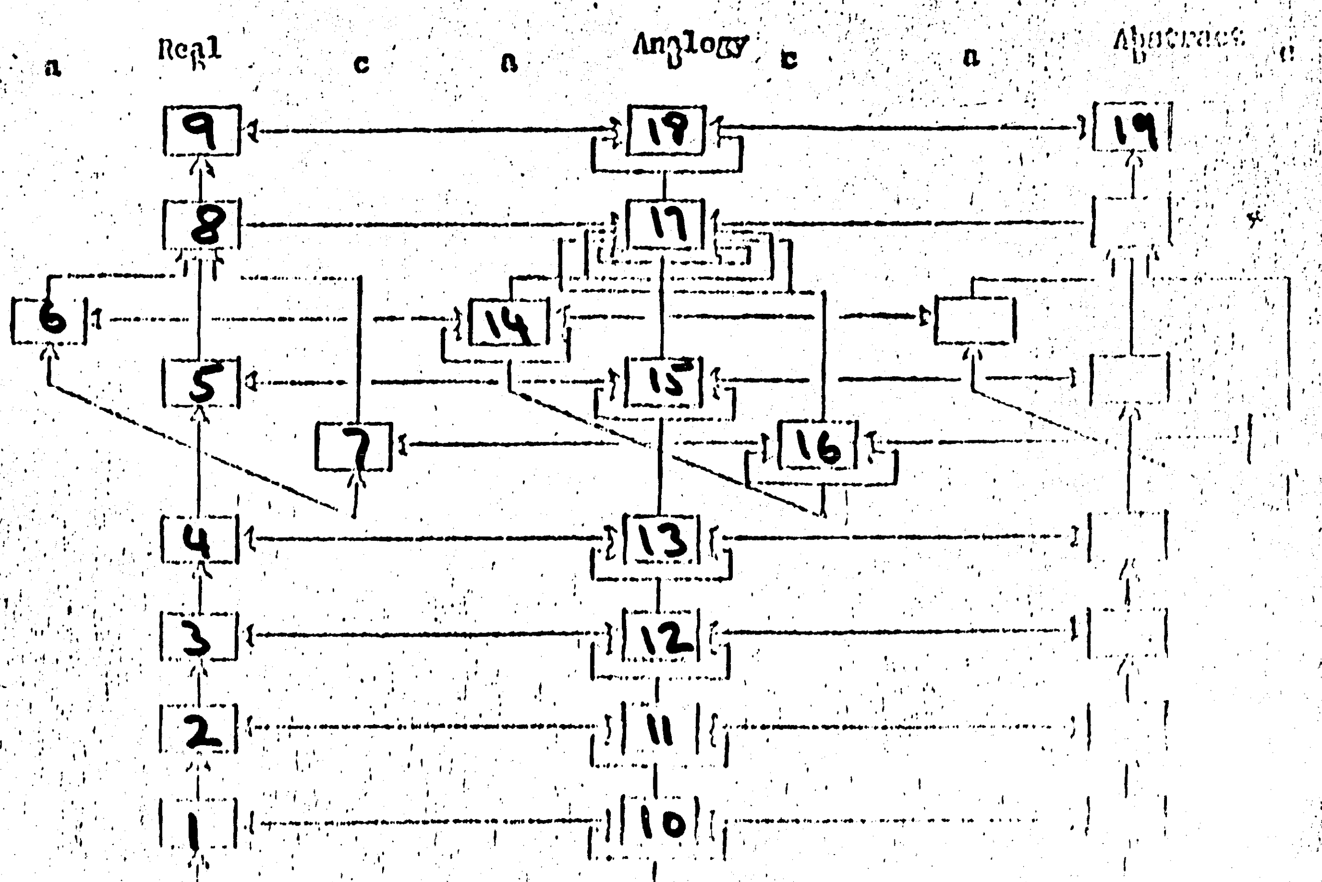


Student No 9

Module 1



Module 2



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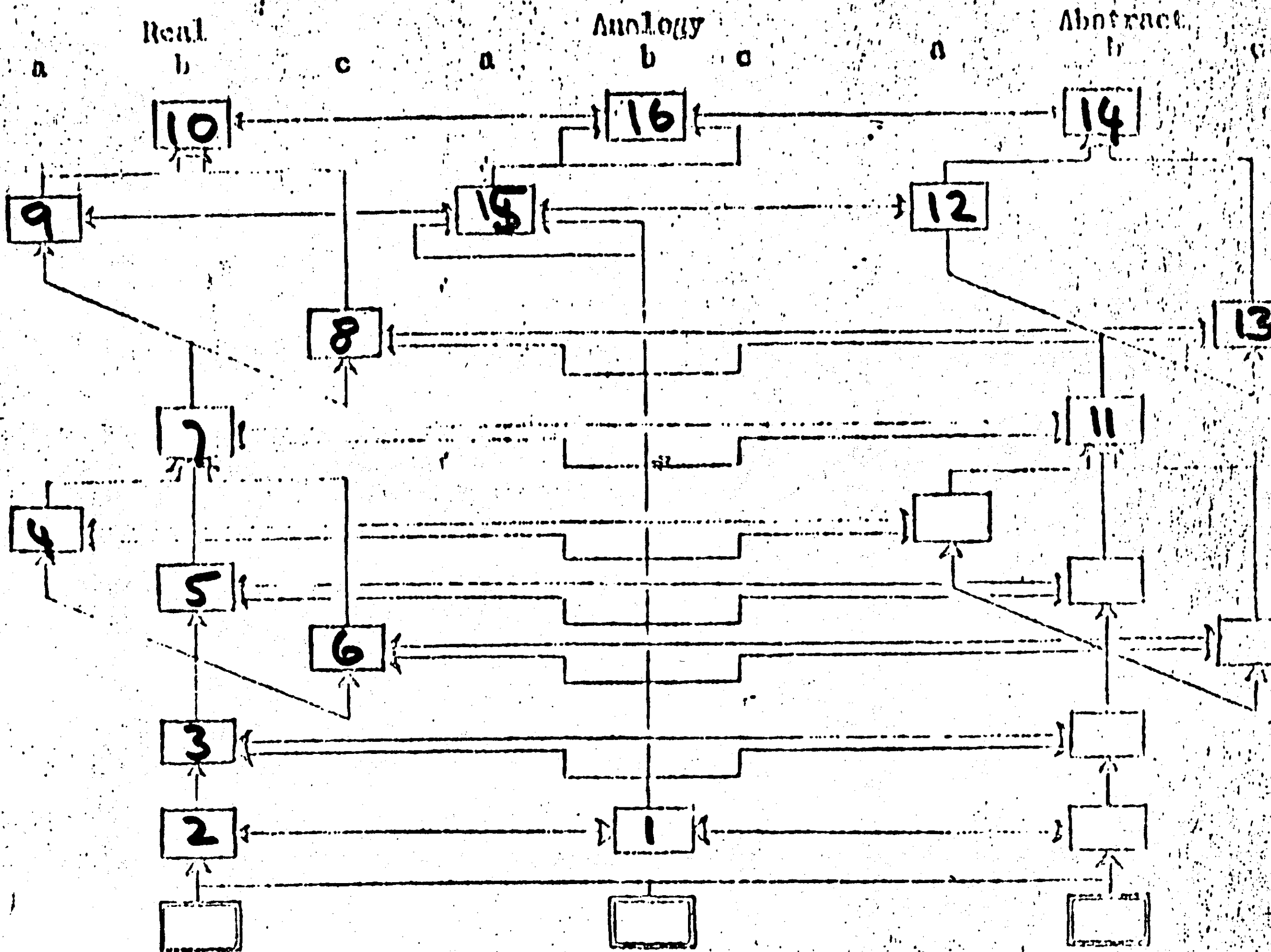
Module 1



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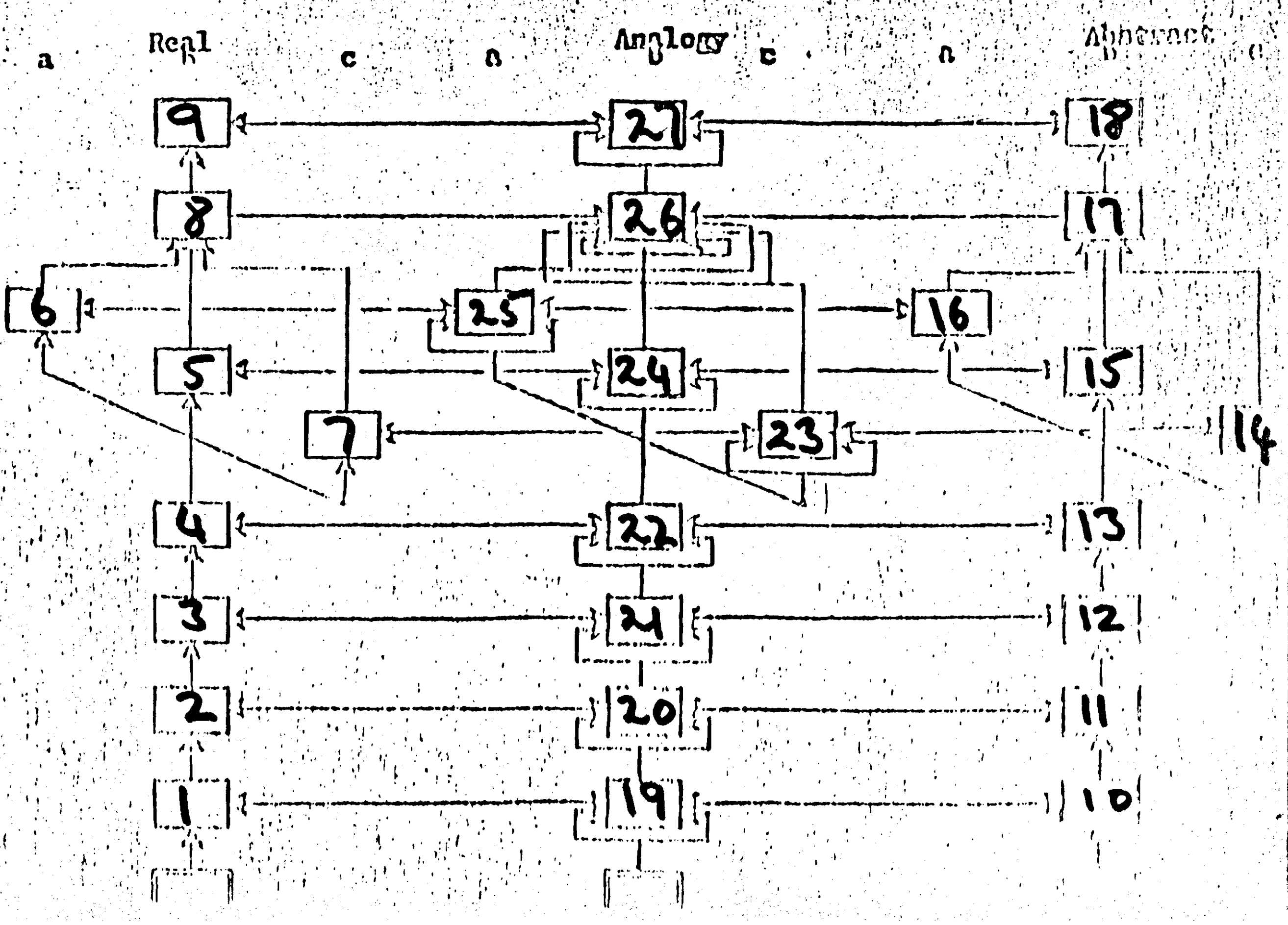
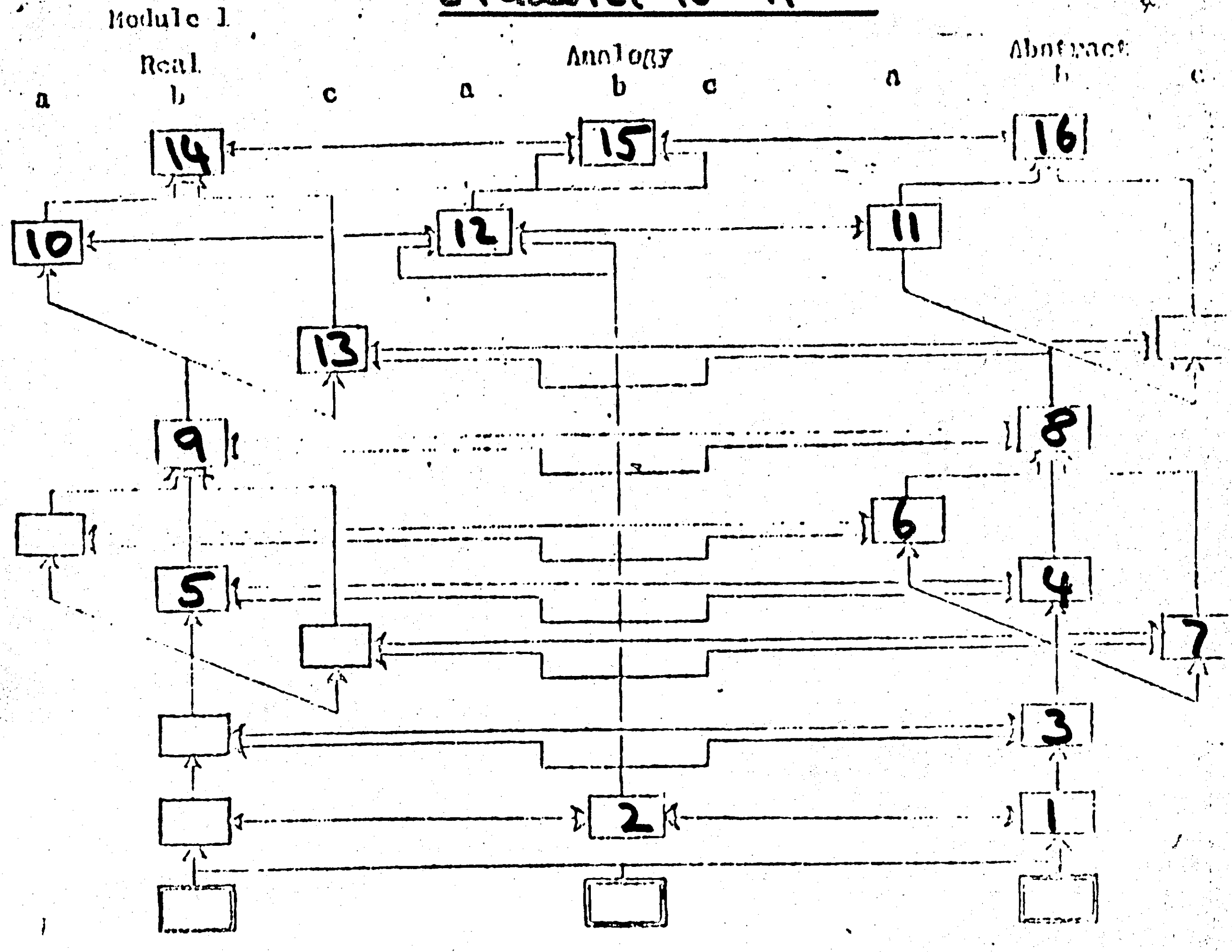


Student N= 11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Real
Anology
Abstract
a
b
c
a
b
c
a
b
c
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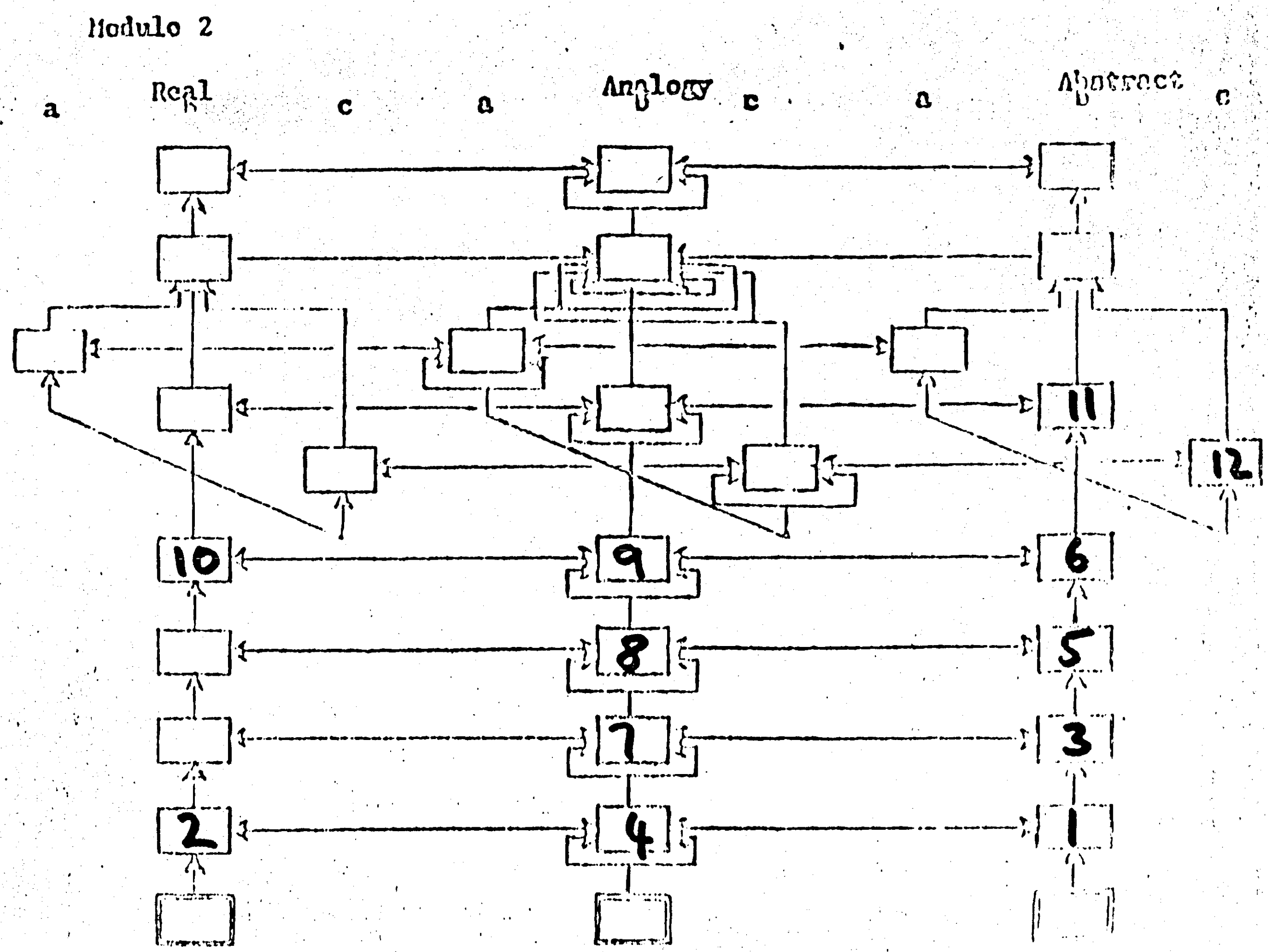
4
7
3
2
1


Module 2
Real
Anology
Abstract
a
b
c
a
b
c
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c
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10
9
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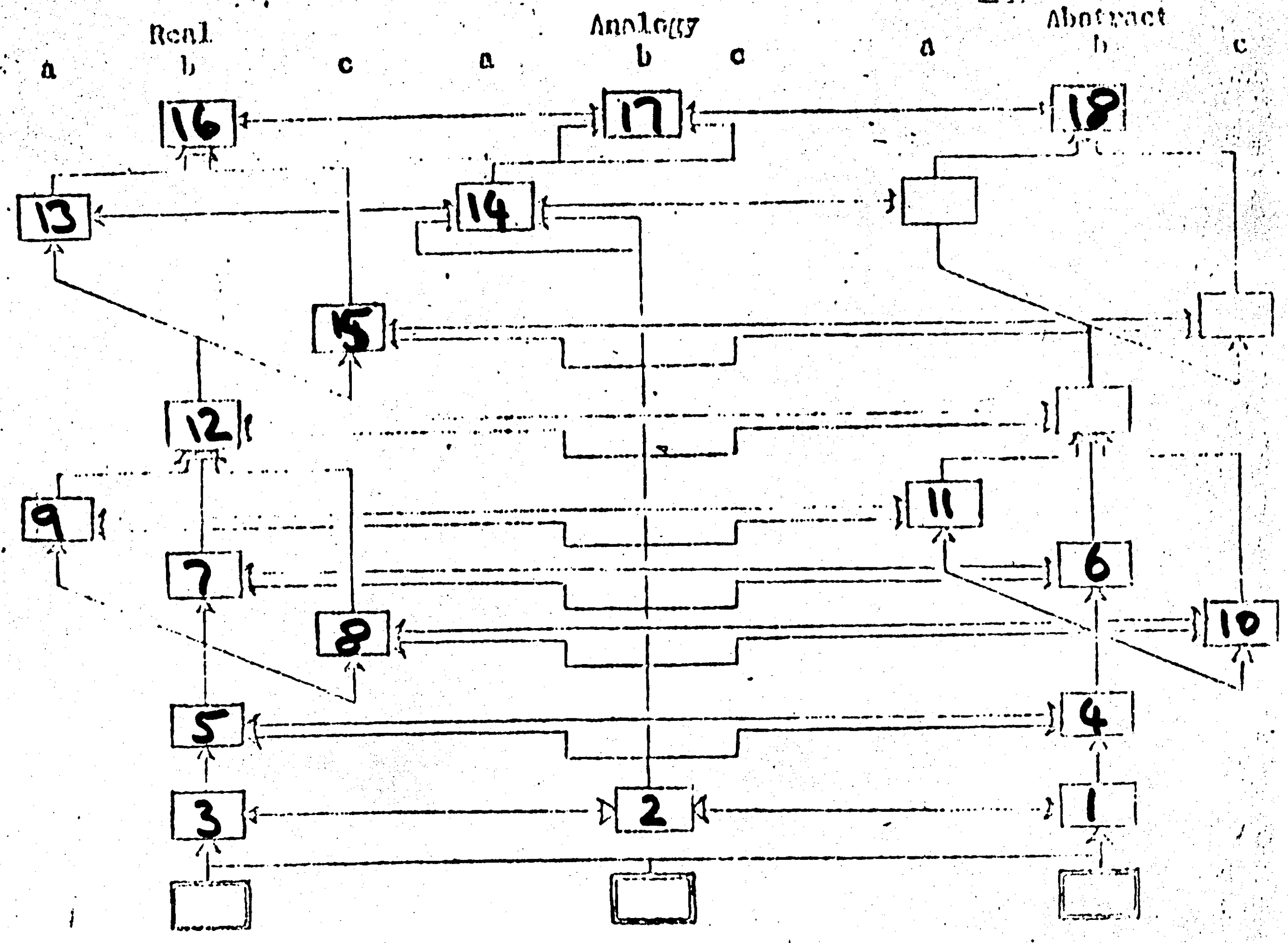
8
5
7
3
2
4
1

Student No 12

Module 1



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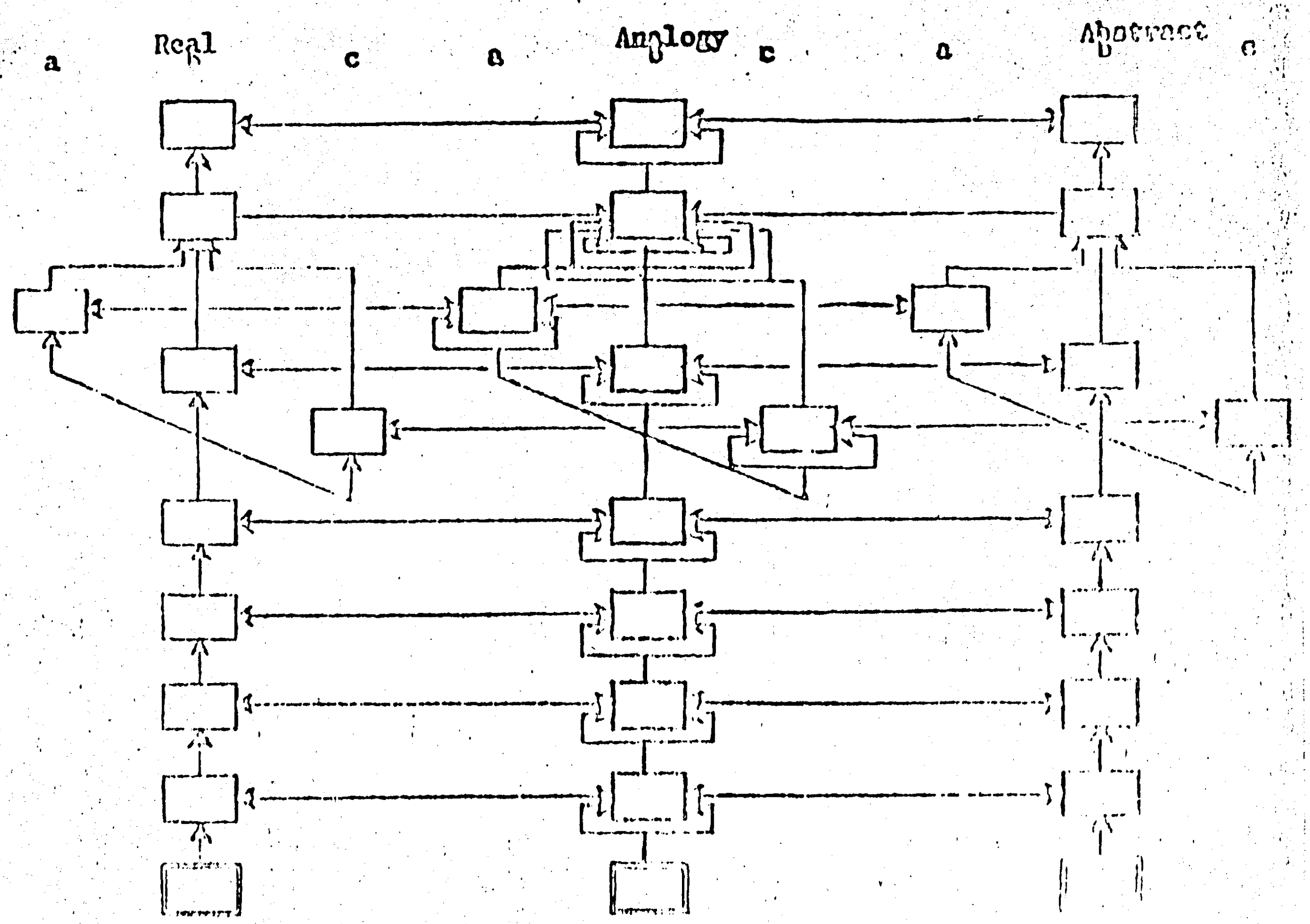

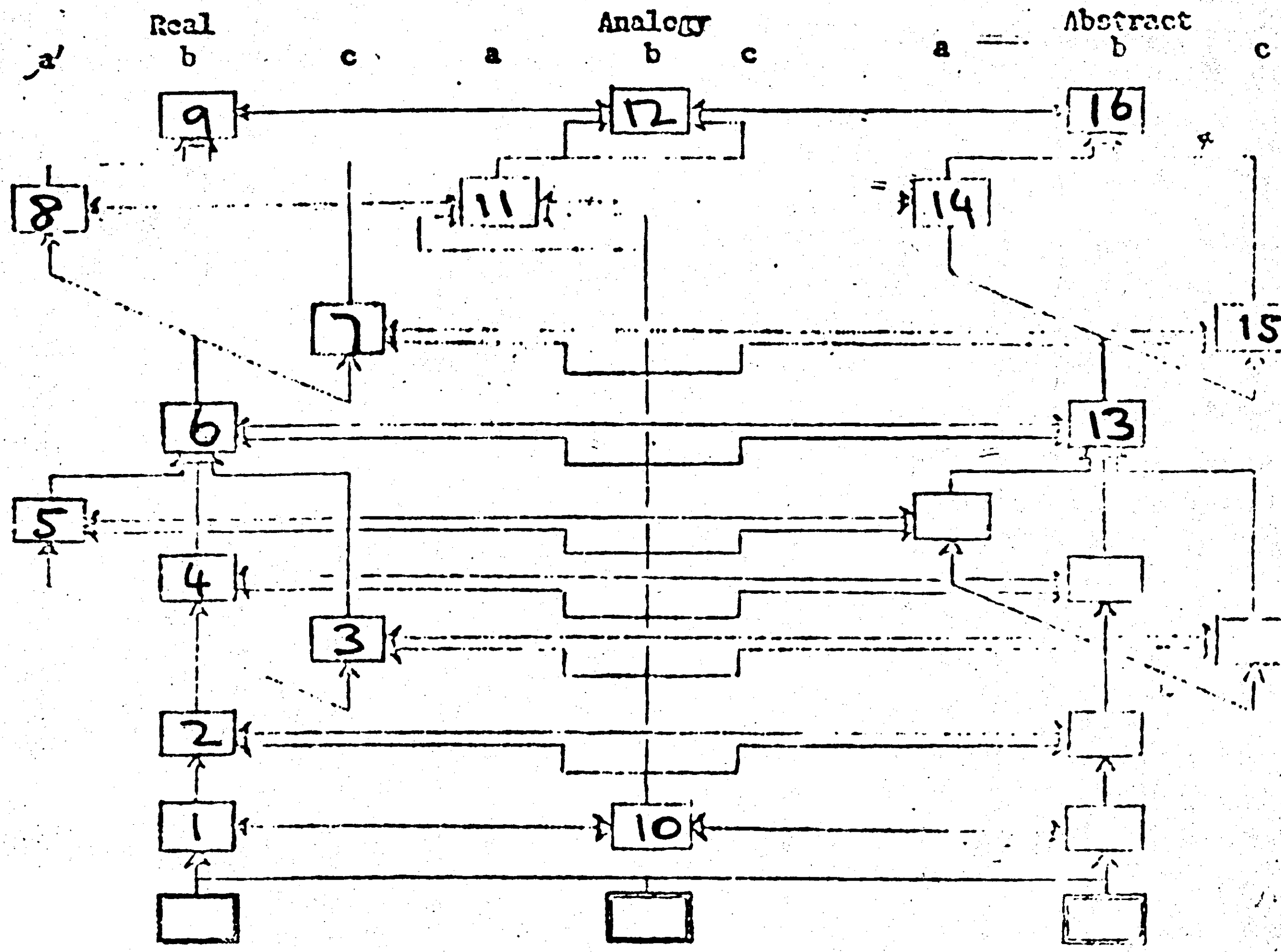
Real
a'
b
c
Analogy
a
b
c
Abstract
a
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12
16
8
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13
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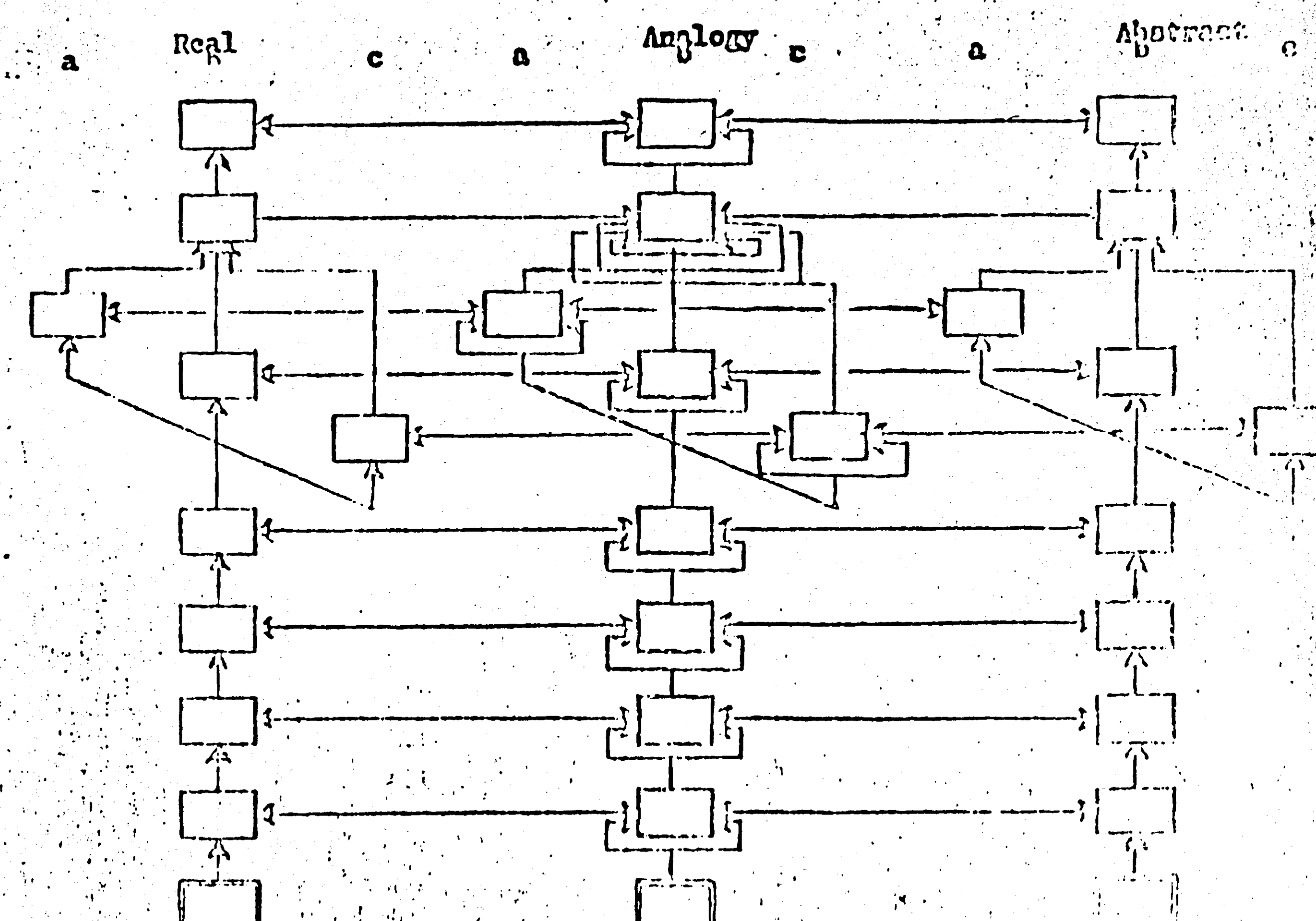
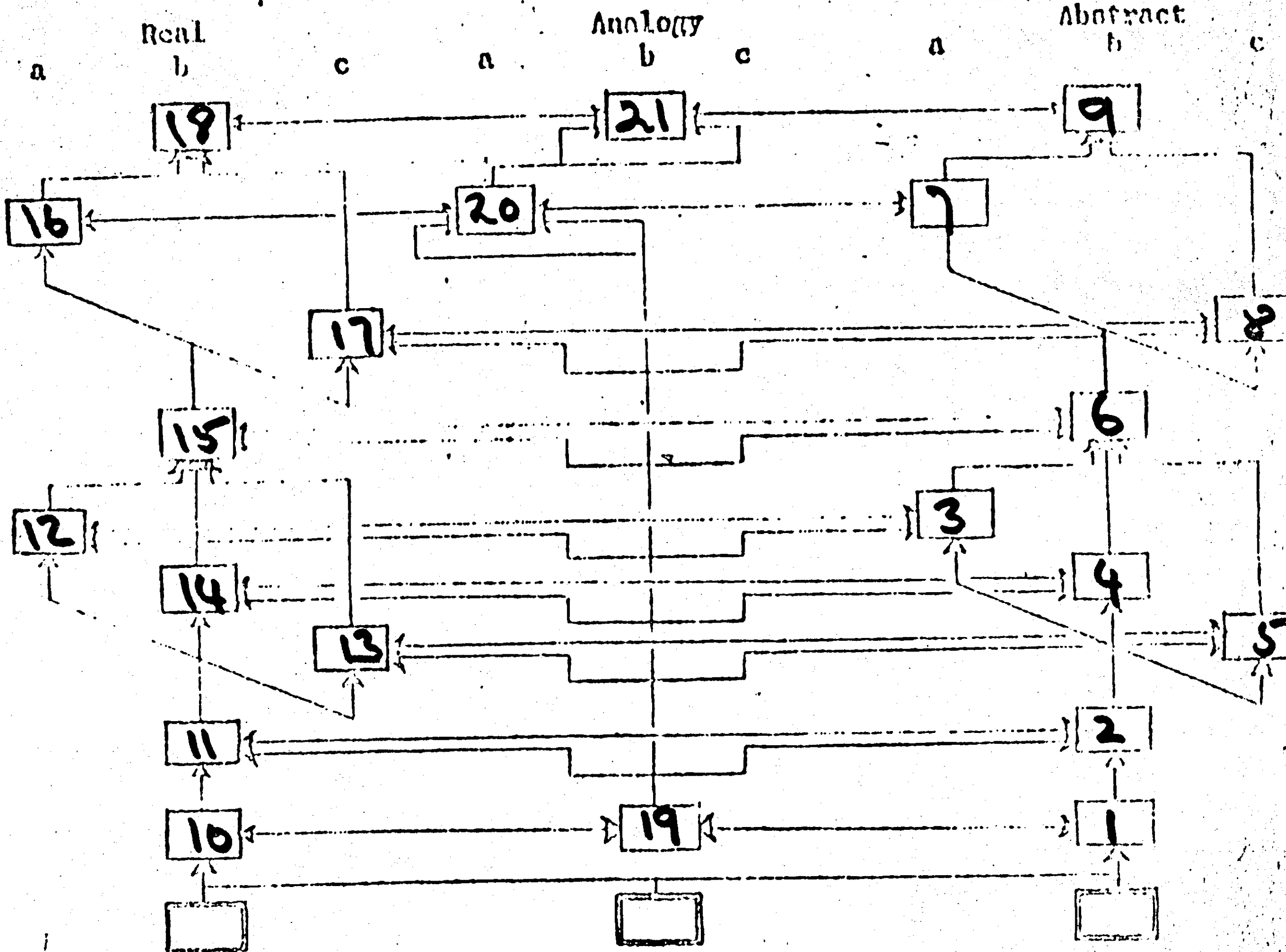
3
2
1
10

Modulo 2


Real
a
b
c
Analogy
a
b
c
Abstract
a
b
c

Student 10 = 14

Module 1



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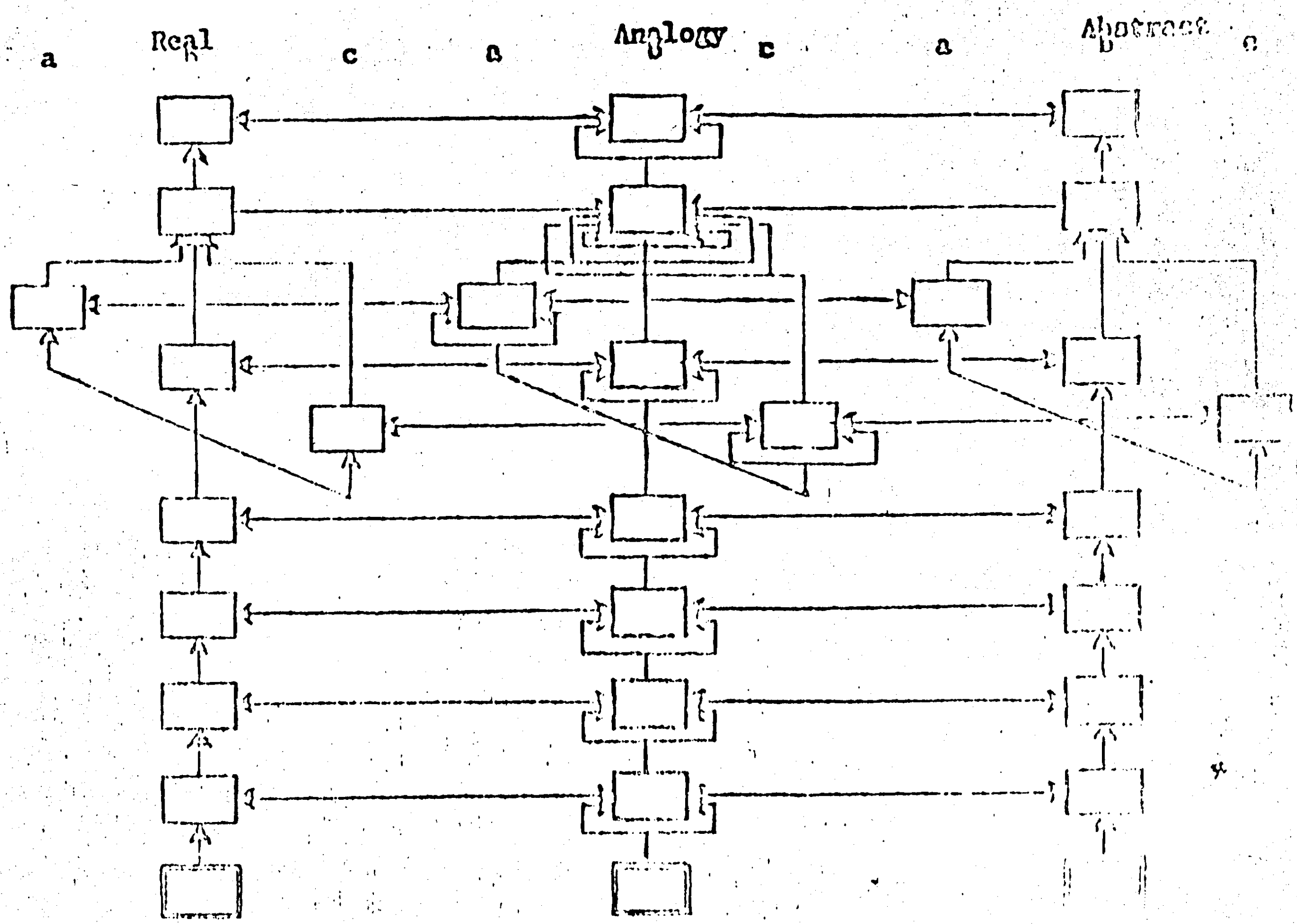


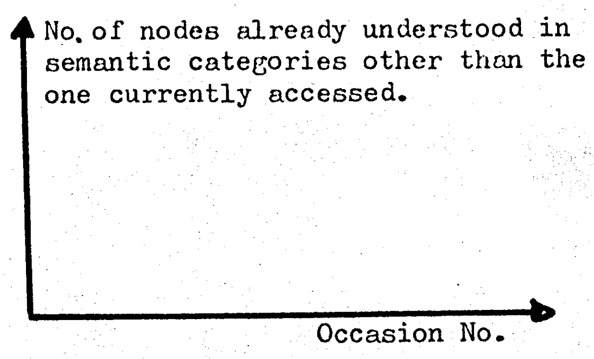
APPENDIX 8

Graphical presentation of Students' progress (Depth/Breadth First)

Appendix 8

Graphical presentation of Students' progress (Depth/Breadth First)

Axes



$$\text{Score} = \frac{\text{Total vertical distance moved}}{\text{No of 'jumps'}}$$

NB

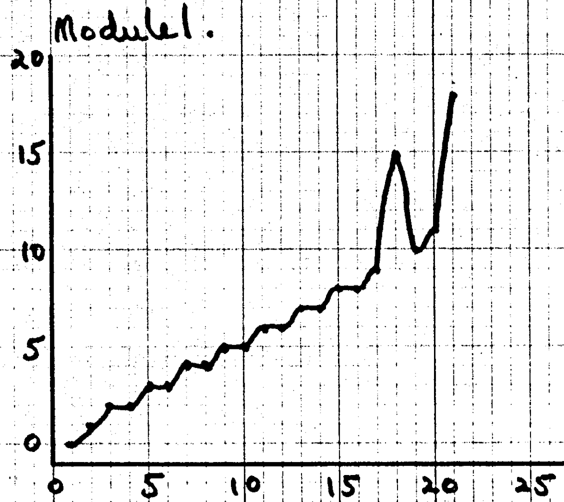
Scores are only computed for module 2.

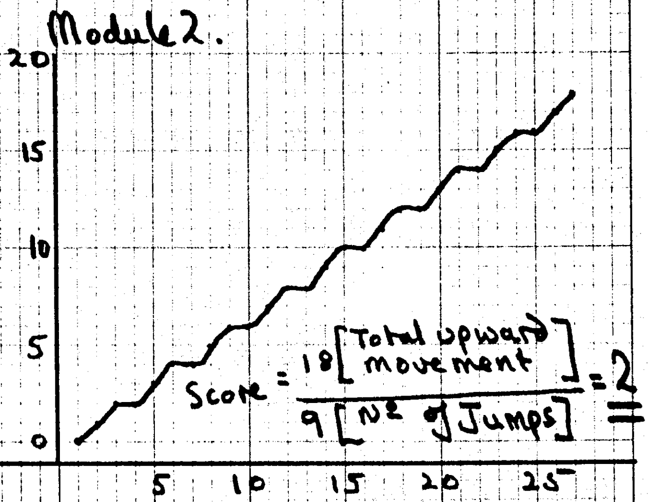
The scores computed are only used to 'rank-order' or dichotomise groups of students.

This method of presentation gives a clear picture of whether students move forward on a broad or narrow front.

GRAPHS OF THEORETICAL EXTREMES

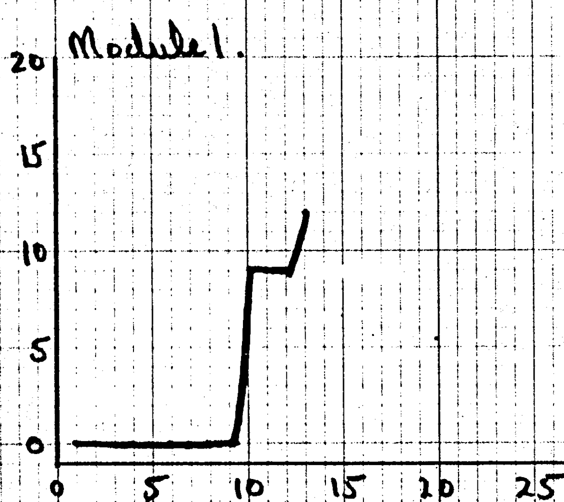
Breadth-First Theoretical Extreme.

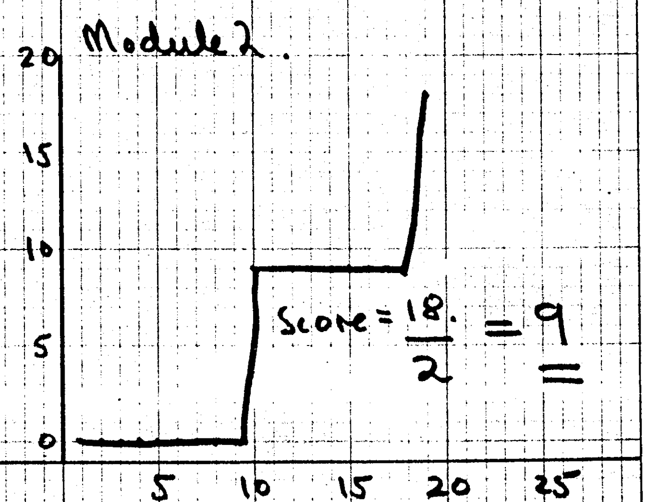




$$\text{Score} = \frac{18\left[\text{Total upward movement}\right]}{9\left[\text{No of Jumps}\right]} = \underline{\underline{2}}$$

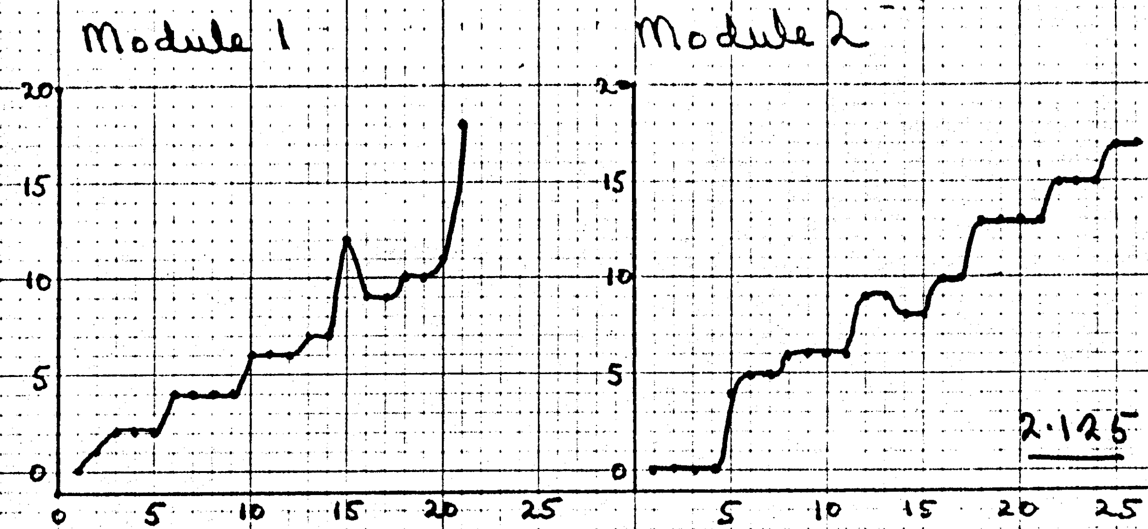
Depth-First Theoretical Extreme





$$\text{Score} = \frac{18}{2} = \underline{\underline{9}}$$

Student Nº 1



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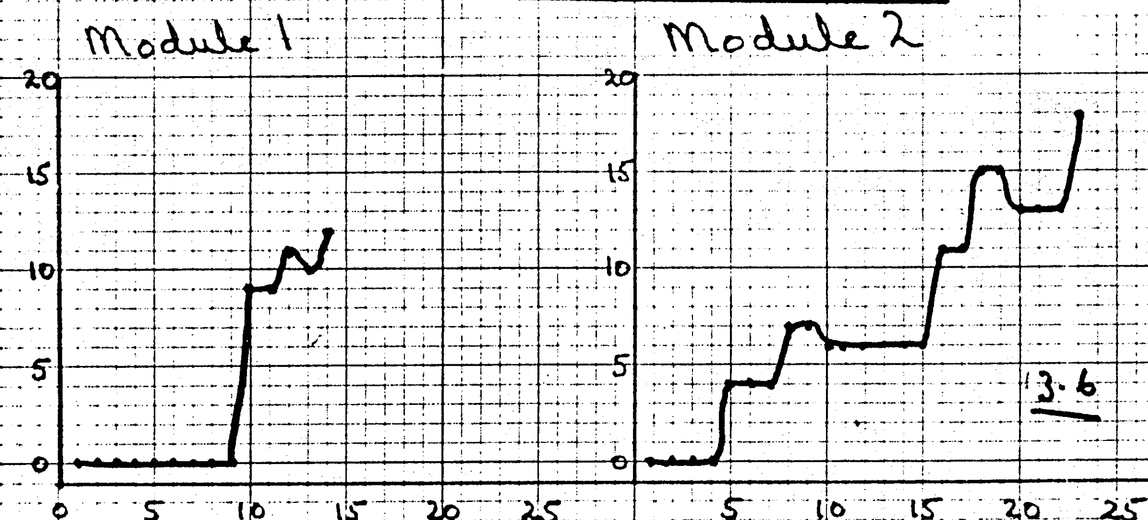

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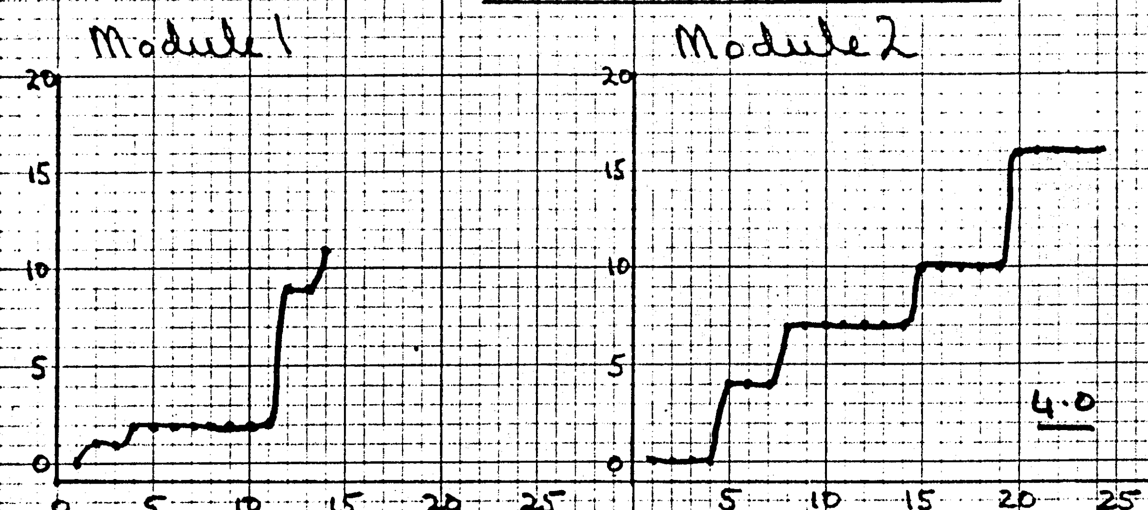
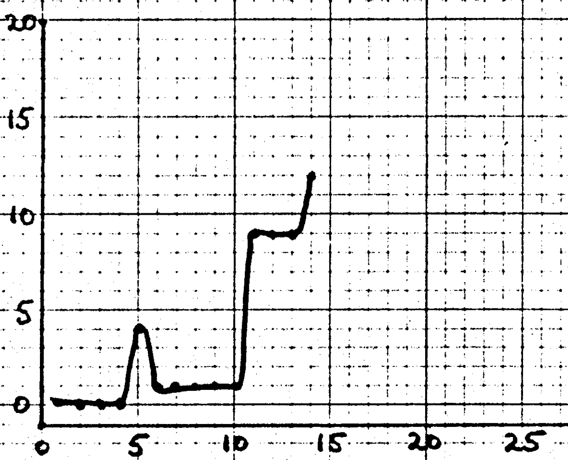
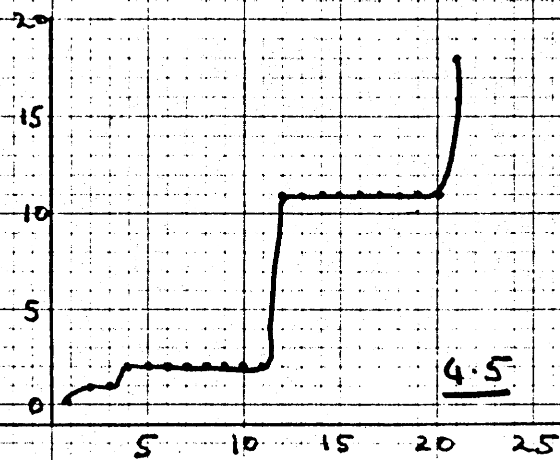


Student Nº 4

Module 1



Module 2



Student Nº 5

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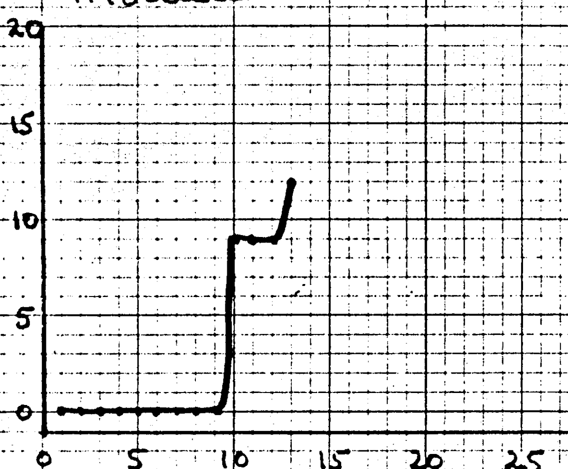

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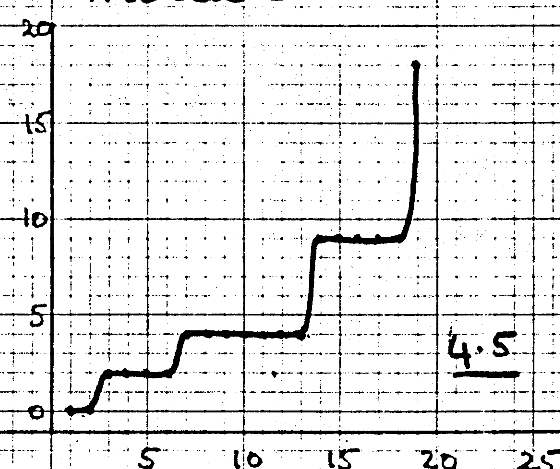

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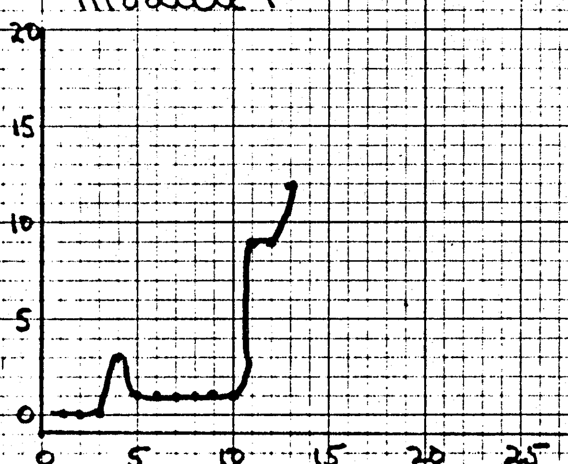
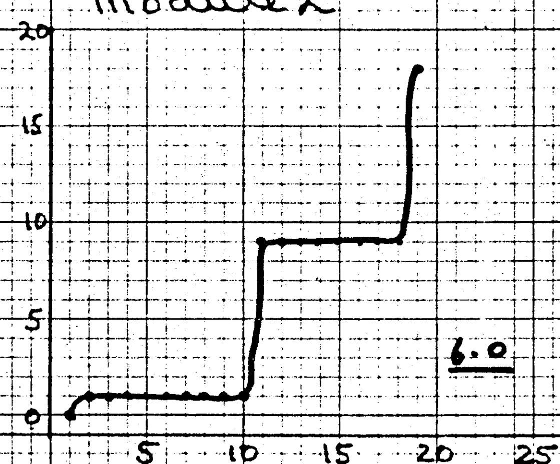
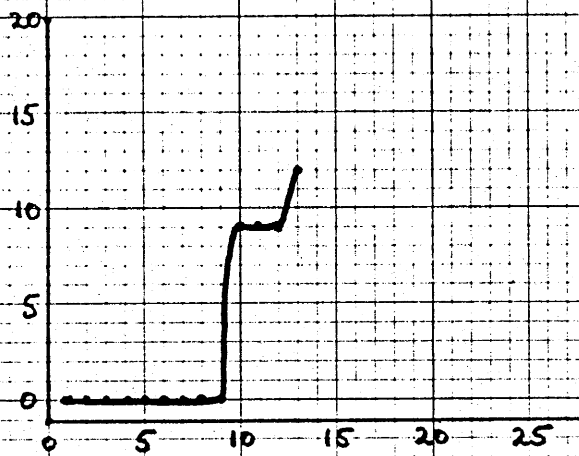


Module 2



Student N° 7

Module 1



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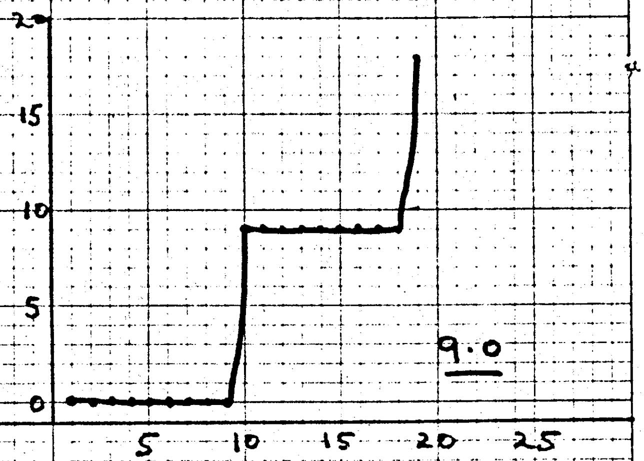

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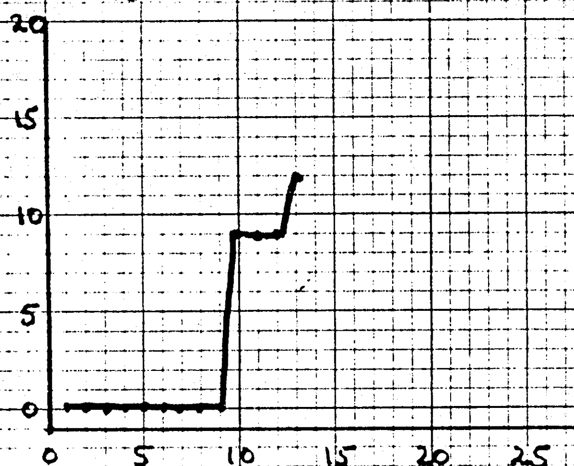
Student N° 8

Module 1



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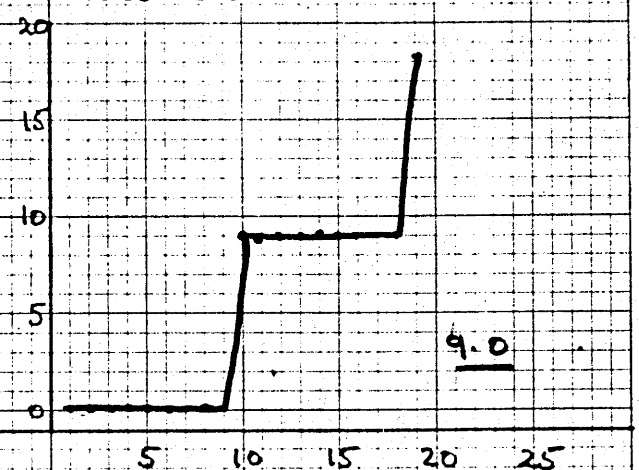

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Student N° 9

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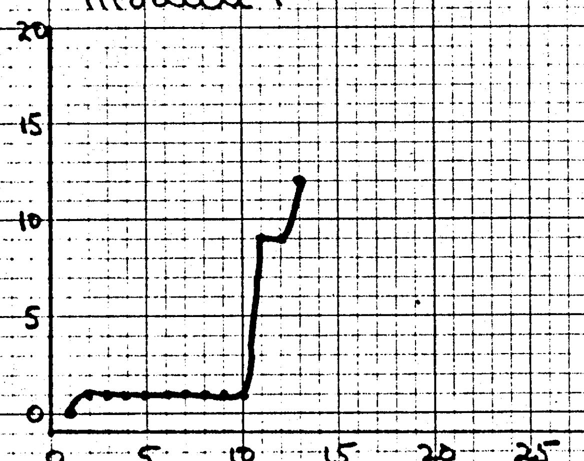

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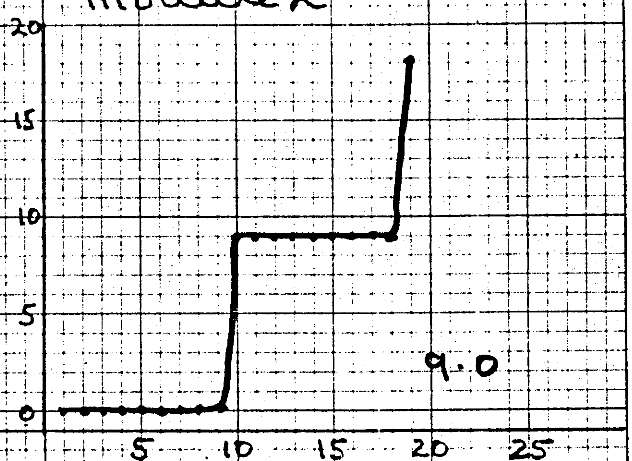

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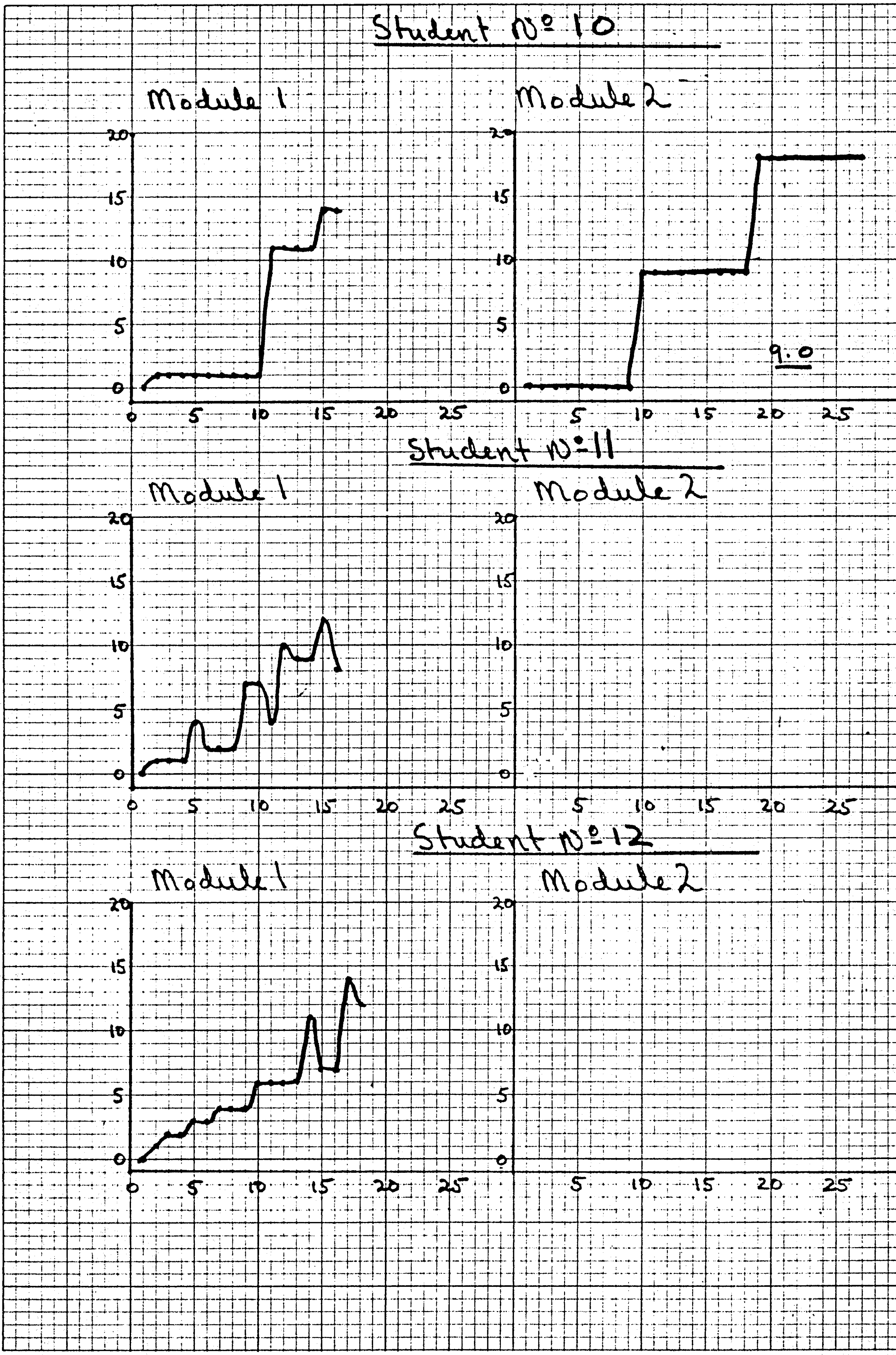
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Module 1
Module 2
9.0
Student Nº 11
Module 1
Module 2
Student Nº 12
Module 1
Module 2
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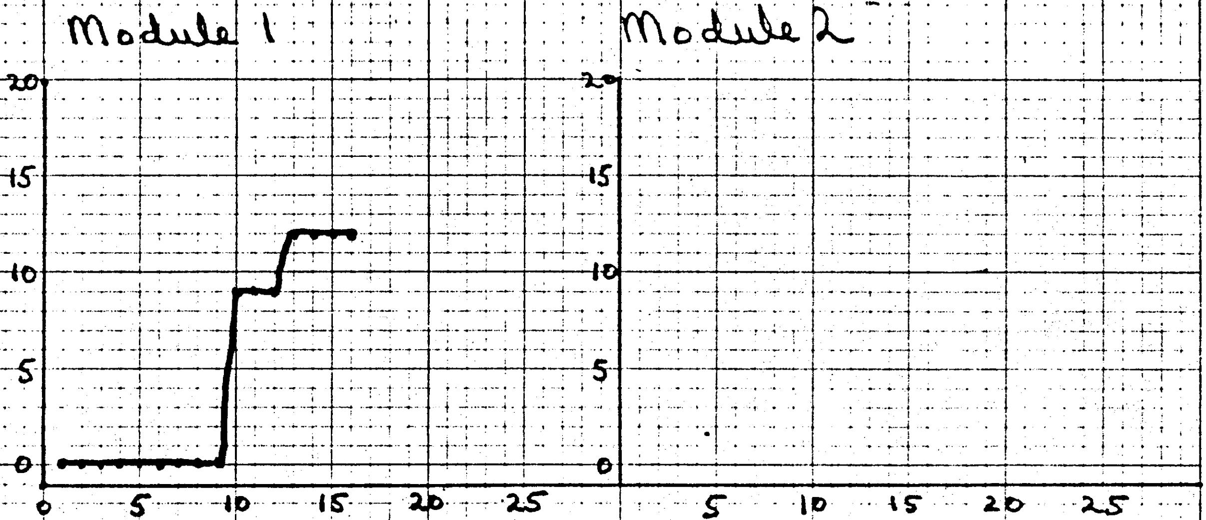
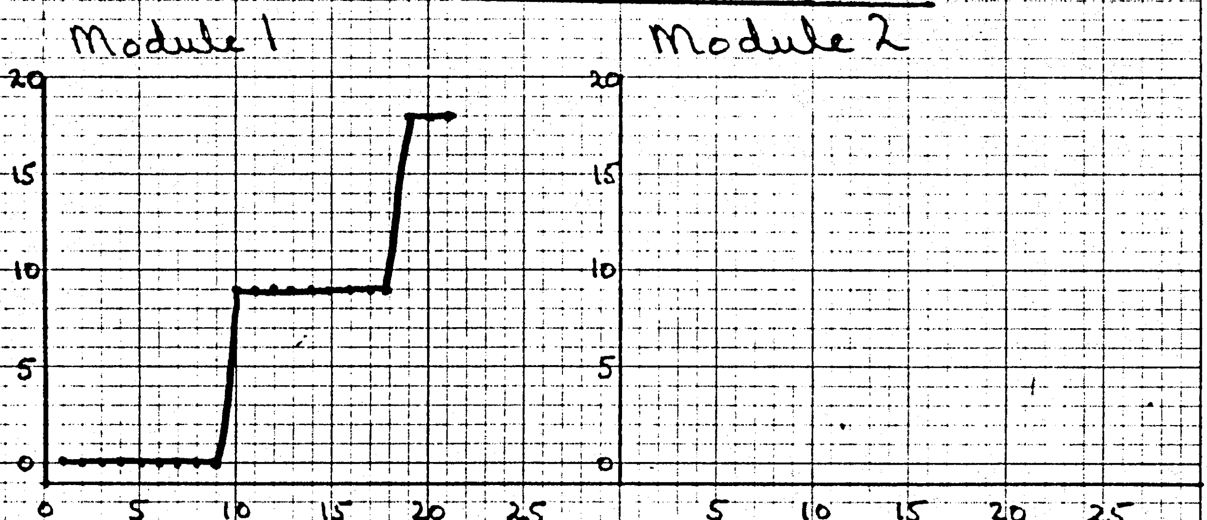
25

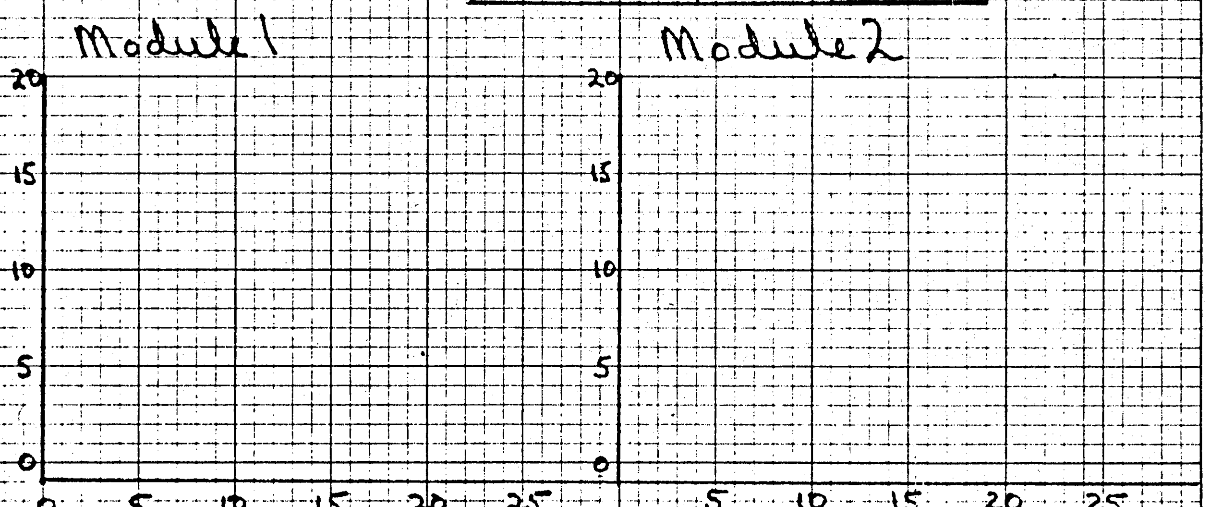
Student № 13



Student № 14



Student №



APPENDIX 9

Words used in the Attention Deployment test

Appendix 9

Words used in the Attention Deployment test

This appendix shows the words used on the Attention Deployment test. The focal list was presented to students in typewritten form on an A4 sheet. The peripheral list was played continuously (one complete reading every 40-45 seconds) during the 10 minute period that students were given to learn the focal list.

The distance from speaker to student and the volume setting was the same for all students.

After attempting to learn the focal list, with interference from the tape list students were given the 30 anagrams in the order shown. The anagrams were typewritten in lower case on cards (3" x 4").

Attention Deployment Test

Typewritten (focal) list given to students	Tape (peripheral) list
River	Royal
Salad	Joint
Evoke	Money
Grave	Smile
Cheap	Price
Board	Raise
Teeth	Eight
Sight	Grant
Yield	Maize
Layer	Jolly
Kind	Noise
Major	Final
Yearn	Thick
Dodge	Geese
Front	Enter
Lover	Third
Utter	Value
Slope	Demon
Purse	Chill
Maker	Bonus
Giant	Jewel
About	Music
Visit	Knock
Hawk	Lunch
Nerve	Organ

Anagrams

1. lrayo	11. yldie	21. hetiw
2. amrjo	12. tasny	22. nkcko
3. elcna	13. gieht	23. eoevk
4. ejelw	14. gtian	24. daymo
5. sldaa	15. rappe	25. linaf
6. earbz	16. nijot	26. etteh
7. cithk	17. eynar	27. lndba
8. itrsi	18. snowk	28. eeges
9. alvet	19. eonym	29. ogedd
10. iezma	20. virer	30. aedmr

APPENDIX 10

List of significant people used in Beiri test

Appendix 10

List of significant people used in Bieri test

1 Yourself

2 Person you dislike

3 Mother (or mother figure)

4 Person you'd like to help

5 Father (or father figure)

6 Friend of same sex

7 Friend of opposite sex

8 Teacher

9 Person difficult to understand

10 Person with whom you feel most uncomfortable

APPENDIX 11

The Problem-Solving Exercise

Appendix 11 - The Problem-Solving Exercise

INTRODUCTION

You are about to be appointed as the Personnel Manager of a medium sized manufacturing company employing 1,000 people.

The union in the company have made certain demands for improved conditions, payment rates etc., and it will be up to you to negotiate with them.

The board of directors of the company have set aside a certain sum of money, £80,000 that can be used in meeting the unions requests and have also worked out a set of guidelines for you to work within.

Your objective is to come to an agreement with the union as quickly as possible and you will be given a bonus depending on how quickly you can gain agreement.

The task before you is meant to approximate a real life industrial situation.

Although there are certain (realistic) rules there are no tricks to learn and you are meant to behave as you would if it were the "real thing".

There is no right answer, as such, you merely have to gain agreement working within the constraints of the situation. You will be shown a record of the last few meetings that the Personnel Manager in another company has held. This is merely intended to indicate to you what CAN happen during a sequence of meetings. It is NOT intended to indicate how you should behave nor to give any clues about how the union behaves.

You will be dealing with a different union and a different set of requests. (The instructor and student then looked through the material presented below to ensure that the student understood what was required.

PROBLEM SITUATION

UNION DEMANDS	COST PER ANNUM
A. Waiting Time. £2 per person per week (500 people)	£52,000
B. Extra Car Park (500 cars)	£52,000
C. Union meetings during working hours ($\frac{1}{2}$ hour per week: 1,000 people)	£26,000
D. Dirt Money. £1 per person per week (500 men)	£26,000
E. Pension Scheme. £1 per person per week.	£52,000

GUIDELINES

1. You have a maximum of £80,000 to spend

   (There is no extra bonus for spending less money)

2. You cannot agree to any of the union's requests in full.

3. You cannot promise anything for more than one year ahead.

4. You will only be able to discuss one item at any one meeting.

Example

RECORD OF MEETINGS IN COMPANY 'X'

Union Demands

Item One

Double-time payments for

8 am - 12 noon Saturdays

[125 employees @ average of £1 per hour]

Total extra Cost = £26,000 pa.

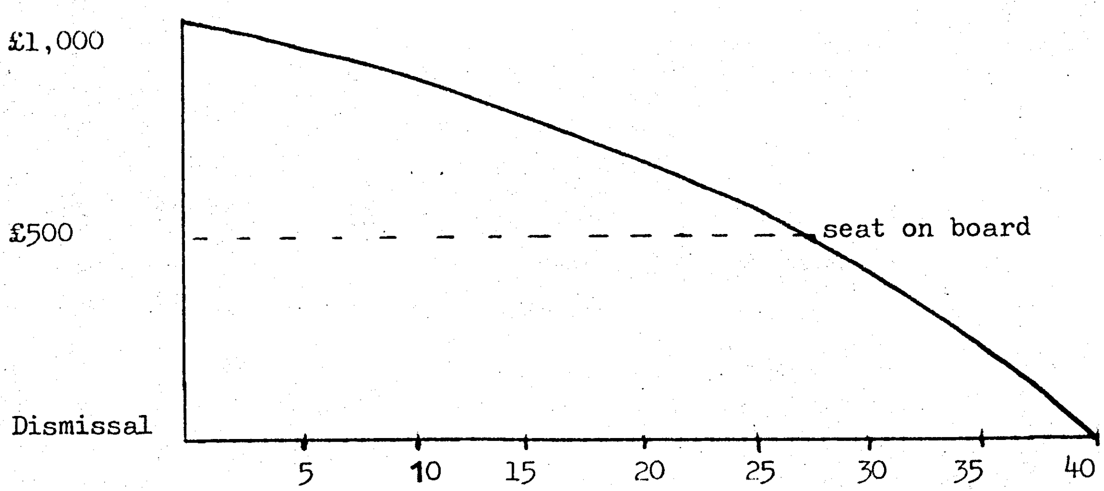
Item Two

New Canteen and Social Club

Total cost = £48,000.

Meeting Number	Item Number	Result	Action
1	One	X	Change offer
2	One	X	Change item
3	Two	X	Repeat offer
	(Causes Strike)		
4	Two	X	Repeat offer
	(Strike Continues)		
5	Two	X	Repeat offer
	(Strike Continues)		
6	Two	✓ Accept.	
	(Strike ends)		
7	One	X	Change offer
8	One	X	Change offer
9	One	X	Repeat offer
10	One	X	Change offer
11	One	✓ Accept	

YOUR BONUS SCHEME



APPENDIX 12

The Self Consistency Test

Appendix 12

The Self Consistency Test

This appendix shows the matrix and trait names used in the self-consistency test.

Students were asked to select 5 traits from each list (I and II) that most closely represented attributes that they possessed. The numbers of the trait names were then transferred to the 10 x 10 matrix - ie they were written in across the top row and down the left hand column (in the same order).

Students were asked to compare each trait with each other and in the appropriate cell indicate whether they were seen as compatible or not, using a four point scale ranging from 0 (Entirely Compatible) to 3 (Incompatible and Contradictory).

Self-Consistency Test

Name ______________________________ Date ______________

List I

1 Optimistic

2 Studious

3 Honest

4 Considerate

5 Reliable

6 Kind

7 Sincere

8 Friendly

9 Cautious

10 Independent

11 Practical

12 Happy

13 Sensitive

14 Tolerant

15 Idealistic

16 Adventurous

17 Intelligent

List II

18 Impatient

19 Worrier

20 Self-conscious

21 Moody

22 Rebellious

23 Immature

24 Quick-tempered

25 Easily Influenced

26 Lazy

27 Gullible

28 Envious

29 Often feel misunderstood

30 Disorganized

31 Guilt-ridden

32 Stubborn

33 Self-centred

34 Noisy