



Australian  
National  
University

---

THESES SIS/LIBRARY  
R.G. MENZIES LIBRARY BUILDING NO:2  
THE AUSTRALIAN NATIONAL UNIVERSITY  
CANBERRA ACT 0200 AUSTRALIA

TELEPHONE: +61 2 6125 4631  
FACSIMILE: +61 2 6125 4063  
EMAIL: [library.theses@anu.edu.au](mailto:library.theses@anu.edu.au)

## USE OF THESES

This copy is supplied for purposes  
of private study and research only.  
Passages from the thesis may not be  
copied or closely paraphrased without the  
written consent of the author.

THE PERCEPTUAL NATURE OF VISUAL IMAGERY

JUDITH ANNE SLEE

A thesis submitted for the  
Degree of Doctor of Philosophy of  
the Australian National University,  
Canberra.

March, 1976

This thesis describes original research carried out by the author during the tenure of an Australian Government Postgraduate Research Award in the Department of Psychology of the Australian National University from March, 1973 to March, 1976.

A handwritten signature in cursive script, appearing to read "J. A. Slee".

J. A. Slee.

## ACKNOWLEDGEMENTS

I acknowledge, with gratitude, the help of my supervisor, Professor Gavin Seagrim. His encouragement and guidance, and his editorial comments on the draft of the thesis have been invaluable.

I also sincerely thank Dr. Michael Cook, whose continued interest in the study, valuable criticisms and participation in discussions of the work as it progressed have been of great assistance.

The help of Mr. Neville Whitworth, a technician in the Psychology Department, is much appreciated. From instructions which, at best, could only be described as imprecise, he built and maintained the precise and elegant equipment used in Experiment V.

I am grateful to Mrs. Jess Giddings who not only typed the thesis but also offered constructive suggestions concerning its presentation and appearance, and to Miss Kathy Griffiths who willingly gave her time to help with the finishing-off touches.

Finally, I thank my husband, Michael, for his patience and support, especially in the final stages of preparing the thesis.

## TABLE OF CONTENTS

ACKNOWLEDGEMENTS	iii
ABSTRACT	ix
PART I. INTRODUCTION	
CHAPTER 1. A CRITIQUE OF THE MAINSTREAM OF RESEARCH ON VISUAL IMAGERY AND AN OVERVIEW OF THE PRESENT RESEARCH	1 2
PART II. METHODOLOGICAL PROBLEMS	
CHAPTER 2. THE CONSISTENCY OF DIFFERENT EXPERIMENTAL MANIPULATIONS OF IMAGERY	14 15
2.1 General Introduction	15
2.2 Experiment I: The Mutual Consistency of Three Manipulations of Visual Imagery	18
2.2.1 Introduction	18
2.2.2 Subjects	23
2.2.3 Materials	24
2.2.3.1 Sentences	24
2.2.3.2 Response protocols	25
2.2.4 Apparatus	25
2.2.5 Design and presentation order	25
2.2.6 Instructions	26
2.2.7 Procedure	26
2.2.8 Results	27
2.2.9 Discussion	31
2.3 Experiment II: The Consistency of Instructional and Individual Differences Manipulations of Visual Imagery Across Stimulus Types	34
2.3.1 Introduction	34
2.3.2 Subjects	35
2.3.3 Materials	35
2.3.4 Recall questions	35
2.3.5 Apparatus	37
2.3.6 Design and presentation order	37
2.3.7 Instructions	37
2.3.8 Procedure	38
2.3.9 Results	39
2.3.10 Discussion	40

2.4	General Discussion: Implications of Experiments I and II for Finding an Appropriate Manipulation of Visual Imagery	44
CHAPTER 3.	THE CONSTRUCTION AND EXPERIMENTAL VALIDATION OF A "VISUAL ELABORATION" MEASURE OF INDIVIDUAL DIFFERENCES IN VISUAL IMAGERY	47
3.1	General Introduction	47
3.2	Meeting the Criteria for a Useful Measure of Individual Differences in Visual Imagery	48
3.2.1	The criteria	48
3.2.2	How the criteria were met	49
3.2.2.1	Capacity for tapping the degree to which imaginal representation is spontaneous	49
3.2.2.2	Sufficient length to ensure reliability	50
3.2.2.3	Reasonable content coverage	50
3.2.2.4	Choice of dimensions particularly relevant to visualisation	51
3.2.2.5	Removal of the necessity for the subject to provide a subjective standard for responding	51
3.3	The Original Form of the Visual Elaboration Scale	52
3.4	Administration of the Original Form of the Visual Elaboration Scale	54
3.4.1	Aims of the administration	54
3.4.2	Subjects	55
3.4.3	Procedure	55
3.4.4	Results	56
3.5	The Second Form of the Scale	56
3.6	Administration of the Second Form of the Visual Elaboration Scale	60
3.6.1	Aims of the administration	60
3.6.2	Subjects	61
3.6.3	Procedure	61
3.6.4	Results	61
3.6.5	Discussion	66
3.7	Experiment III: Validation of the Visual Elaboration Scale	67
3.7.1	Introduction	67
3.7.2	Subjects	69

3.7.3	Materials, apparatus, design and presentation order, instructions, and procedure	69
3.7.4	Results	70
3.7.5	Discussion	71
PART III. VISUAL IMAGERY AND VISUAL PERCEPTION		75
CHAPTER 4.	THE LITERATURE ON THE RELATIONSHIP BETWEEN VISUAL IMAGERY AND VISUAL PERCEPTION	76
4.1	General Introduction	76
4.2	Theoretical Discussions	76
4.2.1	Hebb's view of visual memory imagery as a short-circuited perceptual process	76
4.2.2	Konorski's gnostic units theory	78
4.2.3	Neisser's definitional solution to the problem of the relationship between visual imagery and visual perception	79
4.2.4	Piaget's views on imagery	81
4.2.5	Pylyshyn's thesis that the visual image is not perceptual	82
4.2.6	Summary of theoretical discussions	83
4.3	Empirical Work on the Perceptual Nature of Visual Imagery	84
4.3.1	Introduction	84
4.3.2	Studies of commonality in behavioural outcome	84
4.3.3	Studies of similarity in the structure of the internal representations produced in visual imagery and visual perception	89
4.3.4	Studies of the use of the peripheral apparatus of visual perception in visual imagery	93
4.3.5	Studies of the use of the central apparatus of visual perception in visual imagery	95
4.3.6	Summary of empirical studies	98
CHAPTER 5.	DOES VISUAL IMAGERY ACTUALLY UTILISE THE CENTRAL APPARATUS OF VISUAL PERCEPTION?	100
5.1	General Introduction	100
5.2	Experiment IV: The Visual Perceptual Component of Visual Imagery	100
5.2.1	Introduction	100
5.2.2	Subjects	103

5.2.3	Scale administration	103
5.2.4	Materials	103
5.2.5	Apparatus	104
5.2.6	Procedure	106
5.2.7	Results	108
5.2.8	Discussion	113
CHAPTER 6.	VISUAL IMAGERY AS A PROCESS SPECIALISED FOR THE RECALL OF DETAILED VISUAL INFORMATION: I	121
6.1	General Introduction	121
6.2	Experiment V: Functional Representation, Structural Representation and the Visual Image	122
6.2.1	Introduction	122
6.2.2	Subjects	125
6.2.3	Materials	127
6.2.4	Apparatus and technical details	128
6.2.5	Presentation time and order of presentation	129
6.2.6	Procedure	130
6.2.7	Results	131
6.2.8	Discussion	134
CHAPTER 7.	VISUAL IMAGERY AS A PROCESS SPECIALISED FOR THE RECALL OF DETAILED VISUAL INFORMATION: II	138
7.1	General Introduction	138
7.2	Experiment VI: Structural Representation Without Functional Representation	139
7.2.1	Introduction	139
7.2.2	Subjects	142
7.2.3	Materials	143
7.2.4	Order of presentation	144
7.2.5	Procedure	144
7.2.6	Results	147
7.2.7	Discussion	149
7.3	General Discussion of the Results of Experiment V and Experiment VI	152
CHAPTER 8.	VISUAL IMAGERY AS A PERCEPTUAL PROCESS	154
8.1	General Introduction	154
8.2	Review of Experiments IV, V and VI	154
8.3	Is Visual Imagery Perceptual?	156

8.4	In What Ways is Visual Imagery Perceptual?	157
8.5	Is the Visual Image a Cognitive Luxury?	160
CHAPTER 9.	CONCLUDING COMMENTS	163
9.1	Individual Differences in Visual Imagery	163
9.2	Are Low Scorers on the V.E.S. Really Non-Imagers?	164
9.3	What is the Nature of the Stored Structural Information Which is Retrieved in Visual Imagery?	165
9.4	Why do "Good" Imagers Make Errors in Recall?	167
9.5	How Do "Non-imagers" Interpret Stimuli in Recall?	168
APPENDIX 1.	EXPERIMENT I	170
APPENDIX 2.	EXPERIMENT II	174
APPENDIX 3.	EXPERIMENT III	180
APPENDIX 4.	EXPERIMENT IV	182
APPENDIX 5.	EXPERIMENT V	191
APPENDIX 6.	EXPERIMENT VI	200
REFERENCES		222

## ABSTRACT

This study was concerned with visual imagery conceived - in general terms - as the mental event involved in the subjective experience of "seeing" absent objects. Most recent studies of visual imagery, in this sense, have been concerned with its usefulness, rather than with its nature. The present study departed from this purely functionalist standpoint and investigated a specific question concerning the nature of visual imagery - namely, the question of whether this subjectively perception-like experience, and the processes giving rise to it are, in fact, perceptual in nature. The reasons for this departure are outlined in Part I (Chapter 1) of the thesis.

Before this question could be investigated experimentally, it was necessary to select an index, or manipulation, of visual imagery. This needed to control the presence and absence of the particular mental process of interest (and not other modes of recalling, or representing, absent objects), so that the performance of subjects employing it could be compared with the performance of subjects not doing so. Only by such a comparison is it possible to determine whether visual imagery has a special relationship to visual perception, or whether it is no more closely allied to perception than are other methods of representation or recall.

Part II of the thesis, then, is concerned with studies oriented to this methodological problem. Experiments I and II (Chapter 2) showed that three common manipulations of visual imagery (varying noun concreteness, varying instructions, and selecting subjects on scores on the revised Betts' Questionnaire upon Mental Imagery) failed to meet the requirement outlined above. However, these experiments did indicate

that individual differences in imagery ability would be the most appropriate basis for manipulating imagery. Consequently, a new measure of such differences, the Visual Elaboration Scale, was constructed (Chapter 3). The final form of this scale was both internally consistent and capable of discriminating among subjects in a logical fashion. Its construct validity was established by the results of a picture memory experiment (Experiment III, Chapter 3).

Part III of the thesis deals with the questions first of whether, and subsequently of how, visual imagery is perceptual. Chapter 4 reviews and discusses the relevant literature. Chapter 5 reports a study (Experiment IV) in which subjects varying on visual imagery ability, as measured by the Visual Elaboration Scale, were found to be affected differentially by the introduction of visual interference into a task requiring the mental representation of previously seen letters (after Brooks, 1968). The pattern of the results suggested that visual imagery makes a specific use of the apparatus of visual perception.

Experiment V (Chapter 6) and Experiment VI (Chapter 7) report investigations of the implications of the use of the perceptual apparatus by visual imagery. In these studies strong differences were found between subjects classified as "non-imagers" and other subjects in the ability to recall distinctively visual information, and in performance on a perception-like task related to the availability of this type of information.

Chapter 8 reviews the results of Experiments IV-VI in terms of their implications for the perceptual nature of visual imagery. Chapter 9 outlines problems raised by the study and, where possible, offers some solutions.

PART I  
INTRODUCTION

## CHAPTER 1

### A CRITIQUE OF THE MAINSTREAM OF RESEARCH ON VISUAL IMAGERY, AND AN OVERVIEW OF THE PRESENT RESEARCH

In attempting to explain how man processes information, cognitive psychologists have increasingly reverted to the subjective or experiential elements in perception and memory which were so important to their predecessors (Natsoulas, 1974). The revival of visual imagery as a prominent topic is one example of the return of contemporary cognitive psychologists to the subjects, if not the methods, of pre-behaviourist introspective psychologists. It is again accepted as an unavoidable fact that many people say that they think about objects, not present as sense data, by "seeing" them. It is visual imagery, in this sense of conscious, quasi-visual mental experience, which is the object of study of the present thesis.

There are, potentially, serious methodological difficulties associated with introspective accounts of "seeing" absent objects. The difficulties arise if one assumes that the verbal accounts themselves disclose the intrinsic qualities of visual images and proceeds from that assumption in studying imagery. The flaws inherent in assuming the veridical, reflective nature of verbal descriptions are neatly illustrated by Neisser (1972) with an excerpt from Shakespeare, in which Hamlet and Polonius are discussing a cloud:

*Hamlet:* Do you see yonder cloud that's almost  
in the shape of a camel?

*Polonius:* By the mass, and 'tis like a camel indeed.

*Hamlet*: Methinks it is a weasel.

*Polonius*: It is backed like a weasel.

*Hamlet*: Or like a whale?

*Polonius*: Very like a whale.

Hamlet, Act III, Scene 2.

Neisser's point is that, as verbal reports are susceptible to demand characteristics of the situation and to bias induced by others, they do not constitute a good basis for assumptions about the nature of phenomena. Most recent studies of imagery have ignored this point. Researchers have tended to assume that we know what images *are* because of both what other people say about them and what we intuit ourselves, and that, therefore, the only research problem is to discover what they *do* in cognition. Thus, the mainstream of research on visual imagery has been purely functionalist in orientation.

Paivio (1969) summarises the bulk of contemporary imagery research in saying,

"...images ... are operationally defined and the concern is with their functional significance" (p. 243).

A detailed account of this type of research is contained in Paivio's (1971) book. It can be summed up briefly as follows: To start with, notions of the nature of visual imagery are derived from what people say about it and from researchers' own introspections; several different "operational definitions" are employed which have only a superficial relationship to the assumed nature of imagery (see Chapter 2 of this thesis); and the "operational definitions" are then discarded in favour of the original intuitive and informal notions of imagery when the experimental results obtained by the use of these "definitions" are explained.

Before proceeding, it should be said that the term "operational definition" is an unfortunate one which has little currency in contemporary philosophy of science (e.g., see Kaplan, 1964). What Paivio terms "operational definitions" are actually nothing more than experimental manipulations of imagery. The term "manipulation of imagery" rather than "operational definition", will be used in subsequent discussion.

A single example which well illustrates the predominant, functionalist approach summarised above is that of Paivio himself.<sup>1</sup> In his book (1971, Chapter 2), Paivio starts with the purely informal notion that visual images are non-verbal, concrete, spatially organised representations. One gets the idea of pictures in the head. But his principal method for manipulating imagery, to ensure its presence on some occasions and its absence on others, is to oppose concrete and abstract nouns in paired-associate learning tasks. The consistent superiority of recall that he finds for concrete over abstract nouns is attributed to the formers' imageability and the latters' non-imageability. Having attributed the difference in recall between the two types of nouns to the presence/absence of visual imagery, Paivio returns to his original picture-type notion in order to explain why imagery aids the recall of paired-associates. He does so in terms of spatial organisation, parallel processing and other such features of pictures and of picture-perception (Paivio, 1971, p. 387 ff.).

Although there is evidence that, on demand, subjects say that they visualise the referent of a concrete noun more readily than they visualise that of an abstract noun (Paivio, Yuille and Madigan, 1968),

---

<sup>1</sup> Other researchers with the same approach, though sometimes using different imagery manipulations and different tasks include Bower (1972), Bugelski (1968), Marks (1972), and Reese (1970).

there is no evidence that subjects visualise the referents of the former type of noun when they are not explicitly requested to do so. Granting that they may do so, however, there is no direct evidence that it is visual imagery, as such, which makes the recall of concrete nouns easier than that of abstract nouns. In this connection, Kintsch (1972) has cited results which suggest that the greater lexical complexity of abstract nouns, rather than their lack of access to the imaginal code, may be the reason that they are more difficult to recall.

Finally, even if there were evidence of the kinds discussed above, it would not, of itself, explain *why* the generation of images aids paired-associate learning. Paivio's explanation is in terms of his informal notion of visual images as spatially organised representations which permit parallel processing to take place in the storage and retrieval of information. Parallel processing, in turn, i) in some way reduces the memory load in storage and, ii) enables easy redintegration of the information and a rapid readout at retrieval. There is a problem concerning exactly what parallel storage and retrieval could mean - filing things as complete detailed wholes, and merely opening the correct file to retrieve them in toto, perhaps? Apart from this problem we have, as yet, little reason to accept the proposition that images are spatially organised in any really functional way (though the phenomenal soundness of the view that they are often so organised is undeniable).

Many other researchers (see Fn. 1) could have been cited as proponents of the functionalist approach to imagery. As will be discussed later, other supposed manipulations of imagery are just as open to question as Paivio's. Similarly, other functionalists when explaining differential performance resulting from use of their manipulations, tend to return to informal ideas of imagery whose connection with the manipulations has not been demonstrated. In short, despite the existence of a considerable

body of research which purports to demonstrate the functional utility of visual imagery, important questions still remain unanswered. To recapitulate, these are:

- i) Do the various manipulations of imagery actually ensure the presence/absence of the quasi-visual experience which they are supposedly making available to experimental examination?
- ii) Accepting, temporarily, that the manipulations do ensure the presence/absence of visual imagery, does this exhaust the possibilities of explaining differential performance resulting from their employment? Or can the presence/absence of imagery be seen as a mere (perhaps non-essential) concomitant of a more fundamental factor, such as that suggested by Kintsch (1972) to explain the recall inferiority of abstract, as opposed to concrete nouns?
- iii) Even if the presence/absence of visual imagery does exhaust the explanatory possibilities, *what* is an image, and *why* does it function as an aid to recall?

The failure of the most common approach to imagery, exemplified here by Paivio's work, to answer these and other pertinent questions has led Pylyshyn (1973) to formulate a strong critique on the current state of imagery theory and research. Pylyshyn is especially critical of two aspects of the contemporary literature which beg fundamental questions about the nature of visual imagery and about its role in cognition. He objects strongly to its use as a primitive construct in explaining task performance. The functional utility of visual images is frequently

overestimated because they are available to conscious inspection. That is, because we know images occur, we tend to make them prime candidates for explanatory purposes. This is considered erroneous by Pylyshyn.

Pylyshyn sees as inescapable the conclusion that non-conscious processes play important causal roles in cognition. That non-conscious mental events have significant functions is not a new idea. The work of Bartlett, Freud, and Piaget led each of them to express a similar view. And Holt deduces from a range of evidence that,

"... it is no longer necessary to assume that thought processes are identical with what can be reported by the thinker as his conscious contents, whether imageless or not... Consciousness is not a necessary defining property of cognitive processes" (Holt, 1964, p. 260).

In attributing successful performance on cognitive tasks solely to the presence of conscious visual imagery, the roles of non-conscious mental events are ignored.

The second feature of the functionalist literature to which Pylyshyn takes exception is its widespread use of a picture metaphor. While there is surely nothing amiss in the use of metaphors *as* metaphors, to mistake them for accurate descriptions can have misleading implications. Pylyshyn cites many examples of how imagery researchers and theorists have been led astray in this way, and makes explicit the consequences, following from a picture view of visual imagery, which he considers theoretically untenable.

The most unfortunate consequence from Pylyshyn's stand-point is the implication that, when we image, we retrieve from memory some relatively undifferentiated pattern with all its constituent pieces simultaneously available. This, like a picture presented directly to our sensory systems, requires perceptual scanning and interpretation before it becomes meaningful. Here Pylyshyn is making explicit the notion,

implicit in equating image and external picture, that the former consists of pre-perceptual signals which have not yet been interpreted by the cognitive system. Given that all sensory events are unique it is, *prima facie*, dubious that the brain has the capacity for their long-term storage in raw form. And, indeed, a large body of research on pattern perception (e.g., Neisser, 1967; Sperling, 1963) demonstrates that the persistence of sensory information, as such (i.e., before it is interpreted), is of extremely brief duration.

In Pylyshyn's opinion, the only reasonable alternative to the brain's storage of raw sensory data is the storage of abstractions from them in forms which are geared to stimulus types, rather than to individual instances, or tokens. A relatively small number of such forms is required to cover an extensive domain of instances, whereas the "perception-before interpretation" notion implied by the picture view of the visual image requires storage of an unlimited number of sensory patterns.

Taken as a criticism of the bulk of the recent literature on visual imagery, Pylyshyn's article is cogent. However, he overstates his case. Although he initially denies that he is challenging the unique status of imagery either as subjective experience or as object of scientific study, he leaves the reader with the impression that the image is a mode of representation comparable in every way with any other mode of representation. Thus, his criticism is not only of one approach to imagery, it is also, effectively, an attack on the idea that imagery is a unique kind of mental event. This intent is evident in his article's sub-title, "A critique of mental imagery."

The sub-title could just as well read, "A critique of conscious experience." Pylyshyn quite correctly highlights the role of non-conscious processes in cognition but, in doing so, he finds it necessary to downgrade

conscious experience. Stating that,

"... what is available to conscious inspection may not be what plays the important role in psychological processes" (1973, pp. 2-3),

he goes on to suggest strongly that this is, in fact, the case. That conscious modes of representation are denigrated in this way seems paradoxical, given that one criterion consistently invoked in distinguishing human intelligence from that of other animals is man's capacity for conscious, reflexive thought. Here images and/or inner speech are essential. It is one thing to recognise the importance of non-conscious processes; it is quite another to deny any functional significance to conscious experience.

Again Pylyshyn goes further than is reasonable in deploring the use of the picture metaphor. In claiming that an image cannot feasibly be conceived as a picture, he also says that it cannot be perceptual in any way. In his article no clear distinction is made between the terms "pictorial" and "perceptual". But, the proposition that the image is not pictorial in any functional sense does not entail the conclusion that it cannot be perceptual, unless there is interpolated between the two the further proposition that perception involves having pictures in the head. And this proposition does not square with recent ideas on visual perception (e.g., Gibson, 1966; Neisser, 1967).

Although there can be unfortunate consequences of a "perceptual" view of visual imagery if "perceptual" is taken to mean "pictorial", these do not follow from a view that the construction of the image may involve utilisation of the visual perceptual apparatus. If the other major form of internal conscious representation, "inner speech", requires use of the articulatory apparatus - as Watson claimed, and the Russian psychologists have shown - it is not too radical to speculate that the construction

of the image requires the use of at least the "output" end of the apparatus of visual perception.

One real trap in accepting any metaphor as an accurate description of a visual image is that such an acceptance pre-judges the nature of the image in the absence of concrete evidence. In this way, the study of imagery is all too easily limited to its functions. But there can be no real understanding of its functions if its genuine, as opposed to metaphorical, nature is not appreciated. Pylyshyn, while decrying the use of the picture metaphor, is actually replacing it with another. This could be called a "program metaphor". It is influenced only by computer programs of information processing systems which are currently fashionable. In saying that, subjective reports to the contrary notwithstanding, the image is a form of representation *like any other*, and that it cannot be perceptual, Pylyshyn is himself pre-judging the nature of imagery.

The "program metaphor" is an attempt to get away from the subjective report, for two reasons. First, the referent of such a report is necessarily conscious experience, and this is seen by Pylyshyn as having no real functional significance. This point has already been queried. Second, verbal reports of mental events are metaphorical and cannot be taken as accurate reflections of what goes on in the mind; therefore, a mental event cannot be accepted as being different from other mental events on the basis of such reports. While accepting this point to some extent, one should note an analogical point made by Neisser (1972) after his Shakespearean parable. This is that, although there are undoubted difficulties associated with Polonius' changeable metaphoric descriptions of clouds, this fact hardly implies that clouds do not exist as unique phenomena.

Neisser might further have qualified his remarks on verbal reports by acknowledging that they do have some positive uses. Such reports, from a variety of sources, provide confirming evidence for the existence of, for example, clouds, in the absence of which the latter might be thought to be mere flights of fancy on the part of a single informant. The utility of the reports is proportional to the degree to which they are based upon facts about clouds, and is inversely proportional to the degree to which they are based upon fanciful opinions of the type expressed by Hamlet and Polonius.

The difficulties inherent in the approach to imagery criticised by Pylyshyn largely disappear if verbal accounts of "seeing" absent objects are taken as indicating the presence of a particular kind of conscious mental event, without necessarily disclosing its intrinsic properties. One can accept that spoken words do not accurately reflect an internal, non-verbal experience, but convey only propositions about that experience. But, while accepting this, there is no reason also to doubt that there is *some* concomitant variation between verbal reports of modes of awareness and the modes of awareness themselves. If the type of mental event underlying reports of "seeing" absent objects is taken, not as a potential explanation of performance on a range of cognitive tasks, but as something itself requiring explication and explanation, then there is no more difficulty in studying it than there is in studying any other kind of mental activity. Of course, this is not to say that there is no difficulty at all.

The original question motivating the research reported in this thesis stemmed from the standpoint adopted in the preceding paragraph. That is, the question concerned the nature, rather than the functions of visual images. It is the most elementary question which can be asked about their nature, viz., Are visual images actually perceptual - and in

what ways? - or is the image vocabulary only a metaphor for communicating an experience which has no real functional similarity to visual perception?

Although some empirical work outside the mainstream of contemporary research on visual imagery has been carried out on this question, there is no real evidence to settle it either way (the status of the evidence is discussed in Chapter 4). And theoretical discussions of the possible relationship of visual imagery to visual perception have concluded both that the image is perceptual (Hebb, 1968; Neisser, 1967) and that it is not (Pylyshyn, 1973). Therefore the present research was not constrained by a well-established viewpoint, and could be undertaken in an exploratory spirit.

However, before the question which provided the original motivation for the work of the thesis could be addressed, a preliminary problem had to be resolved. This was the problem of manipulating the conscious quasi-visual process which was the intended object of study. Statements about the nature of visual imagery cannot legitimately be made unless there is reasonable certainty that it is this process, and not some other, which is being experimentally manipulated.

As noted above, there are already a number of different manipulations of visual imagery, but their relationships to quasi-visual experience are not firmly established. And, although the effects of these manipulations on a subject's internal processing are assumed to be both consistent from one to the other and consistent across experimental situations, these types of consistency have not been demonstrated convincingly. If consistency, in both senses, could be established empirically, there would be a case for using the usual manipulations to study the nature of visual imagery. If, on the other hand, the effects of each were found to be unrelated to the effects of the others, this

would serve as an indication that each was giving rise to a different kind of mental process; in this case, not all of them could be said to be manipulating visual imagery. Or if the manipulations produced effects consonant with the presence/absence of visual imagery in some experimental situations, but not in others, it would prove difficult to devise new experimental paradigms for studying the nature of visual imagery.

Although the original aim of the research of the thesis was to study the nature of visual imagery, the problem of ensuring that it was quasi-visualisation, and not some other process, which was being manipulated required attention. Only with this problem resolved was it possible to proceed to answering questions about the nature of imagery.

Thus, the present research was, in fact, addressed to two different problems:

- i) Methodological problems concerning the usual manipulations of imagery employed by functionalist researchers, and their resolution.
- ii) The problem of establishing whether visual imagery is perceptual in any but a metaphoric, or subjective, sense. The actual methods used in tackling this problem do not differ radically from those employed in purely functional studies. The difference between the present approach and that outlined at the beginning of this chapter is primarily one of orientation.

PART II  
METHODOLOGICAL PROBLEMS

## CHAPTER 2

### THE CONSISTENCY OF DIFFERENT EXPERIMENTAL MANIPULATIONS OF IMAGERY

#### 2.1 GENERAL INTRODUCTION

This chapter considers the various established manipulations of imagery and the consistency of their effects, with a view to establishing whether or not it would be possible to use them in studying the nature of quasi-visual processes. One experiment reported here explored the relationships between three common manipulations of imagery, in order to discover whether the effects produced by them are of the same kind. A second experiment reported in this chapter was concerned with the generality, - i.e., consistency across experimental situations - of the effects of two of these manipulations, whose mutual consistency appeared to be demonstrated by the first experiment. The aim of these experiments was to determine whether each of the manipulations examined actually controlled the presence and absence of subjective visualisation, and the processes underlying it, which were the intended objects of later investigation.

The principal types of imagery manipulation are enumerated in an article by Paivio (1970). They are:

- i) The manipulation of stimulus attributes designed to encourage or inhibit the arousal of visual images.  
This involves varying item imagery.
- ii) The use of instructions designed to affect differentially subjects' employment of visual imagery.
- iii) The selection of subjects according to individual differences in the ability to generate images.

By far the most common manipulations of Type i) involve varying item imagery by opposing concrete and abstract nouns, and by opposing pictures and nouns, in memory tasks. The idea in the first case is that concrete nouns are represented imaginally, whereas abstract nouns can only be mediated verbally. In the second case, the notion is that pictures are more readily represented as images than are words (see Paivio, 1971, p. 179).

The Type ii) manipulation consists of giving some subjects instructions to mediate imaginally while executing the experimental task, and giving other subjects instructions to mediate verbally, or other alternative instructions, either specific or non-specific with respect to task strategy.

There are three distinct classes of the Type iii) manipulation (and within each class there are variations). The first is subject selection based on differential responses to self-report imagery scales. There are several such scales, the best known being the revised version (Sheehan, 1967) of the Betts' (1909) Questionnaire on Mental Imagery (Q.M.I.), and Gordon's (1949) test of visual imagery control. The second class of Type iii) manipulation involves the selection of subjects on the basis of very high and very low performance scores on tasks assumed to require visual imagery for their execution. The tasks used here are numerous, though most have in common a spatial component (e.g., Kuhlman-Hollenberg, 1970; Stewart, 1965). Finally, individual differences in imagery ability have been gauged by differences in physiologically-based measures. Examples of these are the amplitude of the resting alpha-rhythm records (e.g., Short and Walter, 1954) and breathing patterns (e.g., Chowdhury and Vernon, 1964).

It was originally proposed that the following visual imagery manipulations would be employed in the present study:

- i) The Type i) manipulation of opposing concrete and abstract nouns to vary item imagery.
- ii) One Type ii) manipulation, namely contrasting visual imagery instructions and verbalisation instructions.
- iii) One manipulation of the first class of Type iii), this being subject selection on the basis of scores on the visual section of Sheehan's (1967) revised version of the Betts' (1909) Q.M.I. This self-report instrument is designed specifically to gauge the vividness of imagery, but scores on its seven-point rating scales are usually treated as a measure of general imagery ability.

However, these three manipulations were not used immediately in experimental work on the nature of visual imagery. The wide variations in their sources - respectively, the stimulus material, the experimenter, and the subject - raised the question of whether effects concomitant with the employment of one are of the same kind as effects resulting from the employment of any other(s). It is evident from the imagery literature that the effects of the three on overt performance are often quite similar. The question here is whether this similarity among experimental correlates of the various manipulations is due to their all encouraging/inhibiting the arousal of a single intervening mental process, or whether a different underlying process is responsible for the performance effect in each case. There are a number of mental strategies for enhancing task performance, the employment of any of which could be concomitant with the various manipulations commonly used by imagery researchers.

Experiment I examined the question of consistency among processes mediating the overt effects of the manipulations above, by employing the three simultaneously and examining the relationship among their

effects on memory. The simultaneous employment of manipulations from all three categories enumerated by Paivio (1970) is not reported in his (1971) summary of the imagery literature, though some experiments using manipulations from two categories have been carried out.

## 2.2 EXPERIMENT I: THE MUTUAL CONSISTENCY OF THREE MANIPULATIONS OF VISUAL IMAGERY

### 2.2.1 Introduction

When one considers the possible relationship between the different manipulations of visual imagery, it is obvious that it is not one of identity in the sense that a Type i) manipulation is identical with a Type ii) manipulation. As noted above, the basis of manipulation is different for each type. If, however, their effects on internal processing are of the same kind, they should interact. The patterns of interactions across categories of imagery manipulation have been only partly explored in previous experiments, which have used manipulations from two of the categories, but have omitted a manipulation from the remaining one.

There are two classes of two-factor memory experiments which bear on the question of the across-category consistency of visual imagery manipulations. In the first class, instructions and item imagery are varied at the same time; in the other class, the variations are of imagery ability and item imagery.

When instructions and item imagery are varied simultaneously, an assumption of consistency between the internal effects of the two implies that imagery instructions should interact with item imagery in such a way that the former facilitate recall when items are high on imagery value, but not when they have little imagery value. The assumption of consistency in question involves the beliefs that "high imagery"

items are inherently imageable, and are best represented imaginally, that "low imagery" items are inherently non-imageable, and that alternative instructions encourage and inhibit the arousal of that same imagery process which is useful for representing "high imagery" items.

Studies of consistency between these two manipulations have usually involved simple paired-associate learning (PAL) of concrete and abstract noun pairs, subjects being given imagery or alternative instructions. These studies have sometimes failed to confirm the relevant interaction (e.g., Paivio and Yuille, 1967; Yuille and Paivio, 1968) and at others confirmed it (Paivio and Foth, 1970). In a PAL study more complex than those run by Paivio and his associates, Griffith and Johnston (1973) produced *independent* main effects for instructions and item imagery on recall. Moreover, through their employment of an interference technique during learning and recall periods, Griffith and Johnston found that imagery instructions had their facilitating effects in the learning phase of the experiment, whereas high item imagery had its effect in the recall phase. The latter finding suggests that the overt effects of the two imagery manipulations are mediated by different kinds of internal events, that is, that their effects on processing are of different kinds.

Overall, however, it is not clear from the mixed results cited above whether there is a consistency between the internal effects of the manipulations of item imagery and instructions. The interaction of interest has been elusive, but it has occasionally been confirmed. A clearer picture may have been provided had a check been made on subjects' imagery ability.

In studies in which item imagery and subjects' imagery ability are varied together, one might expect an interaction between the two, whereby "good" imagers are superior to "poor" imagers on high-imagery items, but not on "low-imagery" items. The expectation is based on an

assumption of consistency, *viz.*, the assumption that the ability gauged by an individual differences measure is in the generation of the same process which is useful for representing high-imagery items.

Two experiments relevant to this expectation were carried out by Stewart (1965). In her first study, Stewart classified her subjects as "good" or "poor" imagers from their performance on a battery of spatial tests. Item imagery was varied by opposing pictures and words, and the task was recognition. In this study, the relevant interaction was found. "Good" imagers were better than "poor" imagers on picture recognition, but not on word recognition.

Stewart's second study of interest involved comparing the performance of "good" and "poor" imagers, classified as such in the same way as for the first experiment, on free recall. Item imagery was varied by using words high, medium, and low on imagery value. In this experiment, subject imagery ability did not interact with item imagery in the way it had with the picture-word item imagery manipulation.

Thus, the consistency, or otherwise, of the internal effects of item imagery and imagery ability is no more clearly determined than is that of instructions and item imagery. The inclusion of instructions as a guarantee that subjects with imagery ability made use of that ability in representing high-imagery words may have clarified the situation. An expectation that an ability useful in performing spatial tasks will be transferred automatically to verbal learning (as in Stewart's second experiment) is the quintessence of wishful thinking. It is entirely likely that use of this ability is specific to stimuli with spatial layouts (such as the pictures in Stewart's first experiment), unless its application in other contexts is suggested.

In the present experiment, the three manipulations detailed in the previous section were employed together. The task was to learn sentences and to recall critical nouns from them. Sentences were used instead of paired-associates firstly because of reservations about the latters' interest for subjects and about their representativeness of everyday learning situations (cf. Doob, 1972; Palermo, 1970), and, secondly, because a sentence mediates connections between nouns. It was intended to oppose imagery mediation to verbal mediation rather than to rote learning.

Subjects were divided into four groups based on combinations of high and low imagery ability, and imagery and verbal mediation instructions. All subjects were required to learn both concrete (high item imagery) and abstract (low item imagery) sentences.

On an assumption of the consistency of the effects of the three manipulations on internal processing, it might be expected that, in the situation of Experiment 1, "good" imagers with imagery instructions, and only these subjects, would recall concrete nouns better than abstract nouns. They are set by their instructions to use their natural capacity for generating the type of representational or mediational process which gives concrete nouns a recall advantage over abstract nouns. However, if the instruction manipulation actually encourages/inhibits the generation of this process, "good" imagers with verbal instructions should not recall concrete nouns better than abstract nouns; they are precluded from using the process whose generation is responsible for the superiority in recall of concrete nouns. And "poor" imagers lack the ability for effective imaginal representation and, therefore, should not recall concrete nouns better than abstract nouns, whether or not they are instructed to use imagery. On the assumption of the consistency of the effects of all three manipulations it might also be expected that the superiority of "good"

imagers with imagery instructions in recalling concrete nouns, would disappear in the recall of abstract nouns. Abstract nouns are opposed to concrete nouns because they are inherently non-imageable, so no advantage should accrue to subjects from the use of imagery with them.

Even if the expectations above, which are based on an assumption of consistency among the internal effects of all three manipulations, were not met, it would still be possible for a mutual consistency to exist between the internal effects of any two of them. On an assumption of such consistency of effect between instructional and item imagery manipulations (the effect of imagery ability being inconsistent), it might be expected that subjects with imagery instructions would recall concrete nouns better than subjects with verbal instructions, but that the latter subjects would recall abstract nouns better than the former. Concrete nouns, though they can have their meanings, and connections between them, mediated verbally, are most effectively represented, or mediated, imaginally. Consistency of effect between these two manipulations implies enhanced recall performance on concrete nouns of all subjects with imagery instructions, relative to subjects with verbal instructions, as the former instructional set encourages the realisation of the potential of these nouns for highly effective imaginal mediation. On the other hand, images "... are of little functional significance in dealing with abstract concepts" (Paivio, 1971, p. 28); the only way of mediating the meaning of abstract nouns, or of mediating connections between them, is by verbal processes (though these do not lead to the same level of performance as does imaginal representation of concrete nouns). Thus, subjects with imagery instructions could be expected to be disadvantaged in the recall of abstract nouns relative to subjects with verbal instructions.

An assumption of consistency of effect on internal processing between the imagery ability and item imagery manipulations (the effect of

the instructional manipulation being inconsistent) could lead to an expectation that all "good" imagers would recall concrete nouns better than would all "poor" imagers, but that the recall superiority of "good" over "poor" imagers would disappear with the recall of abstract nouns. "Good" imagers are the only subjects with an indicated ability to generate the process most effective for representing/mediating concrete nouns; but this process which "good" imagers can readily generate has no utility in handling abstract ideas.

Finally, an assumption of the consistency of effect on the subject's processing of the instructional and imagery ability manipulations (the effect of item imagery being inconsistent) could give rise to an expectation that imagery-instructed subjects high on imagery ability would have better recall of nouns, irrespective of the latter's imagery value, than subjects low on imagery ability given the same instructions, and than subjects of both ability levels given verbal instructions. Imagery-instructed "good" imagers are given a learning strategy, for use of which they have a measured high degree of natural ability.

The expectations above are not hypotheses derived from theory or from previous experimental results. Rather, they are based on a commonsense approach to the question of the consistency of the effects of the three manipulations on a subject's processing.

### 2.2.2 Subjects

Subjects were 20 females and 20 males from a first year Psychology course, for whose participation course credit was given. They were chosen on the basis of their scores on the visual imagery section of the revised Betts' Q.M.I. (Sheehan, 1967) which had been administered to 254 Psychology I students three weeks before the experiment began. Ten females and 10 males selected for the experiment had scores in the top quartile (i.e.,

were "poor" imagers); and 10 subjects of each sex had scores in the bottom quartile (i.e., were "good" imagers). The means for the 20 "good" imagers and for the 20 "poor" imagers were approximately one and a half standard deviations below and above the mean visual imagery score of the original group of 254.

### 2.2.3 Materials

#### 2.2.3.1 Sentences

There were 12 sentences, six concrete and high on item imagery and six abstract and low on item imagery. They were composed as six matched pairs to equate them for everything except the imagery value of three nouns. Members of each sentence pair shared the same frame, but three critical nouns of the first pair member were always abstract nouns which were low on rated imagery (below 3.30 on the Paivio, Yuille and Madigan (1968) seven-point imagery rating scale), while those of the second pair member were always concrete nouns, which were high on rated imagery value (above 6.30 on the Paivio *et al.* imagery ratings) and whose referents were capable of being visualised. Below is an example of a sentence pair:

- a) These *positions* need *minds* with plenty of *ideas*.
- b) These *women* need *friends* with plenty of *dollars*.

The full set of sentences is presented in Appendix Ia.

Within sentence pairs, nouns were also paired - e.g., *positions* with *women*; *minds* with *friends*, and so on -- and each pair of nouns was matched closely for Thorndike-Lorge frequency, and, as far as possible, for *m*, a measure of verbal association also established by Paivio *et al.* (1968). The sentence pairs varied in length from seven to eleven words. Each sentence was typed onto a white unlined systems card, photographed, and processed as a slide.

#### 2.2.3.2 Response protocols for recall

These consisted of 12 slips of paper, each containing one of the 12 sentences, which was complete except for the second and third critical nouns. The first critical noun was left as a cue. The positions of the missing nouns were occupied by lines which were always the same length so that no information was provided about numbers of letters in the nouns to be recalled. The protocols were arranged in booklet form. Subjects were required to work through the booklet filling in the missing nouns.

#### 2.2.4 Apparatus

The slides were projected by a Carousel projector fitted with an automatic timing device which controlled both display time and the length of the interval between slides.

#### 2.2.5 Design and presentation order

The four groups of subjects were:-

- i) Group 1: "Good" imagers with imagery instructions;
- ii) Group 2: "Good" imagers with verbal mediation instructions;
- iii) Group 3: "Poor" imagers with imagery instructions;
- iv) Group 4: "Poor" imagers with verbal mediation instructions.

As subjects in each group were required to learn both concrete and abstract sentences, the experiment used a 2x2x2 design, with repeated measures on the item imagery factor.

The order of presentation of the 12 sentences was randomised for 10 subjects, with the restrictions that, over this number of subjects, each sentence appeared in the first, middle and last thirds of serial positions an approximately equal number of times, and that the concrete and abstract member of a sentence pair were presented in serial positions 1-4, 5-8 and 9-12 an equal number of times over 10 subjects (for example,

if sentence *a*) above appeared in positions 1-4 for three subjects, 5-8 for four subjects, and 9-12 for three subjects, sentence *b*) did so also). The same 10 orders of presentation were followed for each experimental group.

#### 2.2.6 Instructions

A subject was told that 12 sentences would be presented, and that each would be displayed for 10 seconds, with a 10 second interval between the projection of sentences. He was instructed also that, when the sentences were on the screen, he should study them carefully, noting their exact wording, as he would be required to recall two nouns from each.

A subject with imagery instructions was then instructed to use the ten-second interval between sentence displays to rehearse the sentence he had just seen by forming a visual image of the situation it conveyed in a manner which connected the nouns in a meaningful way, and an example of how this might be done was given verbally. He was told to concentrate on his image only, as his rehearsal strategy.

A subject with the verbal mediation instructions was told to use a rehearsal period by repeating the whole of the sentence just displayed as an aid to connecting its nouns meaningfully, and to use this as his only rehearsal strategy. This condition differed from a rote repetition condition, in that verbal mediation was provided by the sentences themselves.

#### 2.2.7 Procedure

Each subject was tested individually. After outlining the general experimental procedure, the experimenter read the set of instructions appropriate for the subject's group. When the subject had indicated his understanding of the instructions, the 12 slides containing the

sentences were projected for 10 seconds each, with a 10 second rehearsal interval before the onset of the next slide.

Immediately following the presentation-rehearsal phase, the subject was given brief instructions concerning recall, the principal one being that he could not look at any sentence other than the one he was working on at a particular time. He was then handed the response booklet. The sentences in the booklet were in the same order as that in which they had been presented previously, to ensure that roughly the same amount of material was interpolated between the presentation of each sentence and its recall.

#### 2.2.8 Results

One point was allocated for each noun correctly recalled. The mean numbers of concrete nouns and abstract nouns recalled (maximum possible, 12 in each case) are set out in Table 2.1. The complete set of data is tabled in Appendix Ib.

TABLE 2.1 Mean number of nouns recalled  
by each experimental group.

Group	Concrete Nouns	Abstract Nouns	Total
1	10.5	6.1	16.6
2	8.5	3.6	12.1
3	9.6	4.0	13.6
4	9.5	4.2	13.7

An analysis of variance was run on the number of nouns correctly recalled. The factors, all assumed to be fixed, were subjects' imagery ability, instructional set and item imagery. The first two were between-S factors, the last was a within-S factor. The results of this analysis are presented in Table 2.2

TABLE 2.2 Analysis of variance on noun recall scores.

SOURCE	SS	df	MS	F
<u>Between Ss</u>	<u>190</u>	<u>39</u>		
Imagery Ability (A)	2.45	1	2.45	0.64
Instructional Set (S)	24.20	1	24.20	6.37*
A x S	26.45	1	26.45	6.96*
Error between	136.90	36	3.80	
<u>Within Ss</u>	<u>650</u>	<u>40</u>		
Item Imagery (I)	510.05	1	510.05	134.93**
A x I	3.20	1	3.20	0.85
S x I	0.05	1	0.05	0.01
A x S x I	0.80	1	0.80	0.21
Error within	135.90	36	3.78	

\*  $p < .05$

\*\*  $p < .01$

Although there was a large main effect for item imagery, none of the interactions with this factor were statistically significant. Hence, the data did not confirm the expectation based on an assumption of the consistency of the effects on processing of all three imagery manipulations. This expectation is of a three-way interaction.

The assumptions of consistency of effect on processing between item imagery and instruction manipulations, and between item imagery and imagery ability manipulations, each leads to an expectation of a statistically significant two-way interaction with the item imagery factor. The failure to find such interactions also indicated no support for either of these expectations.

An assumption that the instructional and imagery ability manipulations are consistent in their internal effects gives rise to an expectation of an interaction between these two factors, such that subjects with both "good" imagery ability and imagery instructions recall nouns - irrespective of imagery value - better than subjects in all other instructions x ability groups. The interaction between the factors was statistically significant. The relevant data are shown in Figure 2.1.

Tests of the differences between group recall scores (Winer, 1970, p. 340 ff.) indicated that this interaction was, indeed, due to the recall superiority of the group of imagery-instructed "good" imagers over all other groups. For the difference in overall noun recall between imagery-instructed "good" imagers (Group 1) and verbally-instructed "good" imagers (Group 2),  $F(1,36) = 13.32$ ;  $p < .01$ . For this difference between imagery-instructed "good" imagers and imagery instructed "poor" imagers (Group 3)  $F(1,36) = 5.92$ ;  $p < .05$ . However, imagery-instructed "poor" imagers did not differ significantly from verbally-instructed "poor" imagers (Group 4), the F value for the difference in total recall being .007; and verbally-instructed "good" imagers did not differ significantly from verbally-

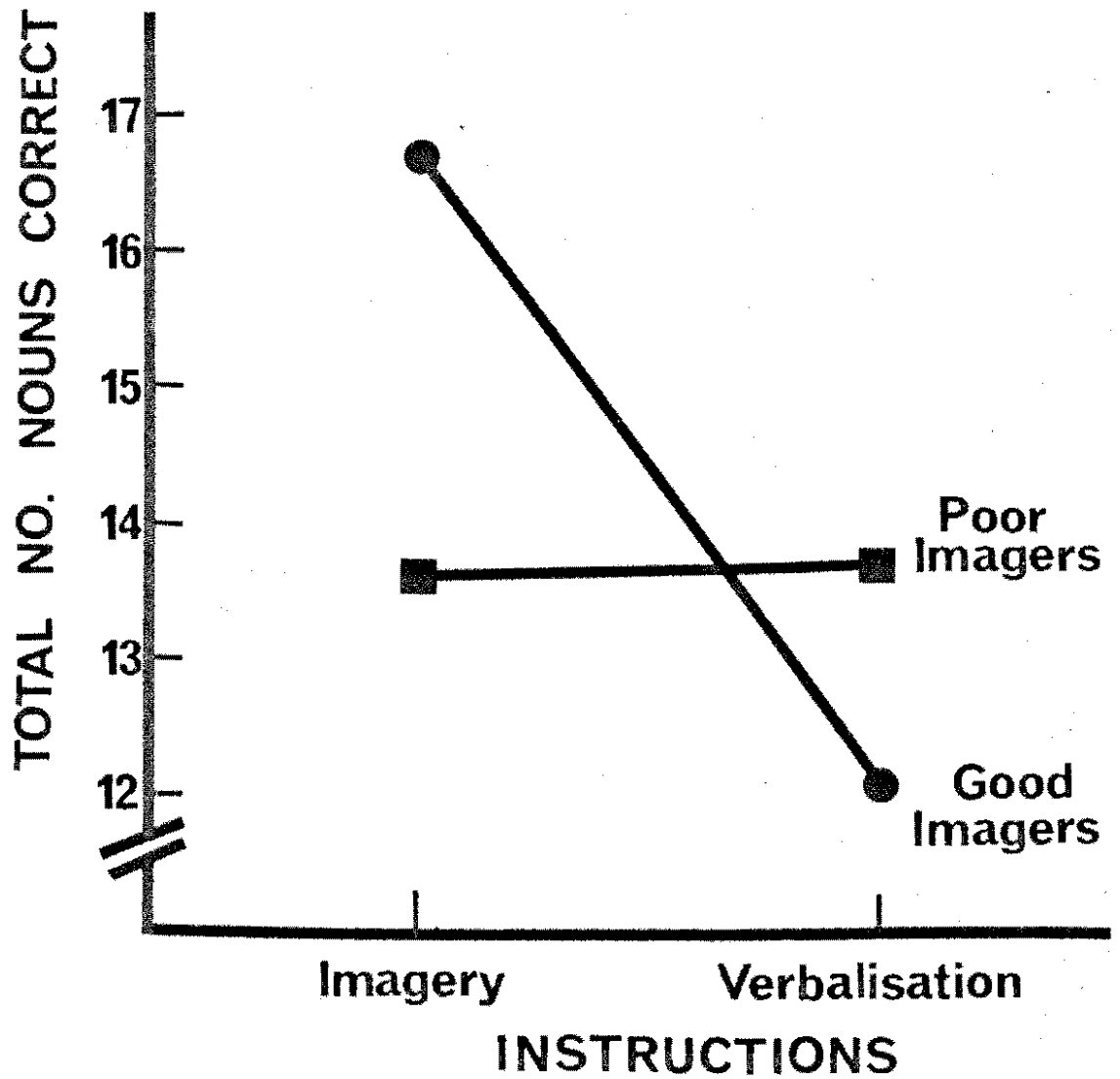


FIGURE 2.1 Mean number of nouns correctly recalled as a function of imagery ability and instructions.

instructed "poor" imagers ( $F(1,36) = 1.68$ ). Thus, on total noun recall, Group 1 > Groups 2, 3 = Group 4.

### 2.2.9 Discussion

In discussions of imagery in the literature, it is often tacitly assumed that the effect of any one manipulation on internal processing is of the same kind as the effect of any other. Paivio (1971), for example, devotes a chapter of his book to experiments involving instructional manipulations, and discusses their effects as if they were entirely comparable with those of the noun concreteness-abstractness manipulation of item imagery.

This experiment, however, raised doubts concerning the mutual consistency of the processes underlying the often similar observable effects of three common imagery manipulations. A surprising number of expectations of interactions, based on assumptions of this kind of consistency, received no confirmation in the data. Although there was an effect for item imagery, it was quite unrelated to the effects of the other two manipulations.

However, the expectation based on an assumption of the mutual consistency of the effects on processing of instructional and imagery ability manipulations - the expectation being that subjects in Group 1 would recall nouns better than subjects in Groups 2, 3, and 4 - was confirmed. This confirmation suggested that instructions to image had their effects by guaranteeing the use of the same process whose operation underlies "good" imagery responses on the Q.M.I.

Assuming that visual imagery was involved in one of the two quite separate effects discussed above, there are two obvious explanations of the results. The first is that visual imagery was the process whose presence/absence underlay the joint effect of instructions and imagery

ability. If this were the case, the failure to find any significant interaction of these factors with item imagery could be taken to suggest that the facilitatory effect of the last manipulation is not due to its arousal/inhibition of imagery processes.

This interpretation poses difficulties for researchers, such as Paivio, who consistently vary noun concreteness-abstractness as an imagery manipulation. To digress for a moment from the experiment's practical purpose of examining the appropriateness of common imagery manipulations, this interpretation also raises questions about the aptness of any theory which is based primarily on data resulting from varying these characteristics of nouns. For example, the duality of coding hypothesis, proposed by Paivio, depends on the tying of concrete and abstract nouns to imaginal and verbal symbolic processes, respectively. If the functional connection between concrete nouns and imagery is dismissed, the notion of duality of coding loses its justification, and it becomes possible to conceive of stimulus coding as being more complex and varied - for instance, as proceeding along a "depth" continuum (cf. Craik and Lockhart, 1972) or as involving any of a large number of mental processes.

The alternative interpretation of the experimental results is that noun concreteness is such a powerful arouser of imagery that it overrides strict instructions to use verbal mediation and that it causes efficient imaginal representation to occur, even in "poor" imagers. This interpretation does not dispel the difficulties posed by the failure to find interactions between imagery ability and instructions, on the one hand, and item imagery on the other. It merely translates the question of the appropriateness of the noun concreteness-abstractness manipulation of imagery into a question of the appropriateness of the other two manipulations. If, under some stimulus conditions, subjects instructed to use an alternative strategy actually generate visual images, the utility of

instructional variation as a manipulation of the presence/absence of imagery is doubtful. And if, with some stimuli, "poor" visual imagers can employ imagery highly effectively, scores on the individual differences instrument used for subject classification do not have much general usefulness as bases for manipulating imagery.

Of these two interpretations, the first appears more plausible. The second interpretation carries the implication that there is something inherent in concrete nouns which dictates that their internal representation be imaginal - that, indeed, as regards his coding and representation of such nouns, the subject is completely stimulus-bound. This implication appears untenable. It presents an unnecessarily simplistic view of cognitive possibilities and ignores the likelihood that subjects differ in capacities or propensities for using particular modes of representation. On the other hand, the first interpretation is quite credible. It takes account of the importance of a subject's own representation-related ability or preference in determining how a stimulus will be dealt with internally.

Because of the considerations above, variation of the imagery value of nouns was abandoned as a visual imagery manipulation for later work, and the joint manipulation based on Q.M.I. scores and instructions was retained for further examination in a second experiment. This was necessary to determine whether or not these two manipulations together are consistent in a second sense - that is, to determine whether or not they serve to arouse/inhibit visual imagery with stimuli other than nouns.

## 2.3 EXPERIMENT II: THE CONSISTENCY OF INSTRUCTIONAL AND INDIVIDUAL DIFFERENCES MANIPULATIONS OF VISUAL IMAGERY ACROSS STIMULUS TYPES

### 2.3.1 Introduction

This experiment examined the effects of manipulations of instructions and imagery ability on the recall of stimuli other than nouns, namely simple line-drawing pictures. Spontaneous reports of quasi-visualisation are most frequently emitted when people are recalling a real external scene or a pictorial or spatial representation. The interaction between the two manipulations remaining of interest was found in relation to the recall of nouns.

There appears to be a functional distinction between the representation of nouns by images of their referents and the imaginal recalling of actually perceived events or pictures. In the former case the meaning of the noun is mediated by the subject's concretely presenting to himself a typical example of its referential universe which may, or may not, be identical with an example he has actually seen; in the latter case, the image is a vehicle of conscious remembrance which, even if it is not strictly accurate, has as its intended "object" an event which has previously been presented to, and interpreted by, the visual perceptual system. As the second instance more frequently underlies reports of quasi-visual experience in non-demand situations, it is of greater general interest.

### 2.3.2 Subjects

The subjects from Experiment I also participated in this experiment. They remained in the same ability x instructions groups. Again, course credit was given for participation.

### 2.3.3 Materials

The stimuli were six simple line drawings which are shown in Figure 2.2. Pilot testing with subjects unclassified on imagery ability had shown that, for the types of recall question to be asked, more than six pictures at a time produced a floor effect.

An attempt was made to have the pictures roughly analogous to the sentences of the previous experiment. Each consisted of a framing object which contained three critical depicted objects, one of which subjects, cued with the name of the framing object, were asked to recall.

Within three of the framing objects, the to-be-recalled depicted objects were arranged from left to right; within the remaining three, they were arranged from top to bottom.

Each picture was drawn onto an unlined systems card with a black felt pen, photographed, and processed as a slide.

### 2.3.4 Recall questions

Two types of recall were tested. The first concerned naming, or describing generally, a depicted object in the top/middle/bottom or left/middle/right position within a given framing object. A subject was asked one such position question about each picture. The second type of recall tested concerned some detail of an object recalled in a particular position. A "position" question had to be answered before a "detail" question was asked. Both types of question were presented orally by the experimenter. They are given in full in Appendix 2a.

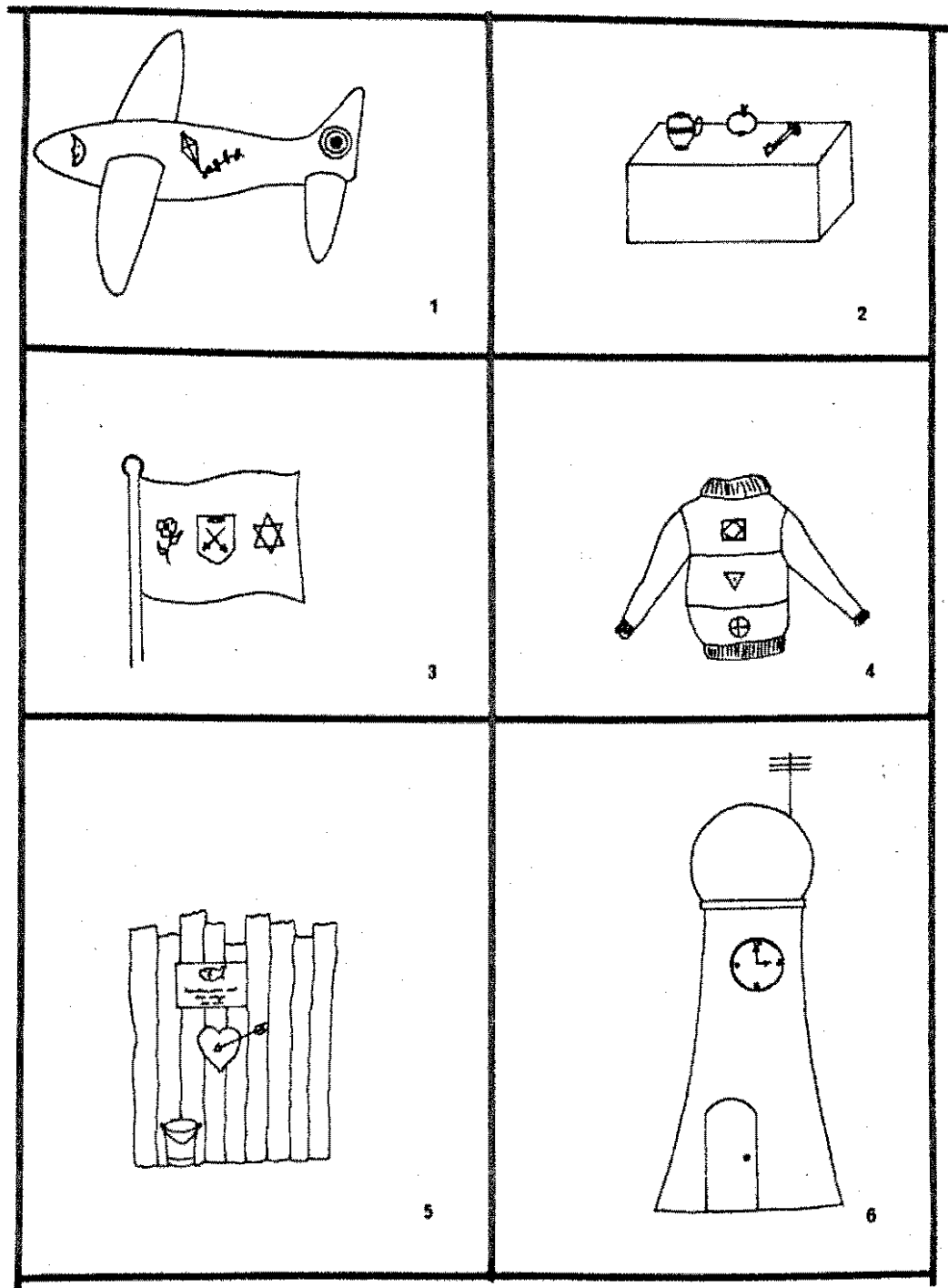


FIGURE 2.2 Stimuli for Experiment II.

### 2.3.5 Apparatus

The apparatus was as for Experiment 1, except for the addition of a tape recorder which was used to record both subjects' responses to the recall questions and responses to questions about their rehearsal strategies which were presented in a brief post-experiment interview.

### 2.3.6 Design and presentation order

There was no item imagery factor in this experiment which used a simple 2 x 2 factorial design, both factors being treated as fixed.

Order of presentation of the pictures was randomised independently for 10 subjects, the same 10 presentation orders then being used for each experimental group.

The positions, within framing objects, of objects asked about in recall were ordered so that each subject in a group of 10 was required to respond to one question concerning each possible object position (left, middle, right; top, middle, bottom), and so that, over 10 subjects, recall questions presented each possible object position at least once in each of the six serial positions.

The orderings of "position" questions were the same for corresponding subjects in each experimental group, and orders of pictures asked about in recall followed presentation order.

### 2.3.7 Instructions

Instructions had to be varied from those given in Experiment 1 to accommodate the different type of stimulus material. A subject was informed of the lengths of the presentation time and of the rehearsal interval, which were the same as for the previous experiment (10 seconds in each case).

Then an imagery-instructed subject was told that, while the picture was on the screen, he should try to learn it in detail, but only by careful visual exploration. He was further instructed that, in the 10-second period after presentation, when the screen was blank, he should hold a mental picture of the stimulus just presented, and should continue exploring this "picture" quasi-visually as his sole means of rehearsal.

After the initial information was given, a verbally-instructed subject was told that, while the picture was on the screen, he should try to learn it in detail by verbally describing it as fully as he could. He was also instructed that, in the 10-second rehearsal period, he should concentrate on repeating his verbal description as his only means of memorising the picture previously presented.

#### 2.3.8 Procedure

Again, subjects were tested individually. After familiarising a subject with the general situation, the experimenter read the appropriate instructions. Then each stimulus was presented for 10 seconds, and was followed by a 10-second rehearsal period before the onset of the next stimulus.

After all six pictures had been displayed, the tape-recorder was turned on, and the subject was asked a "position" question about each (e.g., "Do you remember the flag?-- What was shown at the right of the flag?") If the "position" question was answered correctly a second, "detail" question was asked (e.g., "How many points did the star have?"). The second question was omitted if the subject failed to give the correct answer to the "position" question.

After the recall phase the experimenter reminded the subject of each picture and questioned him about his strategy for rehearsing it.

### 2.3.9 Results

For each of the six pictures, one point was given if the subject correctly named the object in the position indicated. Another point was given for a correct answer to a question about the detail of the object. "Detail" scores were dependent on "position" scores. Therefore, they were converted to percentages.

Table 2.3 shows the mean number of "positions" questions correctly answered (maximum possible, 6), and the "details" percentage scores, for each group. Results for individuals within each experimental group are detailed in Appendix 2b.

TABLE 2.3 Group scores for picture recall.

Group	"Position" Recall	"Detail" Recall (%)
1	4.8	81
2	4.5	76
3	4.7	70
4	4.8	65

The two types of scores were analysed separately. An analysis of variance was run on the "position" recall scores, the factors being imagery ability and instructions. There was no main effect for imagery ability ( $F < 1$ ) or for instructions ( $F < 1$ ) and the interaction between the two factors was not significant ( $F < 1$ ).

The percentage scores for "detail" recall were submitted to arcsin transformation, and a two-factor analysis of variance was run on the transformed scores. Again, there was no effect for imagery ability ( $F(1,36) = 2.08$ ), or for instructions ( $F < 1$ ), and there was no significant interaction ( $F < 1$ ).

#### 2.3.10 Discussion

The failure to replicate with pictures the instructions x ability interaction found with nouns suggests a specificity of effect which creates difficulties concerning the general use of these two manipulations jointly to ensure of the presence/absence of visual imagery.

It could be postulated that the absence of a significant interaction in this experiment was due to the circumstance that objects depicted in the pictorial stimuli could easily be given distinguishing and qualifying verbal labels, and that these were sufficient for the types of recall required of subjects. While this explanation can cope with the finding that both "good" and "poor" imagers with verbal instructions (Groups 2 and 4, respectively) had as good recall as did "good" imagers with imagery instructions, (Group 1), it does not account satisfactorily for the finding that recall for "poor" imagers with imagery instructions (Group 3) was at the same level as that of Group 1 subjects. If the instructions plus ability manipulation had worked in the way expected, Group 3 subjects should have been left virtually without a rehearsal strategy.

In fact, when questioned about rehearsal, only one of the ten imagery-instructed "poor" imagers reported that he was unable to generate an image on any rehearsal occasion. No fewer than six of these subjects reported facility in generating clear images of all pictures. The remaining three reported that they were able to generate such images of some pictures, but not of others. These discrepant reports from

supposedly poor imagers suggest that, whatever "vividness" is, ratings of it are not generally useful as bases for ensuring the presence/absence of visual imagery. Although vividness ratings, together with instructions, seem to be able to predict the effectiveness of a subject's mediation of connections between nouns, they are not predictive of his ability to generate and hold images of pictures, or even of the effectiveness of his imaginal representation of the latter stimuli.

There are two kinds of problems with the Q.M.I. which might explain the inconsistency of the effects of the two manipulations between Experiments I and II. One kind of problem relates to technical shortcomings of the visual section of the scale. The other relates to the employment of ratings on a vividness dimension as bases for manipulating imagery.

The visual section of the Q.M.I. contains only five parts; that is, subjects rate their images only five times. Such brevity does not suggest high reliability. In addition, four of the five parts relate to a single imaged "object", namely a relative. This heavy weighting of a single image has unfortunate implications for the visual section's content validity and, it would seem, for its general predictive validity. Subjects who rate images of persons as unclear may not do so with images of inanimate objects. Yet such subjects would be classified as generally "poor" imagers on the Q.M.I.

There are two separate problems with vividness ratings, as such. One is that, although vividness may well be interpreted by subjects as a salient dimension of visual imagery, it may also be interpreted as a dimension of memory generally (cf. Richardson, 1969). "Vividness" - or "clearness" - which subjects are asked to rate on the Q.M.I., is not necessarily confined to visual imagery. One can have quite a clear and

distinct memory of a person or object, in the sense of possessing a certainty of knowledge of his/its characteristics, without experiencing quasi-visualisation at all. While one of the technical problems of the Q.M.I., its lack of content cover, raises the possibility that some subjects classified as "poor" imagers on its ratings may not be "poor" imagers generally, the problem of the potential applicability of vividness to mental processes other than visual imagery suggests that some Q.M.I. - classified "good" visual imagers may not have vivid visual images at all. There is a distinct possibility that non-imaging subjects could mistake certainty of more abstractly-presented knowledge for the vividness of quasi-visualisation which the visual section of the Q.M.I. attempts to tap.

Even if vividness applied only to visual images, there would remain a problem with using ratings of it as indicators of imagery ability. Asking subjects to rate on this type of criterion is asking them for opinions, rather than facts, about their images. Opinion ratings are highly unreliable even when a single to-be-rated object is publicly available to all raters. When the rated "objects" are variable, and each is available to the conscious awareness of only one rater - as is the case with images - one could conceive that such "objects" of much the same vividness would receive widely different ratings, or that "objects" differing on this dimension would receive the same ratings. In the case of the Q.M.I., the respondent also has to provide his own standards of vividness, and these are likely to differ from the standards of other respondents. For example, "moderately clear and vivid" - which should get a rating of 3 on the Q.M.I. - is likely to mean different things to different people. The subject himself has to decide what sort of mental experience qualifies as "moderately clear and vivid".

From introspective data, it appears that the Q.M.I.'s lack of content cover in its visual section may have contributed to the failure

to find an effect for the imagery manipulations in this experiment. Some subjects who rated their images of relatives low on vividness reported that they were able to generate and hold vivid images of the pictorial stimuli. Whether or not any of the other problems of the scale outlined above also contributed also cannot be determined from the data. However, the problems are real enough and should be recognised, given the failure of the combined manipulation of ability and instructions to produce any effect with pictures, and the introspective data from some subjects contradicting their Q.M.I. classification as generally "poor" imagers.

Two further methodological points deserve mention. One concerns the instruction manipulation. The fact that one imagery-instructed "poor" imager was consistent with his Q.M.I. classification in reporting inability to generate an image of any picture, and that three other subjects from the same group reported difficulty with some pictures suggests that the use of instructions as a sole manipulation of imagery is a rather hit-or-miss affair.

The second point relates to the imageability of pictorial stimuli. A common imagery manipulation is the opposition of pictures and words as experimental stimuli. The idea is that pictures are more-or-less inevitably represented imaginally but that words are not so readily available to the imaginal representational system. This notion received only marginal support from the two experiments described in this chapter.

Six "poor" imagers in the present experiment produced both objective and introspective evidence of having represented the pictures imaginally in order to rehearse them. In the previous experiment the poor recall performance of imagery-instructed "poor" imagers, in relation to that of imagery-instructed "good" imagers, suggested that the former subjects could not effectively represent the verbal stimuli by images. Thus far, the data from the two experiments are in line with the rationale

for the picture-word manipulation of imagery. However, as noted previously, in the present experiment four imagery-instructed "poor" imagers reported either consistent or occasional inability to generate images of the pictures. Taken together, these three items of data indicate that, although imaginal representation of pictures may be more wide-spread than is imaginal representation of words, such representation of pictures is not inevitable (even when instructions to form images are added).

In summary: The failure to find any effect of the two imagery manipulations examined in this experiment led to a reflection on possible problems with them. These were not difficult to find. Unfortunately, the problems were such as to suggest that the dual manipulation which appeared appropriate after the first experiment was not generally useful for studying visual imagery, and that neither manipulation, taken separately, could ensure the presence/absence of imagery.

#### 2.4 GENERAL DISCUSSION: IMPLICATIONS OF EXPERIMENTS I AND II FOR FINDING AN APPROPRIATE MANIPULATION OF VISUAL IMAGERY

In studying visual imagery, we would like to have manipulation which guarantees both its presence and its absence. To understand whether the functions or the nature of the visual image are unique to it, it is necessary that the task performance of subjects using imagery be compared with the task performance of subjects not using it. If such a comparison is not made, it is impossible to determine whether particular aspects of performance are specific to the intervening process of visual imagery, as opposed to their being common to the intervention of a range of representational processes.

From this point of view, the results of the two experiments reported above suggest that none of the three common imagery manipulations examined is generally appropriate. The first experiment demonstrated a lack of mutual consistency among the effects of the manipulations on internal processing. This inconsistency was such as to indicate that either the facilitatory/inhibitory effect of noun concreteness-abstractness, or that of instructions and imagery ability combined, was not mediated by the presence/absence of the process of visual imagery. The implications of an assumption that the presence/absence of visual imagery mediated the effect of noun imagery value are theoretically untenable (see 2.5.10). Thus, it appears that the effect of the manipulation of stimulus attributes along the noun concreteness-abstractness dimension was not due to the stimulus items' imageability/non-imageability and that, therefore, this type of manipulation is not useful in studying visual imagery.

The second experiment showed that the effects of the joint manipulation of instructions and imagery ability, as measured by the Q.M.I., are not consistent across stimulus types. This joint manipulation seemed to work quite well with the verbal stimuli of the first experiment; that is, it appeared there that images of nouns' referents were generated by "good" imagers with imagery instructions, but not by subjects in groups drawn up according to other combinations of ability and instructions. However, it did not work in the same way with pictorial materials, which are of greater interest as stimuli in studying visual imagery as it is normally experienced.

Although the two experiments described in this chapter did not provide encouragement for using any of the manipulations investigated in order to study the nature of visual imagery, consideration of their results did clarify the issue of what type of manipulation is most appropriate for this purpose.

The type of manipulation clearly indicated is one based on individual differences in imagery ability. The experiments' findings, both objective and introspective, made a point which should have been obvious to common sense, namely that it is unrealistically hopeful to vary stimulus attributes and/or instructions in the expectation that these will promote/inhibit the arousal of visual imagery irrespective of the abilities or tendencies of subjects to generate this representational process. The basic factor in the generation or non-generation of images is the subject.

Unfortunately, the second experiment indicated that scores on the individual difference instrument used here, the visual section of the Q.M.I., are not reliable indicators of respondents' abilities or propensities for generating images. However, consideration of possible reasons for the Q.M.I.'s unreliability in this respect indicated what criteria should guide the search for a useful individual differences measure of visual imagery ability. These criteria are discussed in the next chapter, which describes the construction of a new individual differences measure which takes them into account.

## CHAPTER 3

### THE CONSTRUCTION AND EXPERIMENTAL VALIDATION OF A "VISUAL ELABORATION" MEASURE OF INDIVIDUAL DIFFERENCES IN VISUAL IMAGERY

#### 3.1 GENERAL INTRODUCTION

This chapter describes the construction and validation of a new measure of individual differences in visual imagery, which was designed to overcome the problems of the visual section of the Q.M.I. Four of these problems have already been discussed in the previous chapter. They indicate four criteria which should be met by any measure of individual differences in visual imagery ability. These criteria, with one other, and how they were met in the new visual imagery scale, are detailed in the following section.

Prior to the construction of the scale, informal conversations were held with many people concerning their modes of thinking about absent objects or events. So much of interest emerged from these conversations - including the discovery of quite a few persons who claimed not only that they did not usually visualise absent things, but that they *could not* do so, and the discovery of a synaesthetic person - that it was decided to construct a measure which could be administered orally in a structured interview based on specific questions. This allowed for the gaining of more fruitful insights in the initial stages of construction than would have been possible with a pencil and paper test. It also allowed for clarification of the intent of a question to ensure that it meant the same thing to all subjects, and/or for follow-up questions to check that the intended meaning of the question had actually been conveyed.

### 3.2 MEETING THE CRITERIA FOR A USEFUL MEASURE OF INDIVIDUAL DIFFERENCES IN VISUAL IMAGERY

#### 3.2.1 The criteria

A problem with the Q.M.I. which was not noted in the previous chapter is that of inconsistency between what a subject does when responding to this scale, and what he does in other situations. The instructions for the Q.M.I.'s visual section request the subject to form visual images (or to picture "in the mind's eye"). A subject may very well be able to generate visual images, while not necessarily doing so except in a demand situation such as that created by the scale's instructions. There is, then, a potential limitation on the utility of scores on Q.M.I. as bases for an experimental manipulation of imagery. In an experiment which has no instructions regarding representational strategy, even a subject classified as a "good" imager on the Q.M.I. may use an alternative strategy to visual imagery.

Thus, there are five problems with the visual section of the Q.M.I. - the problem noted above, and the four problems discussed in Chapter 2. To recapitulate, the problems are:

- i) Possible inconsistency between what a subject does when responding to the Q.M.I. and what he does in supposed imagery experiments.
- ii) Unreliability due to insufficient length.
- iii) Lack of content coverage.
- iv) The choice of a dimension - "vividness" - which is not necessarily confined to visual imagery.
- v) The requirement that a subject provide his own standard, or metric, for responding, which may differ from that of any other subject.

The new scale was designed to overcome these problems by meeting the following criteria:

- i) Being able to tap the degree to which imaginal representation is spontaneous or habitual for the subject, irrespective of his imagery ability.
- ii) Being of sufficient length to ensure reliability.
- iii) Providing reasonable content coverage.
- iv) Including dimensions particularly relevant to visualisation.
- v) Not requiring the subject to provide a subjective standard for responding.

### 3.2.2 How the criteria were met in the construction of the new scale

#### 3.2.2.1 Capacity for tapping the degree to which imaginal representation is spontaneous or habitual

An attempt to overcome the problem of inconsistency between what a subject does when responding to a self-report scale, and what he does normally, was made in the formulation of instructions for the new scale.

The subject was told that he would be asked to think about absent things which were concrete and tangible. He was *not* asked to try to form visual images. He was further instructed that, after an absent object had been mentioned, he would be given a few seconds to think about it in his *normal* style of thinking; and that, after this period, he would be asked a series of questions, in the form of alternatives, not about the absent object itself, but about the characteristics of his own spontaneous thought about it. It was pointed out that, in asking a series of questions about thoughts on absent objects, the questioner might sometimes be prompting ideas which had not previously occurred to the subject; the subject was instructed to go back to his own original spontaneous thought, and to choose the appropriate alternative with reference to this thought.

It was stressed that there were no right or wrong answers - that the choice of any alternative was totally acceptable and quite common.

#### 3.2.2.2 Sufficient length to ensure reliability

An attempt to produce somewhat greater reliability than is implied by the inclusion of only five items in the visual section of the Q.M.I. was made simply by increasing the number of items to which subjects had to react.

However, a limit was placed on this number by the requirement of the criterion above, which specifies that, if individual differences are to be used as a basis for experimental manipulations of imagery, the instrument used to measure them should tap the degree to which imaginal representation is spontaneous or habitual for the subject. The informal conversations referred to previously revealed that prolonged reference to thought about absent things, which was slanted towards its quasi-visual aspects, led some persons to the belief that they were required to visualise. After some time, quite a few of them accordingly "obliged", even though probing disclosed that they would not normally have visualised the object in question at the time.

Thus, it was decided that, although the number of items in the new scale should exceed five, it should be somewhat restricted. The original form of the scale contained fifteen items.

#### 3.2.2.3 Reasonable content coverage

In the visual section of the Q.M.I. a single imaged "object", a relative, is given virtually the sole weighting. Whether ability to image persons is representative of general imagery ability is an open question.

The original fifteen items of the new scale covered three absent objects. Obviously, three objects do not exhaust the possibilities of an image's content, but they were selected to be representative in that they

covered:

- i) a) inanimate things and,  
b) persons.
- ii) a) highly specified things (the front of a particular house), as well as,  
b) less highly specified things (e.g., a box and a cup on a table).

#### 3.2.2.4 Choice of dimensions particularly relevant to visualisation

As noted previously "vividness" is not a good dimension on which to base a measure of individual differences in visual imagery because it may also apply to other modes of recall.

To ensure that a scale is measuring differences in quasi-visualisation of absent objects, and not differences in other types of recall, it is necessary to formulate items which relate specifically to visual experience. Therefore, the items of the new scale were visual-type items, that is, items relating to aspects of subjective experience which are relevant when one is actually looking at an object. They covered such fields as details of colour, texture and shape, figure-ground relationships, subjective distance and direction from the object, and visual organisation within either figure or ground. The initial set of items is presented below (3.3). The scale's overall aim was to assess the degree of a subject's visual-type elaboration in his normal thought about absent objects. Thus, the scale is referred to henceforth as the "Visual Elaboration Scale" (V.E.S.).

#### 3.2.2.5 Removal of the necessity for the subject to provide a subjective standard for responding

Again, it was noted in Chapter 2 that the Q.M.I., in using vividness ratings to measure individual differences in imagery ability,

requires the subject to give opinions rather than facts; in doing so, it also requires him to provide his own metric. It is highly unlikely, for example, that standards of what is "moderately clear and vivid" are invariant across subjects.

The V.E.S. was designed to tap facts, rather than opinions, concerning a subject's thought about absent objects. That is, the subject was not asked to locate his image along a nebulous dimension such as "vividness", but was required to choose between concrete, factual alternatives. For example, after a subject was asked to think about the front of a particular, familiar house, one set of alternatives offered was, "In your thought, were you clearly aware of the colours of the front of the house? Or wasn't colour really relevant until I mentioned it?" This kind of item is simple and unambiguous, or can easily be made so in an oral presentation. The subject merely has to choose the alternative which corresponds with his own thought.

The five criteria above guided the construction of the scale and the formulation of instructions to subjects. The format of the instructions has already been detailed. The original form of the scale itself is presented below. For each item, choice of the first alternative represents the visual elaboration response.

### 3.3 THE ORIGINAL FORM OF THE VISUAL ELABORATION SCALE

1. *Think about the front of a particular familiar house - that is, the side where the entrance is.*

a) In your thought, were you aware of being to the left, to the right, or directly in line with the front door? Or wasn't your direction from the front door relevant until I mentioned it?

b) Were you aware of being close to, or at a distance from the front of the house? Or wasn't your distance from it relevant in your thought?

c) While thinking about the front of the house, were you aware of anything other than the house itself? Or was the house itself the only object of your thought?

d) In your thought, were you clearly aware of the colours of the front of the house? Or wasn't colour really relevant until I mentioned it?

e) Was the house firmly fixed in its usual setting? Or was it detached from any setting? Or wasn't it there in a physical-type way at all?

2. *Think of a box and a cup on a table.*

a) Describe the *particular* spot on the table occupied by the box. Or didn't you originally allocate it a particular spot?

b) Where was the cup relative to the box? Or didn't you think of the cup's position in relation to the box?

c) Were you aware of the shape of the table? Or wasn't this relevant until I mentioned it?

d) Could you describe the cup you thought of in detail? Or was it an anonymous or abstract cup?

e) Were you aware of the nature of the table's surface? Or wasn't this detail important I mentioned it?

3. *Think of a relative whom you know well.*

a) In your thought did it seem as if you were near to (or far from) your relative in physical distance? Or wasn't your physical distance from your relative relevant, as it is when you look at me now?

b) Were you aware of any specific article of clothing that your relative was wearing? Or wasn't this type of detail included in your thought?

c) Were you aware of any specific background to, or specific location of your relative? Or was your thought of him/her alone?

d) Were you aware of enough of the relative to be able to say that he/she had a special position or posture, for example, standing, sitting, or kneeling? Or wasn't position or posture registered in your original thought?

e) In your thought, were you aware of being to the left, to the right, or directly in line with your relative? Or wasn't your direction from him/her relevant in the way it's relevant when you look at me now?

Scoring was done in a simple dichotomous fashion. For each item a point was given if a subject chose the alternative designated as the "visual elaboration" alternative, and no point if he chose the alternative designated as the "non-elaboration" alternative. The points scored by a subject were summed to produce a total within the range 0-15.

### 3.4 ADMINISTRATION OF THE ORIGINAL FORM OF THE VISUAL ELABORATION SCALE

#### 3.4.1 Aims of the first administration

The principal aim of this administration was to sift items according to whether or not they met two basic criteria of usefulness for present purposes. Failure of an item to meet these fundamental criteria would mean that there would be no point in persisting with it in a later administration whose results were to be submitted to more detailed analyses.

The two criteria employed for evaluating items in the first instance were:

i) Significance of their contributions to the total scale score. One major aim of the scale was to index the presence/absence of a *single* internal process, visual imagery. If an item did not contribute to the total score, it could reasonably be thought to be tapping something different from that which was tapped by all items which did contribute in this way.

ii) Their power of discriminating among subjects. A second major aim of the scale was to assess individual differences in the ability/tendency to generate visual images. Obviously any item which did not discriminate among persons would not be worth its place. A basic measure of an item's discriminating power can be provided by the percentage of persons who respond to it in a "visually elaborated" or in a "visually unelaborated" way. If all subjects were to react in either manner to an item, it could not be said to discriminate persons who can and do recall absent objects in a quasi-visual way from those who cannot and/or do not do so.

#### 3.4.2 Subjects

Forty persons from within the Australian National University were requested to act as subjects. They included undergraduate and post-graduate students, technical, support and office staff members, and academic staff members. No extrinsic reward was offered for participation.

#### 3.4.3 Procedure

The scale was administered orally to each subject individually. After detailing the instructions along the lines set out under 3.2.1, the questioner named the first absent object and allowed the subject approximately five seconds to think about it. She then proceeded with the five items relating to this object. This procedure was adopted for both subsequent objects. Any item which was not understood by the subject was

clarified. "Visual elaboration" responses were followed by requests for details, allowing for a check on the subject's understanding of the item's intent. "Non-elaboration" responses were also checked.

#### 3.4.4 Results

The contribution of an item to the total score was assessed by computing an item-total point biserial correlation coefficient. The level of significance set for the retention of an item was .03.

The percentage limits outside which an item was taken to be a non-discriminator were 80%-20%. Any item responded to in the "visual elaboration" way by more than 80%, or by less than 20% of subjects was to be discarded.

Table 3.1 presents the item-total point biserial correlation coefficients ( $r_{pbi: I-T}$ ) and corresponding  $z$  scores, together with the percentage of subjects who chose the "visual elaboration" alternatives for each item.

It can be seen from the table that items 1c and 2d did not correlate significantly with the total score, and that items 1b, 2b and 3c neither correlated significantly with the total score, nor lay within the designated percentage response limits.

### 3.5 THE SECOND FORM OF THE SCALE

Those items which did not meet the two basic criteria for retention after the administration of the first form of the V.E.S. were discarded, leaving only ten items. This number of items was thought to be insufficient for purposes of reliability and fine discrimination among subjects. Therefore, more items were added to the ten surviving items, and the resulting second form was administered to a new sample of subjects.

TABLE 3.1 Point biserial item-total correlations and percentage of "visual elaboration" responses for each item.

Object	Item	$r_{pbi: I-T}$	$z$	% "visual elaboration" responses
1	a	.3597	2.28*	72.5
	b	.2471	1.56	85
	c	.2933	1.86	45
	d	.3633	2.30*	65
	e	.4849	3.97*	80
2	a	.5558	3.52*	47.5
	b	.2994	1.89	85
	c	.4557	2.88*	60
	d	.2902	1.84	75
	e	.5558	3.52*	47.5
3	a	.5076	3.21*	32.5
	b	.4732	2.99*	30
	c	.2323	1.47	7.5
	d	.4960	3.14*	65
	e	.3472	2.20*	80

\* Significant at, or beyond, the .03 level.

Ten new items were added to the ten remaining from the first form of the scale. The previous form's discarded items were replaced by five new items, each relating to the same object as did the discarded one whose place it took. In addition, another absent object was included (4, below) and five items relating to it were composed.

The revised scale is presented below. The items asterisked are new:

1. *Think of the front of a particular familiar house - that is, the side where the entrance is.*

a) In your thought, were you aware of being to the left, to the right, or directly in line with the front door? Or wasn't your direction from the front door relevant until I mentioned it?

b) Were you clearly aware of the colours of the front of the house? Or wasn't colour really relevant until I mentioned it?

\*c) Did your thought register any specific features of the house other than colour? Or was your thought a more general or abstract idea of a house, not including other specific features?

d) Was the house firmly fixed in its usual setting? Or was it detached from any setting? Or wasn't it really there in a physical-type way at all?

\*e) Can you imagine yourself moving closer to, or further from the house, from the spot from which you first thought about it? Or doesn't the idea of you yourself moving really apply to your style of thinking about the house?

2. *Think of a box and a cup on a table.*

a) Describe the *particular* spot on the table occupied by the box. Or didn't you originally allocate it a particular spot?

\*b) How high off the ground was the table top? Or wasn't this information registered in your own thought?

c) Were you aware of the shape of the table? Or wasn't this relevant until I mentioned it?

\*d) Was the cup one you recognised as familiar? Or was it an anonymous or abstract cup?

e) Were you aware of the nature of the table's surface? Or wasn't this detail important until I mentioned it?

3. *Think of a relative whom you know well.*

a) In your thought, did it seem as if you were near to (or far from) your relative in physical distance? Or wasn't your physical distance from your relative relevant, as it is when you look at me now?

b) Were you aware of any specific article of clothing that your relative was wearing? Or wasn't this type of detail included in your thought?

\*c) Did your thought register specific facial features of your relative? Or was it a general or "mood" idea only of his/her face?

d) Were you aware of enough of the relative to be able to say that he/she had a special position or posture, for example, standing, sitting, or kneeling? Or wasn't position or posture registered in your original thought?

e) In your thought were you aware of being to the left, to the right, or directly in line with your relative? Or wasn't your direction from him/her relevant in the way it's relevant when you look at me now?

4. *Think of an animal skin hanging on a wall.*

\*a) Describe the wall on which the skin was hanging. Or weren't specific details of the wall relevant until I mentioned it?

\*b) Was the skin a long-haired or a short-haired one? Or didn't your thought register this?

\*c) Were you aware of how high on the wall the skin was hanging? Or wasn't this relevant in your thought?

\*d) Did your thought register the precise shape of the skin? Or wasn't its outline clearly defined?

\*e) In your thought did it seem as if the centre of the skin had a position in relation to your own eye level? Or wasn't your eye level in relation to the skin relevant?

### 3.6 ADMINISTRATION OF THE SECOND FORM OF THE VISUAL ELABORATION SCALE

#### 3.6.1 Aims of the administration

In anticipation that this time enough items would pass the basic screening tests used previously, further, more rigorous, analyses were planned to ascertain whether or not the scale was ready for use in experimental work. These analyses were:

- i) The determination of each item's capacity to discriminate among subjects differing on visual imagery ability. This was done by a simple rank ordering of proportions of subjects one standard deviation or more below the mean total score, between one standard deviation below and one standard deviation above the mean, and one standard deviation or more above the mean, who responded to each item by choosing the "visual elaboration" alternative. If an item, though contributing to the total score and lying within acceptable percentage limits, had its "visual elaboration" alternative chosen by equal proportions of persons very low,

in the middle, and very high on total scale scores, it could not be said to be an effective discriminator among different classes of subjects.

- ii) The determination of whether or not the items are ordered. In a unidimensional scale items should be ordered to ensure variation in subjects' scores. In the case of the present scale an ordering of items would be indicated if there were a correlation between the number of subjects choosing an item's "visual elaboration" alternative and the mean total score of subjects making this choice, such that the more persons there were responding to an item by choosing its "visual elaboration" alternative the less was the mean total score of the group making this choice or, conversely, the fewer persons there were choosing an item's "visual elaboration" alternative the greater was their mean total score.
- iii) The computation of Kuder-Richardson reliability.

### 3.6.2 Subjects

Fifty students from a first year psychology course acted as subjects. Course credit was given for their participation.

### 3.6.3 Procedure

The V.E.S. was administered in the same way as previously.

### 3.6.4 Results

The mean "visual elaboration" score was 12.30, with a standard deviation of 4.25. Table 3.2 presents data indicating whether or not each item met the two basic criteria employed in screening items on the initial form of the scale.

To enable easy comparison of data on items remaining from the scale's first form with comparable data from the initial administration (in Table 3.1), their previous item codes are included in parentheses.

**TABLE 3.2** Point biserial item-total correlations and percentage of "visual elaboration" responses for each item in revised scale.

Object	Item	$r_{pbi: I-T}$	$z$	% "visual elaboration" responses
1	a(1a)	.3665	2.59*	76
	b(1d)	.3475	2.46*	68
	c(new)	.4574	3.23*	68
	d(1e)	.5192	3.67*	76
	e(new)	.5504	3.89*	58
2	a(2a)	.6441	4.56*	54
	b(new)	.7359	5.20*	44
	c(2c)	.6305	4.46*	66
	d(new)	.2658	1.88*	62
	e(2e)	.3559	2.52*	42
3	a(3a)	.6187	4.38*	34
	b(3b)	.3410	2.41*	26
	c(new)	.3914	2.77*	70
	d(3d)	.4578	3.24*	62
	e(3e)	.5032	3.56*	70
4	a(new)	.5481	3.88*	44
	b(new)	.2530	1.79*	94
	c(new)	.4578	3.24*	62
	d(new)	.3262	2.31*	80
	e(new)	.2963	2.09	74

\* Significant at, or beyond, the .03 level.

Only three items failed to meet the basic criteria. Items 2d and 4e did not correlate significantly with the total score, and item 4b neither correlated significantly with this score, nor lay within acceptable percentage limits.

The proportions of subjects one standard deviation or more below the mean total score, between one standard deviation below and one standard deviation above the mean, and one standard deviation or more above the mean, who responded to each item by choosing its "visual elaboration" alternative are presented in Table 3.3. The score ranges of these groups of subjects are, respectively, 4-8, 9-16, and 17-20.

Table 3.3 shows that the only proportions not ordered in correspondence with low, medium, and high total scores were for items 4d and 4e. A higher proportion of persons in the low score group than of persons in the middle score group chose the "visual elaboration" alternatives of these items.

The number of subjects answering each item in the "visual elaboration" way, and the average total score of these subject groups are detailed in Table 3.4. Both sets of data were ranked and Spearman's rank order correlation coefficient was computed. The resulting  $\rho$  was  $-.8695$  which, with a  $N$  of 50, yields a probability of much less than .01. Thus, in general, the smaller the number of persons responding to an item in the "visual elaboration" manner, the greater was that group of persons' mean total score. This means that the items are ordered, and that on the whole, the scale permits relatively fine distinctions among subjects such that they can be represented by a gradation along a "visual elaboration" dimension.

TABLE 3.3 Proportions of subjects 1 s.d. or more below, 1 s.d. below to 1 s.d. above, and 1 s.d. or more above the mean total score choosing "visual elaboration" alternative on each item.

Object	Item	1 s.d. or more below*	1 s.d. below to 1 s.d. above**	1 s.d. or more above***
1	a	.636	.667	1.000
	b	.455	.583	1.000
	c	.455	.583	1.000
	d	.455	.750	1.000
	e	.182	.542	.933
2	a	.091	.458	1.000
	b	.000	.333	.933
	c	.091	.708	1.000
	d	.364	.667	.733
	e	.273	.333	.667
3	a	.000	.250	.733
	b	.000	.292	.400
	c	.273	.792	.867
	d	.455	.500	.933
	e	.455	.667	.933
4	a	.182	.292	.867
	b	.909	.917	1.000
	c	.455	.500	.933
	d	.727	.708	1.000
	e	.836	.708	.867

\* N = 11; \*\* N = 24; \*\*\* N = 15.

TABLE 3.4 Numbers, with ranks, of subjects choosing the "visual elaboration" alternative for each item, and mean total scores, with ranks, of subjects so choosing on each item.

Object	Item	No. "visual elaboration" responses	Rank	Mean of group with "visual elaboration" responses	Rank
1	a	38	3.5	13.18	17
	b	34	8.5	13.32	15
	c	34	8.5	13.65	12
	d	38	3.5	13.55	13
	e	29	14	14.31	6
2	a	27	15	14.85	4
	b	22	16.5	15.86	2
	c	33	10	14.24	7
	d	31	12	13.19	16
	e	21	18	14.09	8
3	a	17	19	16.00	1
	b	13	20	14.76	5
	c	35	6.5	13.40	14
	d	31	12	13.84	9.5
	e	35	6.5	13.71	11
4	a	22	16.5	14.95	3
	b	47	1	12.57	20
	c	31	12	13.84	9.5
	d	40	2	13.00	19
	e	37	5	13.05	18

Kuder-Richardson reliability, computed by the K.R. 20 formula, was .7826.

### 3.6.5 Discussion

The results of the administration of the second form of the scale suggested that, with the omission of a few items, an acceptable final form could be produced. The scale as a whole had quite high Kuder-Richardson reliability. In addition, the scale items were strongly ordered, as was indicated by the high negative correlation between numbers of subjects choosing the "visual elaboration" alternatives of items, and the mean total scores of the groups so choosing.

Most of the twenty items met all item criteria set down, in that they contributed significantly to the total score, lay within acceptable percentage response limits, and were responded to "visually" by proportions of persons ordered in correspondence with low, medium and high total scores. However, some items failed on these criteria. Items 2d and 4e did not contribute significantly to the total score, and item 4b neither contributed to this score, nor lay within acceptable percentage response limits (see Table 3.2). Items 4d and 4e were responded to by a higher proportion of persons low on total scores than the proportion of persons medium on these scores (Table 3.3), suggesting that these items had little capacity to discriminate among different classes of respondents. All these items (2d, 4b, 4d and 4e) were deleted from the scale. Item 1a, though meeting all pre-determined item criteria, was responded to in a "visually elaborated" way by more than half the subjects who were one standard deviation or more below the mean total score (Table 3.3). Therefore, it was discarded also, and the scale was left with fifteen items (1b, 1c, 1d, 1e; 2a, 2b, 2c, 2e; 3a, 3b, 3c, 3d, 3e; 4a, 4c).

The fifteen items remaining were accepted as a final form of the scale, subject to experimental validation. Unfortunately, from the standpoint of tidiness and symmetry, these items were unequally distributed over objects. Four related to the house, four to the box and the cup on the table, five to the relative, and two to the animal skin on the wall. However, a lack of tidiness did not seem to be a sufficient reason for rejecting a scale whose items had passed stringent tests of utility for present purposes.

The average score of the fifty subjects on the final fifteen-item scale was 8.44, with a standard deviation of 3.75. This scale's Kuder-Richardson (K.R. 20) reliability coefficient was .7750.

### 3.7 EXPERIMENT III: VALIDATION OF THE VISUAL ELABORATION SCALE

#### 3.7.1 Introduction

The final form of the V.E.S. appeared both internally coherent and capable of discriminating among subjects in a logical and consistent fashion. However, although the scale's items were deliberately designed as "visual" items, there was, as yet, no evidence that the mental event whose presence/absence determined subjects' choices of alternatives was quasi-visualisation, as opposed to some other form of concrete thinking. Before the new scale could legitimately be used to examine questions concerning the perceptual nature of quasi-visual mental processes, its relationship to these processes required confirmation. This relationship was examined in the present experiment.

The experiment was a partial replication of Experiment II, the picture memory experiment described in Chapter 2. Pictures were chosen as stimuli in the validation study as the interest of the research was in

normal memory images which, as remarked earlier, mostly have as "contents" previously perceived objects or spatial representations.

The principal difference between the present experiment and Experiment II was that here subject classification was done on the basis of scores on the V.E.S., instead of scores on the visual section of the Q.M.I. Another difference was that only "position" questions were asked in this experiment (e.g., "What was shown in the middle of the flag?"). This was because of the extremely small numbers which were involved in scores for "detail" questions in Experiment II.

It will be recalled that in Experiment II subjects' imagery ability and instructions were varied simultaneously. This was also the case here. Although it was not intended that an instruction manipulation would be employed subsequently, such a manipulation was necessary in the validation exercise.

The construct validity of the V.E.S. would be demonstrated if subjects who were classified as "poor" imagers, and who were given imagery instructions, had poorer recall than subjects in other ability x instructions groups. If it is the ability and propensity for mental visualisation which underlies "visual elaboration" responses, imagery-instructed subjects classified as "good" imagers on the basis of such responses should be able to obey their instructions to visualise the pictures in order to rehearse them; these subjects, therefore, should recall objects depicted in specified positions quite well. And Experiment II indicated that verbal labelling of objects depicted in the pictures was quite effective for the type of recall required, the objects in question being quite distinctive. Therefore, irrespective of their ability to visualise, subjects with instructions to rehearse only verbally could be expected to display quite good recall. But if subjects classified by the scale as "poor" imagers were genuinely lacking in ability and/or practice in visualising absent objects,

instructions to do this should leave them with no effective memorising strategy.

### 3.7.2 Subjects

The V.E.S. was administered individually to 112 persons, who replied to notice-board requests for subjects. The mean scale score of this group was 8.30 (s.d., 3.44). Twenty subjects (10 male, 10 female) with scores ( $\leq 5$ ) in the bottom quartile of scores, and 20 (10 male, 10 female) with scores ( $\geq 12$ ) in the top quartile were requested to participate in a memory experiment. The mean score of the former group was 3.60, of the latter group, 12.80. The mean in each case was approximately one standard deviation from the mean of the original group of subjects to whom the scale was administered.

Subjects were paid \$2.00 for their participation.

The two ability groups were sub-divided into two instruction groups, these groups, in each case, being matched for sex and for V.E.S. scores. The groups were as for Experiment II, *viz.*:

Group 1: "Good" imagers (mean scale score, 12.70) with imagery instructions.

Group 2: "Good" imagers (12.90) with verbalisation instructions.

Group 3: "Poor" imagers (3.60) with imagery instructions.

Group 4: "Poor" imagers (3.60) with verbalisation instructions.

### 3.7.3 Materials, apparatus, design and presentation order, instructions and procedure

Except for the omission of "detail" questions about depicted objects, these features of the present experiment were as for Experiment II.

### 3.7.4 Results

The mean recall score, over all subjects, on the six pictures was 3.70 (s.d., 1.44). The mean scores of Groups 1, 2, 3 and 4 were, respectively, 4.10, 4.30, 2.00, and 4.40. Scores for individuals within each group are detailed in Appendix 3.

An analysis of variance was run on recall scores, the factors being imagery ability, as gauged by the V.E.S., and instructions. The results are presented in Table 3.5.

TABLE 3.5 Analysis of variance for the effects of imagery ability and instructions on "position" recall.

Source	SS	df	MS	F	p
Imagery Ability (A)	10.00	1	10.00	8.70	<.01
Instructional Set (S)	16.90	1	16.90	14.70	<.01
A x S	12.10	1	12.10	10.52	<.01
Within cell	41.40	36	1.15		

*A posteriori* tests of the differences between group means (Winer, 1970, p. 238), indicated that both main effects were due solely to the poor performance of Group 3 subjects. A test of the effect of imagery ability on verbal instructions (Group 2 *vs* Group 4) produced a non-significant result ( $F < 1$ ), and a test of the effect of instructions at the level of high ability (Group 1 *vs* Group 2) produced a similarly non-significant result ( $F < 1$ ). However, tests of the effects of imagery

ability on imagery instructions (Group 1 vs Group 3) and of instructions at the level of low ability (Group 4 vs Group 3) produced highly significant results (respectively,  $F(1,36) = 19.17$ ;  $F(1,36) = 25.04$ ). In summary, on recall scores, Group 3 < Groups 1, 4 = Group 2. Thus, imagery-instructed subjects classified as "poor" imagers by the V.E.S. were, indeed, significantly inferior in recall to subjects in other ability x instructions groups.

### 3.7.5 Discussion

The results above were very different from those obtained when subjects were classified on imagery ability on the visual section of the Q.M.I. Those classified as "poor" imagers here behaved as one would expect such persons to behave when given imagery instructions. That is, the poor recall performance of Group 3 subjects suggested that they had a genuine difficulty in representing the pictures consciously by visual imagery.

That this difficulty existed was further underlined by the taped introspective reports. Nine of the ten imagery-instructed "poor" imagers reported that it was virtually impossible for them to obey their instructions, though they had tried hard to do so throughout the presentation-rehearsal period. One reported that he could obey them, "sort of" (i.e., after a fashion), but he was not very convincing. Portions of transcripts from tapes of four subjects in Group 3 are presented below.

*Subject 1.* Female - Scale score 3. Recall score 1.

*S:* (When reminded of instructions at end of question period):

It was very difficult.

*E:* When the picture was off the screen, were you able to hold the image at all?

*S:* No, I'd forget half of it (the picture) straight away, more or less, I think.

*Subject 5.* Female - Scale score 5. Recall score 2.

*S:* (When reminded of instructions at end):

I don't remember that way.

*E:* Could you hold an image after the picture went off the screen?

*S:* No, I couldn't do it. I try to remember by words, you know.

*Subject 9.* Male - Scale score 4. Recall score 2.

*S:* (When asked how he found the rehearsal strategy):

Not quite natural . . .

*Subject 10.* Male - Scale score 3. Recall score 2.

*S:* (Spontaneous comment during recall questioning, after having failed to answer two successive questions): See, this is where I've done it wrong (*sic*) because I haven't got a picture in the first place, so I can't look back to a picture, and because when the things were on there (the screen), I wasn't saying them, so (*sic*) I haven't got a word either. So I haven't got anything from it . . .  
(Post-experiment interview).

*E:* That was a normal strategy for you?

*S:* Just making me look like a complete idiot . . . (Pacifying noises by E) . . . I know I *could* remember them.

*E:* How would you?

*S:* I'd tell myself what it was.

These reports suggest that the subjects in Group 3 were not so much "poor" imagers as "non-imagers". In contrast, none of the Group 1 subjects reported any difficulty or strangeness in employing visual imagery as a rehearsal strategy. They indicated that they would normally visualise if they wanted to memorise something they had seen only briefly, though

some added that they would also label objects verbally in a more natural situation.

There is a possibility that the poor performance of Group 3 subjects was affected by experimenter expectation. The effect of this variable is not entirely unknown in imagery experiments, as is plain from Neisser's (1972) discussion of a study by Sheehan and Neisser (1969). However, although the prior grouping of subjects for this experiment necessitated the experimenter's knowing their V.E.S. scores, the possibility of the subjects' detecting the meaning of subtle cues communicated on the basis of this knowledge was remote. The subjects in this experiment were not in the same situation as the subjects in the Sheehan and Neisser study, who had previously rated their images on an explicit imagery scale (the Q.M.I.) and so knew whether they were "good" or "poor" imagers. The present subjects responded to a scale known to them only as a "thinking" scale. They were also informed that any choice of an alternative was quite usual. They had little reason, then, to believe that they were different from other subjects, let alone that they were "non-imagers" (or "good" imagers). Thus, it would have been difficult for them to interpret unconscious cues from the experimenter as to how they should perform under imagery instructions, even if such cues existed. To put the matter beyond doubt, however, the next experiment (Chapter 5) was run "blind", and still found differences in performance corresponding with V.E.S. score differences.

A final point which should be noted because of its relevance to later discussion is that, with the pictures used in this experiment, there was no absolute recall advantage in the employment of visual imagery; the recall of both groups with verbal instructions was just as good as that of imagery-instructed "good" imagers. The reason for this has already been suggested - namely, that the objects in the pictures could easily

be distinguished from each other by verbal labels. As the set of pictured objects was highly heterogeneous, simple verbal labels provided sufficient descriptions of the objects depicted in the pictures.

This experiment demonstrates that V.E.S. scores are accurate indicators of the ability and propensity for the visualisation of absent objects, the study of the nature of which process was the original aim of the research of the thesis. Therefore, classification of subjects on these scores was used as the sole basis for manipulating imagery in experimental work on the question of the perceptual nature of the visual image. This question is examined in Part III, which follows.

PART III

VISUAL IMAGERY AND VISUAL PERCEPTION

## CHAPTER 4

### THE LITERATURE ON THE RELATIONSHIP BETWEEN VISUAL IMAGERY AND VISUAL PERCEPTION

#### 4.1 GENERAL INTRODUCTION

It was noted in Chapter 1 that explicit discussion and study of the nature of visual imagery have been relatively infrequent in contemporary cognitive psychology. However, it is evident from the very use of the term "visual imagery" that there is a widely held assumption about the nature of the mental phenomenon to which it refers, namely that this phenomenon has some connection with the visual sensory modality. Some few contemporary students of imagery have refused to accept this assumption as fact, and have treated it as itself meriting investigation.

There are several different ways of posing the question of the relationship between visual imagery and visual perception. This chapter outlines and discusses the principal approaches to this question, both theoretical and empirical.

#### 4.2 THEORETICAL DISCUSSIONS

##### 4.2.1 Hebb's view of visual memory imagery as a short-circuited perceptual process

Hebb (1968) explains the occurrence of visual images in terms of the same neurophysiological mechanisms which he invokes to account for visual perception. He sees the normal processes of visual perception as involving the activation of three different kinds of cell-assemblies, *viz.*:

- i) First-order (or primary) assemblies which directly register sensory stimulation. This registering of sensory data is highly reliable and so renders the percept clear and detailed.
- ii) Second-order assemblies, each of which is excited by the activity of a particular group of first-order assemblies. At this level there is some degree of generalisation and abstraction which enables the perception of an object as a unified whole, but only in a particular orientation.
- iii) Third-order (or superordinate) assemblies, which are excited by second-order assemblies. Here there is considerable abstraction from the original sensory information. Activation of third-order assemblies enables the perception of an object as such, regardless of its orientation.

Hebb asserts that images arise from use of the perceptual mechanisms. He relates the various types of visual imagery (hallucinatory, eidetic, *etcetera*) to the activation of the different orders of cell assemblies involved in visual perception. Ordinary memory imagery is seen as a short-circuited perceptual process involving only the two higher orders of assemblies. It is because abstraction is involved at both these levels that the visual memory image lacks the clarity and detail of the percept.

This account is, of course, entirely speculative with respect to both visual perception and visual imagery. As an account of visual imagery its main weakness is its failure to tell us what it is that, in visual imagery, excites the second-order assemblies in the absence of activation in the first-order assemblies. Explanation at the neuro-physiological level cannot afford to omit this type of detail which, of

course, becomes irrelevant at less ambitious, more molar levels of explanation.

#### 4.2.2 Konorski's gnostic units theory

Konorski's (1967) account of the relationship between visual imagery and visual perception is also neurophysiological, and is not totally dissimilar to Hebb's. Konorski sees visual perception occurring as the result of the activation of gnostic units in concomitance with the activation of corresponding projective units. Visual imagery occurs when the gnostic units are activated in the absence of activation in the projective units.

Like Hebb's account, Konorski's theory is highly speculative. However, Konorski does make an attempt to explain how the gnostic units, which are excited by activity in the projective units in perception, can be excited without activation of the latter units in visual imagery. The explanation is in terms of classical conditioning. According to Konorski, some emotional state is associated with each perceptual act. This emotional state subsequently serves as a conditioned stimulus that, when aroused, activates the same gnostic units which were activated in the perceptual act with which it was originally associated. Thus, something of the same perceptual experience returns.

There are problems with positing that emotional states are connected with perception and that they subsequently lead to the arousal of specific images. Despite Konorski's assumption to the contrary, many acts of perception are emotionally neutral. It is doubtful that emotional neutrality precludes a percept from being recalled as an image. Even in a case in which an emotion has been associated with perceptual activity, it is difficult to see how the subsequent arousal of the emotion could give rise to activity only in a particular group of gnostic units. Any given

emotion is likely to be associated with numerous acts of perception. This being the case, a logical implication of Konorski's view is that the arousal of a particular emotion should simultaneously give rise to a confused plethora of quite different images. Though memory images may sometimes be experienced as confused, this is not always, or even typically, the case.

#### 4.2.3 Neisser's definitional solution to the problem of the relationship between visual imagery and visual perception

Neisser's approach to the question of the perceptual nature of imagery has changed appreciably since he first discussed it in 1967. In his well-known book of that year, he described visual perception as a process involving the active and constructive synthesis of successive "retinal snapshots". The visual image, which he defined as,

"... something *seen* somewhat in the way real objects are seen, when little or nothing in the immediate environment appears to justify it" (Neisser, 1967, p. 146),

was also interpreted as a process of visual synthesis similar to visual perception. Here Neisser defined imagery in terms of a particular kind of subjective experience.

Later, however, a review of the frequent failure of researchers to relate individual differences in vividness of subjective visualisation to differences in performance on experimental tasks led Neisser (1970) to distinguish between imagery as a constructive *process* implying no necessary subjective visual awareness, and imagery as a subjective "seeing" *experience* which occurs only when subjects accord their imagery-as-process constructions a high "reality status." Here he proposed that individual differences in imagery-as-process are related to performance, but that individual differences in imagery-as-experience are not. By way of analogical argument for the latter proposition, Neisser reminded us, "He that speaks loudest does not always have the most to say" (1970, p. 176).

The inconsistent results of studies using a vividness measure of individual differences in visual imagery may suggest that conscious visual awareness of absent objects has little functional significance in cognition. However, a reasonable alternative conclusion is that vividness is an inappropriate dimension on which to measure individual differences in the ability to generate conscious visual images (see Chapters 2 and 3 of this thesis). Such differences may well prove to be functionally significant if they are reliably gauged.

In his 1970 article Neisser was well on the way to defining out of existence the problem of the relationship between visual imagery and visual perception. In his latest article on imagery, he completes his definitional solution to the problem by stating,

"A subject is imaging whenever he employs some of the same cognitive processes that he would use in perceiving, but when the stimulus input that would normally give rise to such perception is absent" (Neisser, 1972, p. 245).

Although there may be some advantages in defining visual imagery in the terms of the quotation above, there are also considerable disadvantages. Substituting utilisation of perceptual processes for conscious quasi-visual experience as the defining characteristic of visual imagery leaves quite unresolved the problem of the relationship between conscious quasi-visual awareness of absent objects - whatever one might wish to label it - and visual perception. This problem - which was the imagery-perception problem as Neisser (1967) originally conceived it - is the major concern of the present thesis.

Another (potential) disadvantage of Neisser's latest definition is that it could tend to produce somewhat trivial empirical work on imagery. As Neisser himself recognises, this definition allows investigators, if it suits them, to insist that their subjects are imaging; in practical terms, it permits any researcher to claim that he is demonstrating some-

thing about visual imagery, so long as he makes the convenient assumption that the execution of his task requires the use of some of the processes which are used in visual perception.

Neisser's later theorising has little bearing on the question of the relationship between visual imagery and visual perception as this question has been posed in the present thesis. Here subjective visualisation of absent objects has been retained as the defining characteristic of visual imagery and it is the relationship of this type of conscious memorial awareness to visual perception which is the central concern of the thesis.

#### 4.2.4 Piaget's views on imagery

Unlike the preceding theorists, Piaget (1951; Piaget and Inhelder, 1971) does not believe that visual imagery derives directly from visual perception. In his view, imagery derives from a different reality-oriented process, namely the process of imitation.

Piaget's theory of the derivation of the visual image from imitation is complex and detailed, and will not be reviewed in full here. In brief, there are two reasons for his view that the origins of imagery lie in imitation, rather than in perception. The first is that, in the sequence of the child's reality-oriented development, perception is followed by imitation, and not immediately by the visual image. Only after imitation is well advanced do mental images make their appearance.

Another reason which Piaget advances to support his thesis that imagery derives from imitation, and not from perception, is that the form of an image is not the same as that of a perceptual structure. In his book on imagery in childhood (Piaget and Inhelder, 1971), he cites evidence purporting to show that there are systematic differences between perceptual and imaginal distortions. In perception, distortions are of a kind consistent with incomplete reconstruction resulting from limited sampling, or

scanning of an external object; in imagery, distortions seem to arise from excessive liberties taken by the subject in schematising his representation (that is, reducing it to subjectively-defined essential elements), rather than from an originally incomplete sampling of the perceptual information. According to Piaget, some schematisation in imagery is necessary to effect mnemonic economy. Schematisation is also a characteristic of imitation; for example, Piaget's child, Lucienne, is described (Piaget, 1951) as opening her mouth to signify how one deals with a closed box in order to obtain something inside it.

For both developmental and structural reasons, then, Piaget sees imagery as deriving from imitation - indeed, for Piaget, imagery is *internalised* imitation, that is, imitation with abbreviated motor components which can be carried out internally (cf. Furth, 1969).

Although Piaget's ideas on the non-perceptual origin and nature of imagery are sophisticated, they are drawn from studies which do not tap visual imagery as it is conceived here, that is, as subjective visualisation.

The studies on which he bases his ideas on the structure of the image, for example, (Piaget and Inhelder, 1971), involve children in tasks of graphic reproductory and anticipatory representation of objects in particular spatial positions. But no interest is taken in whether or not the children are visualising the objects when they are carrying out the tasks. Although their performances indicate something of the nature and structure of their spatial representations, these performances cannot be taken to indicate anything about visual imagery unless one makes the assumption that spatial representation is necessarily imaginal.

#### 4.2.5 Pylyshyn's thesis that the visual image is not perceptual

Pylyshyn's (1973) views on the nature of visual imagery have

already been discussed in Chapter 1. Briefly, because there are arguments against the notion that the visual image is pictorial, Pylyshyn concludes that visual imaginal processes have nothing in common with visual perceptual processes. As noted in Chapter 1, this conclusion does not follow from the premise that the image is not pictorial unless there is added the further premise that perception is pictorial. The latter premise represents a view which is contrary to contemporary notions of visual perception (e.g., Gibson, 1966; Neisser, 1967) and which Pylyshyn himself does not appear to hold. Thus, his argument against the involvement of visual perceptual processes in visual imagery is internally inconsistent.

#### 4.2.6 Summary of theoretical discussions

The theoretical arguments for and against the notion that visual imagery is related to visual perception are not strong in either case. The two neurophysiological theses reviewed above are speculative both as accounts of visual imagery and as accounts of visual perception. This, in itself, is not a weakness. The problem of both Hebb's and Konorski's theories as accounts of visual imagery is their failure to explain satisfactorily the activation of the higher-order, or gnostic cell units of visual perception in the absence of activation of the units which register sensory data. Neisser's final solution to the problem of the relationship between visual imagery and visual perception is purely definitional. Piaget provides us with a sophisticated theory of imagery as imitational, rather than perceptual, but the evidence he adduces for this theory cannot be taken to demonstrate anything about subjective visualisation. And Pylyshyn's conclusion that the visual image is not perceptual depends on a view of perception which is inappropriate.

Except for Piaget, the theorists discussed in this section have made their pronouncements from the arm-chair. It would seem more appropriate at this rudimentary stage of thought concerning the relationship between

visual imagery and visual perception to consider and test empirically the implications of such a relationship at the behavioural level. We now turn our attention to studies of this nature.

### 4.3 EMPIRICAL WORK ON THE PERCEPTUAL NATURE OF VISUAL IMAGERY

#### 4.3.1 Introduction

Although empirical studies of the relationship between visual imagery and visual perception are relatively few, they are, nonetheless, bewildering in their differences. An attempt is made below to structure the empirical literature by classifying the various studies under four headings, each of which represents a different approach to the question of the perceptual nature of visual imagery. The designation of the approaches and the classification of studies under each are personal and, perhaps, arbitrary, but they do give some form to a presently amorphous set of empirical results.

#### 4.3.2 Studies of commonality in behavioural outcome

In this approach subjects are given tasks under visual imagery conditions and their performance in these conditions is compared with performance in a visual perceptual situation. Similarity of performance in both cases is taken to indicate similarity in the processes underlying it. Several different paradigms have been used in the attempt to demonstrate commonality in behavioural outcome between visual imagery and visual perception.

In a series of experiments, Peterson (1975) required subjects to recall digits in cells of 4x4 matrices. In one experiment subjects were instructed to construct the matrices during learning by imaging them; in a second experiment subjects saw the matrices in the learning period;

and in a third experiment they merely listened to a verbal listing of cell contents.

Peterson found certain similarities in the performances of subjects in the imagery and seeing experiments which were not common to the performance of subjects in the verbal experiment. In the first two experiments, subjects recalled the contents of the corner cells more frequently than the contents of other cells, suggesting that the former cells acted as spatial anchors for these subjects. In the verbal experiment, subjects' recall did not vary according to the position of cells in a matrix. Also, although there was no forgetting from zero to ten seconds in the imagery and seeing experiments, forgetting over this period did occur in the verbal experiment. On the other hand, recall in the verbal experiment showed a serial position effect which was not evident in the other two experiments.

Although Peterson's results are suggestive of a relationship between visual imagery and visual perception, some aspects of his experiments caution against accepting them as conclusive in this respect. Certain significant design features of the imagery experiment were changed in the seeing experiment. Also, Peterson used instructions in his attempt to ensure that the subjects used visual imagery in constructing a matrix. Data from Experiments II and III of this thesis demonstrate that imagery instructions do not necessarily lead to the generation of images by subjects. In Peterson's imagery experiment the subjects could have been affected by their instructions whether or not they actually imaged. They may have taken the imagery instructions as a direction to interpret the to-be-learned material as referring to a spatial layout. Subjects in the verbal experiment, on the other hand, had no reason to interpret this material as anything other than a simple verbal list. It is possible that a spatial interpretation of material, *per se*, produces the recall patterns found in Peterson's first experiment.

A different paradigm for demonstrating a similarity of outcome between visual imagery and visual perception was used by Kosslyn (1973). His subjects were shown drawings, each consisting of an outline object with three small objects within it, arranged either horizontally or vertically. Some subjects were later instructed to recall each picture as a visual image while focusing on the object at one end (top/bottom; left/right). They were then asked to judge whether a named object was depicted in the picture. Kosslyn found that it took least time to verify the presence of a focused object and most time to verify the presence of an object at the opposite end. The time taken to verify the presence of an object in the middle position was midway between the times taken for verification of the presence of objects in the other two positions.

These results were interpreted as demonstrating that the time taken to scan for objects at various locations on an image is a function of their distance from a focus point. A similar relationship might be expected in visual perception between time taken to name objects and the distance of the objects from a given fixation point. Thus, Kosslyn concludes that an imaginal feature "... is essentially perceptual, it is a 'remembered appearance' ", and that, "... the features of an image are in some way isomorphic to 'perceptual features' " (Kosslyn, 1973, p. 94).

It would seem, however, that Kosslyn's results are open to another interpretation. A positive time-distance relationship would be expected in simple rote learning of a list of unrelated words. With such a list, one would expect that a subject who was asked to concentrate on a word at serial position 1 would take longer to verify the presence in the list of a word at serial position 5 than he would to verify the presence of a word at serial position 2. Kosslyn's findings are just as consistent with subjects working through simple lists of object names as they are with subjects scanning images.

Evidence supporting the alternative to Kosslyn's interpretation has been produced by Lea (1975). In one of a series of three experiments, Lea asked his subjects to use the method of loci as a mnemonic technique in list learning. The loci with which they associated list items were buildings on their university campus. In the test phase of the experiment subjects were cued with a starting locus, which varied across trials. In one experimental condition they then had to name the building at one, two, or three removes from the starting locus; in another condition they were required to give the item associated with the building at one, two, or three removes from the starting locus.

In his second experiment, Lea used loci which were more controlled than campus sites with respect to familiarity for subjects and inter-locus distance; and in his third experiment he used these loci again, but required subjects to respond with loci or items at up to five removes from the starting locus.

In none of Lea's experiments did the actual physical distance between loci affect subjects' processing time. The only effect on processing time was due to the *number* of loci through which the subject had to proceed in order to give his answer. Thus, as Lea points out, distance between items and number of items were confounded in Kosslyn's experiment. Lea's results appear to lend more support to the "verbal list" hypothesis proposed above than to Kosslyn's "scanned image" interpretation of his results.

In some more recent experiments Kosslyn (1975) attempted to demonstrate the commonality of outcome between visual imagery and visual perception in another way. Noting that, in perception, parts of visual stimuli are more difficult to resolve when the stimuli are small than when they are large, Kosslyn hypothesised that it would be more difficult to confirm or disconfirm a property as appropriate to an imaged object when

the image was small than it would be to do so when the image was large.

To test this hypothesis Kosslyn devised a series of experiments in which he attempted to control the size of subjects' visual images, in within-subject designs. A subject was informed of the conditions of imaging the critical object (always a common animal), then given the name of the object and a brief period in which to image it at the size indicated. A few seconds later he was presented with the name of a property, either appropriate or inappropriate to the imaged object, which he was required to verify or reject as part of that object. Time taken for verification or rejection was the dependent measure. The data were consistent with Kosslyn's hypothesis. It took appreciably longer to evaluate the appropriateness of a property in small-image conditions than in large-image conditions.

It may appear churlish to indulge in continual criticism, but it should be noted that there is something amiss, even silly, in the rationale underlying Kosslyn's latest series of experiments. To start with, a subject does not need an image to verify that, for example, "claw" is an appropriate property of a cat, or to conclude that "comb" is not. Checking an image is totally unnecessary to the production of such overlearned information as the physical characteristics of cats. This being the case, one might hypothesize that Kosslyn's subjects hesitated in replying in the small-image condition because the within-subject design led them to believe that they *should* perform somewhat differently in this condition from the way they performed in the large-image condition. It would be interesting to see if Kosslyn's results could be replicated with a between-subjects design.

Second, even presuming that Kosslyn's subjects obeyed their instructions and produced subjectively small or large images, this subject-

ive size could not operate in the same way as the objective size of an actual external object operates in perception. In the latter case objective size affects the resolution of properties because it influences the ease with which a detailed internal construction of an object can be made. However, an image of an object, whether it is large or small, is already a construction (though built up from stored information, rather than external visual information). Therefore, it cannot be construction which is made difficult by small images. Thus, even if Kosslyn's results were not due to demand characteristics in his experimental situation, it is still not legitimate to use them as evidence for relating the nature of visual imagery to that of visual perception. If size of an imaged object genuinely has an effect, it is not for the same reason that size of an actual object has its effect in perception.

The "commonality of behavioural outcome" approach to the question of the relationship between visual imagery and visual perception has produced disappointing experimental studies. The basic approach itself, if taken in isolation, represents a weak pursuit of the question of the perceptual nature of visual imagery. Similarity between the external effects of two processes does not, of itself, imply similarity in the underlying nature or structure of the processes. Only with prior and more direct evidence of a commonality in the latter respects between visual imagery and visual perception does the study of similarity in their behavioural effects become a feasible means of investigating the perceptual nature of visual images.

#### 4.3.3 Studies of similarity in the structure of internal representations produced in visual imagery and visual perception

In a lengthy article Cooper and Shepard (1973) review a number of experiments carried out by Shepard and his associates. One of several aims of these experiments was to investigate the notion that the visual

image is, in fact, visual in form (see Cooper and Shepard, 1973, p. 83). The investigators assumed that the internal representation resulting from perceptual activity is isomorphic with the external object being perceived. They reasoned that if a visual image could be shown to be isomorphic with external reality, it could also be seen as visual in form.

The technique employed by Shepard and his colleagues is well known, and will be described only briefly here. It involves subjects in making judgements of whether a stimulus is a normal or mirror-image version of a particular character (letter, digit, or geometrical shape). Sometimes the subject sees the stimulus in an upright position ( $0^\circ$  rotation); at other times he sees it rotated at one of five possible  $60^\circ$  clockwise steps from the upright position. At each rotation the subject is asked to make a judgement on which version of the character he is seeing, and is timed in doing so. The hypothesis is that, for stimulus rotations other than the  $0^\circ$  rotation, the subject has to rotate his normal internal representation - that is, a representation of a character in its upright position. He must then compare the rotated representation with the stimulus. This "mental rotation" should be reflected in the time taken to make a judgement; the further the stimulus is rotated from the  $0^\circ$  position, the longer the subject should take to make his judgement.

Unless advance information about the stimulus orientation is given (in which case the subject can appropriately transform his mental representation *before* the stimulus is presented), reaction time is, indeed, a monotonic (and, in some circumstances, linear) function of the distance of the stimulus from the upright position.

In their theoretical interpretation of this very consistent result, Cooper and Shepard argue that the mental representation which is being rotated is a visual image. Moreover, they argue that, because the image can be transformed in a way which corresponds with an actual rotation,

it must possess an internal structure which is isomorphic with that of the stimulus character. In its isomorphism with an external character, the visual image shares a characteristic of the representation resulting from visual perceptual activity. Therefore, Cooper and Shepard conclude, the visual image is significantly visual in its form.

Seen as demonstrations of human subjects' capacity for performing some mental operations in a more-or-less analogical fashion, the Shepard studies are outstanding in experimental finesse. However the interpretation of their results in terms of the rotation of visual images seems to be an unwarranted extension of the data. Analogical operations need not be carried out on visual images. These operations could, for example, use kinaesthetic images and still produce results similar to those obtained in the Shepard experiments. Alternatively, they could be performed on more abstract representations which are free of subjective sensory elements, and which contain information about the relationships, rather than the features, within a character.

In fact, from a common theoretical perspective, representation of the stimulus character by a visual image could be seen as being disadvantageous in the performance of the Shepard task. Several writers on conscious representational processes have referred to characteristics of the visual image which would seem to make it unsuitable for the kind of mobile, transformational thinking which is necessary to perform a "mental rotation". For example, the visual image is said to be oriented only to a particular instance (Bartlett, 1932) and to be highly concrete and static (Bruner, 1966; Werner and Kaplan, 1963). These hypothesised features of the visual image, although they may facilitate the presentation in consciousness of detailed information about an object in a particular state, hardly seem suitable for conveying information about transformations of the type required in the Shepard task.

Recently, some experimental work in this department produced evidence which is consonant with the theoretical view outlined above. Griffiths (1975) used the basic Shepard technique, but investigated the effects of different kinds of stimulus changes on subjects' performance with rotated stimuli. The changes included the mirror-image variations of Shepard *et al.* but also more subtle variations of the stimulus characters, which were computer-generated shapes. She also administered the V.E.S. to her subjects. Her findings, generally, indicate that there are limitations on the generality of the Shepard results. However, the result of particular interest in this context was the relationship found between V.E.S. scores and subjects' performance on the rotation task.

There was a significant negative correlation between scores on the Imagery scale and reaction times when the stimulus was presented in the upright position, indicating that visual imagery was helpful in this circumstance. But there was a significant positive correlation between scale scores and times indicating the effect of rotation (mean RTs for the 60°-300° rotations minus mean RT for the 0° rotation). The latter correlation indicates not only that the generation and rotation of visual images is not the exclusive method of performing the rotated stimulus task, but also that it is not even the most effective method of doing so.

It is doubtful, then, that Shepard's subjects, other than habitual imagers, rotated visual images in his experiments. If they did not do so, his data cannot be taken as support for claims that imaginal representation is similar to perceptual representation. This is not to say that visual imagery is not perceptual or visual in the way suggested by Shepard, but is only to point out that, if it is so, the fact is not demonstrated by his studies.

#### 4.3.4 Studies of the use of the peripheral apparatus of visual perception in visual imagery

Another approach to the question of the relationship between visual imagery and visual perception is the study of whether or not any of the peripheral apparatus of visual perception is used in visual imagery. Most studies of this type have concentrated on eye movements, although there has also been some interest in pupillary dilation.

Studies of the association between rapid eye movements in sleep and dreaming are well known (e.g., Aserinsky and Kleitman, 1955; Dement and Wolpert, 1958). However, it is the study of eye movements in imagery during the normal waking state which is of interest here.

Antrobus, Antrobus and Singer (1964) asked subjects to imagine either static or active scenes. They found a great increase in the incidence of eye movements in the task involving imagined active scenes over that involving imagined static scenes, though some eye movements were also evident in the latter. Other studies of eye movements have found an increase in their incidence when subjects are given imagery instructions over their incidence when imagery instructions are not given (e.g., Lenox, Lange, and Graham, 1970; Reyher and Morishige, 1969). The results of such studies have led to the hypothesis that visual images are scanned in much the same way as external objects are scanned in visual perception (Marks, 1972; Neisser, 1967).

The scanning hypothesis is a strange one, given that the eyes are oriented to the external world; the visual image is not constructed from external information. In addition to this problem for the hypothesis, there exist data which are not consistent with it. Brown (1968) used an individual difference manipulation of visual imagery in a study of eye movements in subjects during imagined visual pursuit of a metronome beating

at a given rate per second. Her subjects were classified as "visualisers" or "non-visualisers" on the basis of their responses to a questionnaire. Although she found that the "visualisers" made more eye movements than the "non-visualisers", she also found that these movements were frequently independent of on-going mental visualisation of the movement of the metronome. Brown therefore concluded that this kind of peripheral perceptual-type activity is not necessarily related to mental visualisation.

Marks (reported in Marks, 1972) also used an individual differences manipulation to study eye movements, but during static, rather than active imagery. His subjects were classified as "good" visualisers or "poor" visualisers from scores on his Vividness of Visual Imagery Questionnaire (Marks, 1973), an instrument which is very similar to the visual section of the Betts' Q.M.I. Marks found that "poor" visualisers made significantly more eye movements than did "good" visualisers. He considers that the finding for the latter subjects (that is, relatively few eye movements) is consistent with the findings of Antrobus *et al.* on static and active imagery. However, he does not attempt to explain the relatively high rate of eye movements in his "poor" visualisers, which is surely inconsistent with the idea that eye movements in visual imagery indicate a similarity between visual imagery and visual perception by demonstrating that scanning occurs in the former process; genuinely poor imagers should have little, or nothing, to scan.

Marks' finding may have been due, in part, to the fact that his subject classification was based on a measure of the vividness of visual imagery. The weaknesses of this kind of measure have been discussed in Chapters 2 and 3. Nonetheless, his result can scarcely be put forward as evidence for the idea that eye movement studies are useful for demonstrating the perceptual nature of visual imagery.

The data on pupillary dilation in visual imagery are as questionable as the eye movement data. Several studies have shown that in visual imagery, as in orienting in visual perception, the size of the pupil increases (e.g., Simpson and Paivio, 1966, 1968). However, it is reliably documented that pupillary dilation increases when subjects know that they are required to indicate overtly the completion of a mental task (e.g., Bradshaw, 1968; Kahneman, Peavler, and Onuska, 1968). Thus, there exists the problem that pupillary dilation in visual imagery conditions may reflect the increase in muscle tension associated with anticipation of making an overt response, rather than visual imaginal activity.

A basic difficulty with the eye movement and pupillary dilation studies is that they are investigating phenomena which may not be exclusive to visual perception and visual imagery. Increases in eye movements and in pupillary dilation appear to be common to a range of mental and muscle activities, above a certain "resting" level. Thus, such increases do not necessarily demonstrate anything about the perceptual nature of visual imagery.

#### 4.3.5 Studies of the use of the central apparatus of visual perception in visual imagery

The paradigm for investigating whether or not the central apparatus of visual perception is utilised during visual imagery is one of selective interference. Subjects are required to engage in mental representation while simultaneously either attending to an external signal or outputting information. Sometimes the representation, on the one hand, and the external signal or output mode, on the other, are presumed to be within the same sensory modality; at other times the representation and the signal or output mode are presumed to be in different modalities. For example, a subject may be asked to generate and hold a visual image while attending to either a visual or an auditory signal; or he may be

required to generate a visual image while outputting information either in a mode which requires visual perception, or in a mode that involves speaking or motor movements. The mental representations may sometimes be auditory or articulatory images, rather than visual images. Poorer performance in the within-modality condition than in the between-modality condition is taken to indicate some sharing of central mechanisms between visual imaginal representation and visual perception (or between auditory or articulatory imaginal representation and auditory perception, or actual articulation in responding).

The pioneer of the selective interference technique, Brooks (1967, 1968), was not interested in imagery, as such. Rather his interest was in the notion that "... verbal and spatial representation are handled in distinct, modality-specific manners" (Brooks, 1968, p. 349). Whether these manners are, or include, conscious imaginal representations was of little concern. Thus, he did not employ a direct manipulation of imagery, but merely varied the type of "object" to be represented and the type of external signal or response mode.

In one series of experiments Brooks (1967) found that performance on a spatial relations task, requiring the internal representation of a matrix, was worse when the relevant information was presented visually than when it was presented in the auditory mode. Similarly, when the output for a spatial relations task involved reading, performance was worse than when it involved speaking. In another series of studies, Brooks (1968) found that, in recalling a sentence which had been presented orally, a subject could more readily signal information when his method of doing so required simple motor movements or visuo-spatial monitoring, than when it involved speaking. However, when recalling a visually presented line diagram, the subject's transmission of information was easier when he signalled it by speaking, or by motor movements, than when he signalled it in the output mode requiring visuo-spatial monitoring.

Brooks' results are sometimes interpreted as evidence for the view that visual imagery makes use of the central apparatus of visual perception (e.g., Neisser, 1970, 1972). However, this interpretation depends on a different definition of visual imagery from that which is usually employed, that is, a definition in terms of subjective visual experience. Quite correctly, Brooks himself hesitates to draw the conclusion that his work demonstrates a relationship between visual perception and visual imagery in the latter sense; he states that his results show only that spatial representation uses mechanisms specialised for visual perception (see Brooks, 1967, p. 298). Brooks is explicitly reluctant to attribute spatial representation to visual imagery, solely or specifically. When he questioned his 1967 subjects about their task strategies, only two gave reports which corresponded with the usual descriptions of visual images.

Segal and Gordon (1969) first used the selective interference technique to study visual imagery specifically. They found that when their subjects were instructed to image pictures, ability for detection of a visual signal was diminished. In a subsequent study (Segal and Fusella, 1970) it was shown that this interference effect was attributable to the particular instructions given, rather than to a general overload of attention imposed by requiring subjects to do two things at once. The second experiment showed that detection of visual signals was impaired more by instructions to image pictures than by instructions to image sounds, but that, conversely, detection of auditory signals was impaired more by instructions to image sounds than by instructions to image pictures.

The selective interference technique is a sophisticated method for differentiating between representational processes generally. It allows a direct comparison to be made between one type of internal representation and another with respect to the processing systems each involves.

The use of this technique made by Segal *et al.* in studying the relationship between visual imagery and visual perception represents a great advance over the studies of this relationship reported previously.

However, two features of the Segal studies merit comment. The first is their use of an instructional manipulation of imagery. In the absence of any indication of subjects' ability to obey them, it is possible that instructions to image pictures and instructions to image sounds led only to the activation of, respectively, the spatial and temporal processing systems which we all possess, and not to the arousal of the "concrete" conscious representational processes of interest here, in which there are great individual differences. The second feature of the Segal studies which merits comment is one noted by Cooper and Shepard (1973), namely that the task in these studies was one of simple sensory detection, which did not require complex processing of the external signal. Cooper and Shepard reasonably ask whether conflict between visual imagery and visual perception is so obvious when a more complex, cognitive interpretation of the external stimulus is required.

Despite these comments, one should not underestimate the potential of the selective interference technique for indicating whether or not visual imagery utilises some of the central apparatus of visual perception. The comments imply, however, that the technique should be used in conjunction with a more reliable manipulation of imagery than is provided by instructions, and that the task which is carried out concurrently with the imaginal representation should require processing at a more cognitive level than is necessitated by simple sensory detection.

#### 4.3.6 Summary of empirical studies

Only the last of the four empirical approaches above has produced a sophisticated experimental technique for investigating the relationship

between visual imagery and visual perception. If used in conjunction with a reliable manipulation of visual imagery, the measurement of selective interference allows not only the examination of whether visual imagery and visual perception share central mechanisms, but also the examination of whether externally-oriented activities other than visual perception also share the mechanisms used in visual imagery. Thus, this technique makes it possible to determine whether visual imagery is related to visual perception specifically, or whether it utilises mechanisms which are not tied to any one sensory modality. The experimental techniques resulting from the other three approaches cannot do this.

For these reasons, the starting point of the present research on the relationship (if any) between visual imagery and visual perception was a selective interference experiment.

## CHAPTER 5

### DOES VISUAL IMAGERY ACTUALLY UTILISE THE CENTRAL APPARATUS OF VISUAL PER- CEPTION?

#### 5.1 GENERAL INTRODUCTION

In the last chapter we assessed the usefulness of selective interference as a technique for discovering whether or not specific representational processes are tied to particular sensory modalities. Segal and Gordon (1969) and Segal and Fusella (1970) have used this technique in studying the relationship between visual imagery and visual perception; but some reservations were entertained previously regarding the way they purported to manipulate imagery by instructions to the subject, and regarding the appropriateness of their signal detection task. It therefore seemed worthwhile to correct these apparent weaknesses in a selective interference experiment which will now be described.

#### 5.2 EXPERIMENT IV: THE VISUAL PERCEPTUAL COMPONENT OF VISUAL IMAGERY

##### 5.2.1 Introduction

This experiment was designed to investigate whether or not visual imagery, as conscious quasi-visual experience, uses any of the central apparatus of visual perception.

Imagery here was manipulated by classifying subjects on the basis of their scores on the V.E.S., whose construction and validation were described in Chapter 3. It appears that V.E.S. scores can be used

to ensure the presence/absence of "visual" representation. Subjects with high scores on this scale appear to visualise absent objects in recall, even when they are not specifically required to do so (the scale's instructions require subjects only to "think normally" about absent objects). On the other hand, the validation study reported in Chapter 3 showed that subjects with V.E.S. scores of five or less were virtually unable to image; they reported that they could not visualise, even though they were instructed to do so.

The task used in the experiment was one devised by Brooks (1968) for his investigation of the differences between spatial and verbal representation. It involved the classification, in recall, of corners of previously-presented line diagrams of block capital letters. When a diagram was withdrawn the subject was required to classify the corners as top/bottom *versus* middle corners, or as outside (extreme left and extreme right) *versus* inside corners, while proceeding around the letter in a clockwise direction. The subject transmitted the information about the corners in three ways. Sometimes he spoke it, saying "yes" for top/bottom, or outside, corners and "no" for middle, or inside, corners; sometimes he tapped with the left hand to signify top/bottom, or outside, corners and with the right hand to signify middle, or inside, corners; and sometimes he pointed to a sheet of paper containing columns of Ys ("yes"), standing for top/bottom, or outside, corners, and Ns ("no"), standing for middle, or inside, corners. This last task, which provides the visual perception condition, requires more complex processing of the external stimulus than the signal detection task of Segal *et al.*

To discover whether or not visual imagery, specifically, uses the apparatus of visual perception, the pointing output times for subjects with very low V.E.S. scores ("non-imagers") were compared with those for subjects with very high V.E.S. scores ("good" imagers). If "good"

imagers were found to take appreciably longer than "non-imagers" to transmit information in the condition requiring visual perceptual monitoring, this would indicate a conflict between visual imagery and visual perception due to their common utilisation of a processing system. If, on the other hand, no differences in pointing times were found between the two imagery groups, this would indicate that visual imagery makes no greater demands on the apparatus of visual perception than do other modes of representation.

Brooks (1968) found that spatial representation in subjects unselected on visual imagery ability uses some of the apparatus of visual perception; his subjects took much longer to transmit information by pointing than by tapping or speaking. Therefore, it was expected that some disruption of performance in the pointing condition would occur for both "good" imagers and "non-imagers", relative to their performance in the speaking and tapping conditions. The question here was whether there is an *increment* in this disruption with "good" imagers due to additional conflict for them brought about by imaging and perceiving simultaneously.

The speaking and tapping conditions of the Brooks study served principally as control conditions in the present experiment. Performance in these conditions provided baselines which could be used to determine if longer pointing times for "good" imagers, than for "non-imagers", were attributable to a general difficulty for the former in signalling the information about the corners rather than to a particular conflict between visual perception and their imaginal representations.

There was a secondary purpose in retaining Brooks' tapping and speaking conditions, namely to discover if visual imagery enhances performance when no externally-oriented perceptual activity is required. It is easy to signal information about a letter's corners by tapping or speaking when the letter remains present; therefore, it might be expected that

"seeing" an image of the letter would enhance performance in these output conditions.

For reasons discussed in Chapter 3, this experiment was run "blind", that is, the experimenter did not know the subjects' V.E.S. scores until the study had been completed.

#### 5.2.2 Subjects

The subjects were 51 respondents to advertisements posted around the university. The advertisements offered \$3.00 for answering a "thinking" questionnaire and for subsequent participation in a "visual memory" experiment. The persons responding were mainly undergraduate students, but they also included post-graduate students, members of ancillary staff and two interested senior members of the academic staff of another discipline.

Although only the performances of subjects very high and very low on V.E.S. scores were to be examined, the precaution of running the experiment "blind" necessitated that all 51 persons replying to the advertisements be taken through the experimental procedure.

#### 5.2.3 Scale administration

The V.E.S. was administered to each subject individually. Items and responses were taped, and the tapes stored until after the experiment had been run. Only then were subjects' responses scored and totalled.

#### 5.2.4 Materials

Three different block capitals, F, G, and N were used as stimuli in the experimental trials. In addition to these, the letter H was used for demonstrating the task, and the letter Z for practice trials. A letter was drawn in outline on each of three cards. An asterisk beside the letter indicated the starting point, and an arrow near the asterisk

indicated that the corners were to be followed in a clockwise direction. A sample letter is shown in Figure 5.1.

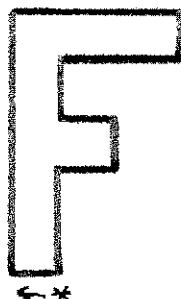


FIGURE 5.1 A sample block capital.

One card for each letter was designated as the stimulus for the tapping mode of output; another card for the same letter, with a different starting point, was designated as the stimulus for the speaking mode; and a third card for the letter, with yet another starting point, was designated as the stimulus for the pointing mode. Card-output mode combinations were the same for each subject.

For the pointing mode of output Ys and Ns in even rows, but in staggered columns, were distributed over an A4 sheet of paper (see Figure 5.2). The staggering of columns was designed to force close visual perceptual attention on the part of the subjects (Brooks, 1968).

#### 5.2.5 Apparatus

An electric timer, which was started and stopped by a foot-operated switch, was used to record the time taken by a subject to classify the corners of a letter.

Y		N
	Y	N
Y		N
	Y	N
Y		N
	Y	N
Y		N
	Y	N
Y		N
	Y	N

FIGURE 5.2 A response sheet for the pointing mode of output.

A tape recorder was used to record answers to questions concerning a subject's ordering of preferences for the three output modes, and the reasons for the ordering, which were asked at the end of the experiment.

#### 5.2.6 Procedure

Subjects were run individually. A subject was seated at a table with the experimenter. The table was fitted with a screen, and seating positions were such that the experimenter could see what the subject was doing, but the subject could not see the experimenter's equipment, or how she was marking his responses.

The subject was instructed in the task. He was informed of the bases of classification, and top/bottom, and outside corners were pointed out by the experimenter on the letter H. This letter remained in front of the subject while the experimenter demonstrated both types of classification with all modes of output.

The demonstration was followed by practice trials on the letter Z. The subject was shown one of the three cards containing the letter, and examined it until he indicated that he could draw it from memory. The card was then removed; the subject took a pencil and paper and reproduced the letter, starting with the asterisked corner, proceeding clockwise, and including both asterisk and arrow. He was required to point out the top/bottom and the outside corners of the letter. The drawing was then removed. The experimenter informed the subject of the required mode of output, and allowed him approximately two seconds to get ready. She then asked if he knew where he was starting on the letter, and on his affirmation she said, "Top/bottom. Go!" or, "Outside. Go!", starting the timer simultaneously with the uttering of "Go!". The subject proceeded with his corner classification, saying "End!" when he thought

he had completed it. On "End!" the timer was stopped. This procedure was followed with the two other cards for Z, that is, until the subject had completed one trial in each output mode.

For the experimental trials nine cards, comprising three versions each of F, G, and N, were placed in a deck. The subject was required to shuffle the deck, face downwards, until the experimenter said "Stop!" (after the deck had been shuffled for approximately five seconds). The experimenter took back the deck, turned the top card, noted the mode of output designated for it, and handed it to the subject for his inspection. The procedure described above for the practice trials was then followed. The determination of the stimulus card by shuffling continued until the last trial, unless the subject drew the same letter three times in succession, in which case the experimenter replaced the top card in the deck and took the second top card.

The criteria for corner classification (top/bottom or outside) were randomly distributed over serial positions of trials, with the restriction that the subject had to classify at least four times on each criterion over nine correct trials. If an error occurred in classifying a corner, or if a subject ended his classification too early or too late, the trial was terminated; the card containing the letter being classified was set to one side, and was not returned to the deck until another trial had been run. Thus, at least one other trial intervened before an error trial was repeated.

The procedure described above varies a little from that of Brooks. The starting point on a letter here was different for each mode of output; this was not the case in the Brooks experiment. Also, in the present experiment the same letter was not presented on three successive trials as it was in Brooks' study. Both these variations were precautions against a subject's rote learning of response patterns for a letter's corners.

Finally, in this experiment the subject was required to say "End!" when he thought he had completed his corner classification; this was to guard against the premature termination of a trial by the experimenter.

### 5.2.7 Results

One subject was almost totally unable to perform the task with any mode of output. After several painful trials, which took about 30 minutes, and which produced only two error-free performances, his participation was terminated. Thus, only 50 subjects were considered in the data analysis.

The taped V.E.S. responses of the 50 subjects were scored. The mean V.E.S. score for the group was 8.50, with a standard deviation of 3.32. Subjects with scores of five or less ("non-imagers") and subjects with scores of 12 or more ("good" imagers) were selected for the comparison on output times. These groups were, respectively, more than one standard deviation below, and more than one standard deviation above the mean V.E.S. score for the original 50 subjects. The number of "non-imagers" was 10, of "good" imagers, 13.

The mean times taken by these two imagery groups to complete their output in each of the three conditions are shown in Table 5.1. The numbers in the table represent the averages of three trials in an output mode for each subject in a group, summed and averaged over the number in that group<sup>1</sup>.

---

<sup>1</sup> Times taken in each output mode were considerably less than those taken by Brooks' subjects. This was probably due to the fact that more extended demonstration and practice were given in the present experiment than in the Brooks study.

TABLE 5.1 Mean output times, in seconds, of  
"good" imagers and "non-imagers".

	Output mode		
	Tapping	Speaking	Pointing
"Good" imagers	9.04	7.92	17.39
"Non-imagers"	8.09	7.49	12.97

$t$ -tests for independent groups were run on the mean difference between imagery groups for each of the three output modes. There was no significant difference between the two groups in tapping times ( $t = 0.667$ ) or in speaking times ( $t = 0.490$ ). However the difference between the imagery groups in pointing times was significant ( $t = 2.68$ ;  $df.$ , 21;  $p < .02$  on a two-tailed test).  $t$ -tests on the mean difference between the imagery groups in *differences* in times among output modes strengthened these results. The mean difference between tapping and speaking times was not significantly greater for "good" imagers than for "non-imagers" ( $t = 1.70$ ). The pointing time minus tapping time difference, however, was greater for the former group than for the latter group ( $t = 3.64$ ;  $df.$ , 21;  $p < .01$  on a two-tailed test); and the pointing time minus speaking time difference was similarly greater for "good" imagers than for "non-imagers" ( $t = 3.90$ ;  $df.$ , 21;  $p < .001$ ). Thus, not only did the "good" imagers take significantly longer than the "non-imagers" in the pointing condition, but their performance in pointing was more disrupted relative to their performance in the other two conditions.

As a matter of secondary interest, it was decided to inspect the results of the other 27 subjects as well. Typically, "middle" imagers

are not used in studies employing individual differences as a basis for manipulating visual imagery; the standard procedure is to use only subjects with extreme scores on an imagery ability measure.

The mean output times (in seconds) of the 50 subjects were: tapping, 8.94; speaking, 7.77; and pointing, 16.79. Individual averages for three trials on each output mode, together with individual V.E.S. scores, are presented in Appendix 4a.

Times for each output mode are plotted against V.E.S. intervals in Figure 5.3.<sup>2</sup> Each point on the graph represents the average time over three trials for each subject within the respective interval, summed and averaged over the number of subjects within it.

Inspection of Figure 5.3 suggested that there was no relationship between V.E.S. scores and output times for tapping and speaking, but that there was an asymmetrical inverted-U relation between the two factors for pointing.

These observations were tested using Ferguson's non-parametric trend analysis (Ferguson, 1965, Ch. 7). This provides separate tests of trend for monotonic, bitonic (two-branched), tritonic (three-branched) - *etcetera* - functions when, as in the present case, the treatment variable is ordinal, rather than ratio or interval. In the analysis, subjects were grouped according to their V.E.S. scores, and each different score group, from 1 to 15, was taken as a treatment group.

The observations above on the pointing time curve in Figure 5.3 suggested a bitonic trend. This trend, and also monotonic trend, were tested on the time data for each mode of output. The complete results

---

<sup>2</sup>Times are plotted against V.E.S. intervals, rather than against single score groups, as some of the latter groups have only one, or no, subjects.

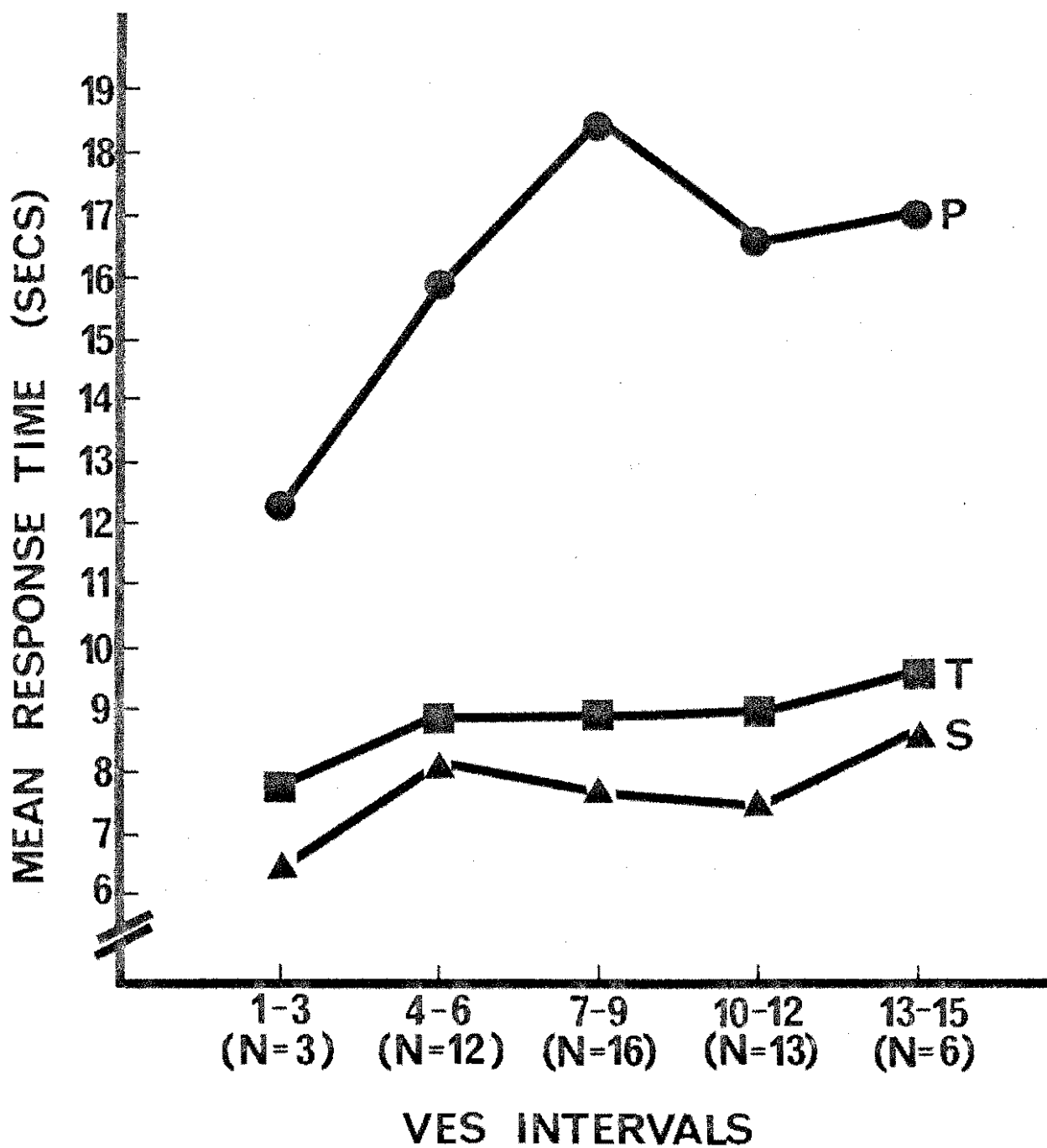


FIGURE 5.3 Mean output times for tapping (T), speaking (S), and pointing (P) as functions of V.E.S. scores (grouped).

of the tests are included in Appendix 4b, where a brief exposition of Ferguson's technique is also given. The analyses showed that there was no significant monotonic or bitonic trend in the data for tapping or in the data for speaking. There was a weak monotonic trend ( $p = .16$ ) in the data for pointing. However, there was a significant bitonic trend, based on a value of minus sign (indicating an inverted-U relation), in the pointing data ( $p = .013$ ). A similar bitonic trend was evident when an analysis was carried out on the differences between pointing and tapping times ( $p = .011$ ) and this trend was even more pronounced when the analysis was performed on the differences between pointing and speaking times ( $p = .007$ ).

The significant bitonic trends confirm the impression of an inverted-U relation which is gained on inspection of the pointing data in Figure 5.3. The  $t$ -tests reported above confirm the impression that this relation is asymmetrical. The last observation implies that the monotonic trend in the pointing data should be significant. While this was not the case, the relevant values did approach the required level (see Appendix 4b).

In summary, the data analyses showed:

- i) That there were no differences between "good" imagers and "non-imagers" in output times for tapping or speaking, but that "good" imagers were significantly slower than "non-imagers" in pointing.
- ii) That, when all subjects were included, there was no relationship between V.E.S. scores and output times in the tapping and speaking conditions, but that there was a significant inverted-U relation between the two factors in the pointing condition.

### 5.2.8 Discussion

The results of this experiment show that subjects, irrespective of their imagery ability, had their output times increased when they were required to engage simultaneously in spatial representation and visual perceptual activity. However, the results also show that, in this condition, "imagers" (both "middle" and "good") were much slower than "non-imagers". "Imagers" were not slower than "non-imagers" in transmitting the corner information when no externally-oriented perceptual activity was involved. Thus, their poorer performance with pointing must have been due to demands made by visual imagery on the visual perceptual system which were in addition to the demands made on this system by more abstract spatial representations.

It appears that the additional demands of visual imagery pushed the visual perceptual system close to capacity so that, when external visual monitoring was required, "imagers" had to engage in constant shifts of attention between their internal imaginal representations and the external letters which had to be monitored. This constant shifting of attention would have increased output times. Introspective reports from subjects with scores of six and above on the V.E.S. indicate that they were themselves aware of continually having to change their focus of attention in the pointing condition. Portions of transcripts of taped reports from two of these subjects are presented below:

*Subject 5.* Female - V.E.S. score, 8.

(After S had reported that her ordering of preferences was speaking, tapping, and pointing, and that she had gone around a "visual figure in my head" during output in the first two modes).

*E:* What about pointing?

*S:* Same (i.e., she had gone around a "visual figure" here, too).

*E:* Could you do it easily?

*S:* No, much more difficult. Because I had to move between moving my mental eyes around the letter and my visual eyes around this (pointing to response sheet).

*Subject 2.* Male - V.E.S. score, 12.

(After he had expressed a distinct last preference for pointing, and had stated that with tapping and speaking he had followed around a whole "neon-lit mental letter.")

*E:* You say you found pointing hardest. What were you doing then? What caused the difficulty?

*S:* It was hard to see the letter and the page at the same time. I could go around the letter like before (i.e., as with tapping and speaking), but I had to keep going away from it all the time . . . I had to leave it to work out what was a "Y" and a "N" on the page.

All other subjects within the 6-15 score range on the V.E.S. similarly indicated that pointing was their least preferred mode of output; and few of them failed to specify that their difficulty with it lay in having to divide their attention between their internal representation and the letters on the response sheet. Generally, they reported that they had had such problems as, "losing my place on the letter," "losing the corners," and "not being able to see the letter," when they were looking at the pointing response sheet.

The reports of the "non-imagers" (i.e., subjects with V.E.S. scores of five or less) were somewhat inconsistent with those above (and were considerably less illuminating). Although most of these subjects also reported that pointing was their least preferred mode of output,

they were much less able to specify why they had experienced difficulty with it. Where some attempt was made to specify the source of the difficulty, the reasons given were different from those given by the "imagers". For example, one subject with a V.E.S. score of four said that pointing was hard for him because he had to watch where he was going on the page, and because he had to change sides (to get from a Y to a N, and the reverse). Neither of this subject's stated reasons suggested that he was aware of having divided his attention between his internal representation (which did not rate a mention) and the letters on the response sheet. Even more inconsistent with the "imagers' " reports were the claims of two "non-imagers", with V.E.S. scores of three and two, that they had had no preferences among the modes of output.

The failure of "non-imagers" to acknowledge or explain their difficulty with pointing suggests that their only problem with it was due to a conflict between visual perception and some non-conscious form of representation. Thus, it appears that utilisation of the apparatus of visual perception occurs at at least two levels in the processing of visuo-spatial information - at some level of representation which is not available to conscious inspection, and at the level of conscious visual representation.<sup>3</sup>

It is interesting that the output of "middle" imagers was disrupted more than that of "good" imagers by having to attend to external visual information while engaging in mental representation. This result

---

3

This suggestion follows Neisser's (1970) distinction between non-conscious representations of visual information and conscious representations which are subjectively visual. However, whereas Neisser refers to both as "imagery", this term here refers only to the latter representations.

is consistent with the finding of Coltheart and Glick (1974) that an habitual and very good imager was more able to resist external interference from masking than were three "normal" control subjects ("middle" imagers?). The reason for this greater resistance to external interference on the part of "good" imagers, as opposed to "middle" imagers, is not clear from the data. Perhaps it was due to a kind of practice effect. That is, the "good" imagers' more-or-less habitual tendency to represent absent things imaginally<sup>4</sup> may have made them more efficient in the use of the perceptual mechanisms in visual imagery than persons less practised in generating visual images; thus, quasi-visual processes in "good" imagers may use somewhat less of the visual processing capacity than they do in "middle" imagers. Whatever the reason for it, the fact that the greatest adverse effect on performance caused by perceptual activity occurred in "middle" imagers has methodological import. It suggests that the usual technique for using individual differences to manipulate visual imagery - i.e., selecting only subjects with extreme imagery ability scores - may lead to a loss of information.

The fact that visual imagery did not facilitate performance in the tapping and speaking conditions is surprising, especially since it was so detrimental to performance in the pointing condition. These two findings present us with a paradoxical situation. That visual imagery did not aid performance in the tapping and speaking modes of output suggests that information about previously-seen letters can be represented in recall just as readily by other representational media as by the visual image. On the other hand, the finding that imagery was detrimental to

---

4

That "good" imagers on the V.E.S. are also habitual imagers is indicated by the fact that they consistently choose "visual elaboration" alternatives, although they are not requested to visualise.

performance with the pointing mode of output indicates that it uses some of the apparatus of visual perception which, in turn, suggests that imagery is involved in the processing of information which is in addition to the information available *via* other representational media. It is unlikely that imagery's use of the apparatus of visual perception is meaningless in functional terms.

The resolution of this paradox brings us to a distinction which is of primary significance in the subsequent empirical work of the thesis. The distinction concerns types of information which are recalled when we are thinking about objects which have been presented to, and constructed by, the visual perceptual system. It will be outlined first and then applied to the problem raised by the findings discussed in the preceding paragraph.

To appreciate the kinds of information about previously-seen objects which may be available in recall, it is necessary to consider briefly the kinds of information which are available in visual perception itself. When we perceive an object we construct an internal model of it, which will be referred to as a *perceptual organisation*. A perceptual organisation has two aspects, both of which enter our awareness. It represents the object as a set of local colour, brightness, and texture properties (that is, it represents the object's appearance). But it also represents the object as a specific meaningful configuration - a square, say, as opposed to something else; this aspect of the perceptual organisation is the result of a particular interpretation of the relationships between basic properties of visual structure. As we apprehend an object in both these ways in perception, we may possibly be retrieving, or re-constructing, two kinds of stored information in recall:

- 1) Stored information about the functional aspects of our original perceptual organisation of the object, for

example, the fact that it was a square, and thus had certain square-like features - four equal sides, four right angles, *etcetera*. It is obvious that all normal human subjects must have at least this kind of abstracted information available in order to recall anything of what they have seen previously. The recall of information about a previous functional interpretation is henceforth termed *functional representation*. It would appear that there are at least two (possibly more) modes of effecting functional representation. Stored information about a previous interpretation of an object as a square could be represented in consciousness by an image of a square, or by the words, "square", "four equal sides", and so on (or by both image and words).

- ii) Stored information about structural aspects, such as colour, brightness and texture properties, which are independent of any *specific* functional interpretation. Because this kind of information is uncommitted to any one functional interpretation, its availability should permit new functional interpretations of ambiguous objects or visual patterns to be made in recall. It is not suggested that information about features of visual structure is an alternative to information concerning a previous functional interpretation, but, rather, that it *may be* retrieved in addition to the latter. The recall of detailed visual information is referred to hereafter as *structural representation*. It is not immediately obvious that the storage of this kind of

information and subsequent structural representation (in recall) actually occur in all, or any, subjects<sup>5</sup>; but such storage and retrieval are theoretical possibilities. *Prima facie*, the only likely candidate for the mode of structural representation is the visual image. Verbal terms, or more abstract modes of awareness, do not capture visual appearances.

Bearing in mind that the distinction above is tentative, let us now consider how it could be used to resolve the problem raised above, namely that the data of the present experiment suggest both i) that information about previously-seen letters can be represented as efficiently in other modes of recall (or representational media) as in the visual image, and, ii) that the visual image conveys information not available through other modes of recall.

This problem can be resolved if we hypothesise that the involvement of the perceptual apparatus in imagery is related to structural representation. If the apparatus of visual perception is employed in imagery, one might reasonably suppose that its use is connected with specifically visual information. However, structural representation would not have been an advantage in carrying out the task of the present experiment; assuming such representation is possible, its advantage is that it makes available the specifically visual information which permits new functional interpretations to be made in recall. To recall and classify the corners of, say, a block F, the subject does not need to interpret this visual

---

5

It is recognised that the concept of structural representation, as it is formulated here, is inconsistent with current theories of memory for visual configurations. This matter is pursued in the following chapter.

pattern as anything other than a block F, which has the usual F-like characteristics of ten corners, rectangularity, *etcetera*; that is, this task requires only that the subject have available a representation of information about the functional interpretation he made in perception. Such a representation is a functional representation, which, as suggested above, can be effected by modes of recall other than the visual image (though it may also be effected by the image as was obviously the case for the "imagers" in this experiment). Thus, it is suggested that the "imagers" did represent more information about the letters than the "non-imagers", but that they performed no better than the latter subjects in the tapping and speaking conditions because the execution of the experimental task did not require the kind of additional information they had available.

Of course, the distinction above, and the explanation which is based on it, are both highly speculative. There is no direct evidence in the data of this experiment to suggest that structural representation does occur, let alone that it occurs only *via* the visual image. These data indicate only that visual imagery utilises the apparatus of visual perception to a greater degree than other representational processes; they do not demonstrate that this greater use of the perceptual apparatus is for the purpose of structural representation. But the hypothetical account presented above seems the only reasonable way of reconciling certain apparently paradoxical features of the present results. Therefore, the ideas proposed in this account are examined in the next chapter.

## CHAPTER 6

### VISUAL IMAGERY AS A PROCESS SPECIALISED FOR THE RECALL OF DETAILED VISUAL INFORMATION: I

#### 6.1 GENERAL INTRODUCTION

Certain apparently contrary results of Experiment IV led to a distinction between functional representation, that is, the recall of stored information corresponding with a prior interpretation of an object or pattern as a particular meaningful whole, and structural representation, that is, the recall of stored information about the visual features of the object, which are independent of any specific functional interpretation and from which, therefore, new functional interpretations can be derived. It was postulated that, whereas functional representation may be effected equally well by several modes of recall (including visual imagery), visual imagery alone is specialised for structural representation.

Although these ideas were derived from the results of Experiment IV, that study did not provide adequate conditions for testing the proposition concerning structural representation (see Section 5.3.8 of the previous chapter). The proposition that detailed visual information is accessed, or reconstructed, by visual imagery processes can be tested only by manipulating imagery in circumstances in which such information is necessary to the execution of the experimental task, that is, in circumstances in which a functional re-interpretation is required in the recall of an object or visual pattern. Experiment V, below, attempted to provide these circumstances.

Subjects classified on imagery ability were presented with ambiguous patterns. The presentation time was limited so that only one functional interpretation of any pattern (e.g., "two overlapping triangles") could be made in the subjects' perception of it. Then they performed a reconstruction task which, on some trials, required that a new functional interpretation of the pattern (e.g., "two overlapping parallelograms") be made. The idea was that, if visual imagery is specialised for the recall of the distinctively visual information which is necessary to derive a new interpretation of a pattern, performance on these trials should be related to visual imagery ability.

In addition to the trials described above, the experiment included trials in which the subjects' reconstructions could be based on the recall of information corresponding with their previous functional interpretations of a pattern. These trials provided the condition for testing the other proposition put forward above, namely that the representation of information about a prior functional interpretation (i.e., functional representation), unlike the representation of information about features of visual structure (i.e., structural representation), can be achieved as efficiently by other modes of recall as by visual imagery. If this proposition is valid, there should be no relationship between visual imagery ability and performance in the latter trials.

## 6.2 EXPERIMENT V: FUNCTIONAL REPRESENTATION, STRUCTURAL REPRESENTATION AND THE VISUAL IMAGE

### 6.2.1 Introduction

As indicated above, this experiment tested a two-part hypothesis, *vis.*: That functional representation is ubiquitous (that is, it occurs in

all normal subjects), and can be effected by modes of recall other than visual imagery; and that structural representation is possible, but is dependent on visual imagery processes.

The second part of the hypothesis is contrary to currently fashionable theories of the storage of visual patterns. These theories state that a visual pattern is stored only as a description of a subject's perceptual organisation of it, which is based on a *particular* interpretation of relationships between its parts (e.g., Reed, 1973, 1974, 1975; Sutherland, 1968). On this view, a subject can recall or recognise only those aspects of a pattern which are parts of his original functional interpretation of it. To illustrate, let us suppose that, when a subject sees the ambiguous pattern in Figure 6.1 (below), he interprets it in a manner corresponding with the verbal description, "two isosceles triangles of the same size which overlap so that the apex of each bisects the base of the other"; according to the theories of Sutherland and Reed, this subject will subsequently recall or recognise the triangles, or parts of them, but will not recall or recognise the parallelograms which can also be abstracted from the pattern. Couched in the present terminology, these theories state that the recall of a visual pattern can only be in terms of functional representation.<sup>1</sup>

---

1

Reed (1974) uses the term "structural description" to refer to the kind of pattern information which he claims is the only information in *storage* - that is, information about a particular functional interpretation of the pattern. The present terms "functional representation" and "structural representation" refer to *recall*, rather than to storage. Even with respect to storage, however, Reed's term is not appropriate in the present context; it does not capture the distinction made here between information about a specific functional interpretation and information about visual features which are not committed to any particular interpretation.

The theories summarised above depend on the kind of evidence provided by Reed (1974). His subjects were presented with an ambiguous pattern. Shortly after its removal, they were presented with a second, more simple pattern which was sometimes a fragment of the first pattern, (i.e., was a "positive fragment"), and at other times was not (i.e., was a "negative fragment"). They were asked to judge whether or not the second pattern was a constituent of the first one.

Reed found that his subjects frequently failed to recognise positive fragments as parts of the ambiguous patterns. This implies that they did not re-interpret the patterns in recall, that is, that they used only information corresponding with previous functional interpretations. However, it does not necessarily imply that the subjects *could* not re-interpret the patterns in recall, although this was Reed's conclusion. They were aware that negative fragments, as well as positive fragments, could be presented to them; being given the choice of accepting or rejecting a fragment as a part of a pattern, they were not forced to re-interpret the latter. In this circumstance, it is not at all surprising that they rejected any positive fragment which was not immediately obvious as such (i.e., which was not consistent with the way the pattern had been functionally interpreted at the time of perception).

The present experiment was based on Reed's study, but was designed to overcome the weakness noted above. As in Reed's experiment, the subject was first presented with an ambiguous pattern. However, the fragment which followed was always a positive fragment and the subject was told that this was the case. Thus, he was not asked to decide if a fragment was a part of an ambiguous pattern. Instead, he was required to reconstruct a pattern around the fragment by drawing its missing parts with a pencil.

The element of re-interpretation which was necessary to test the experimental hypothesis was provided in the following way: Reed's data

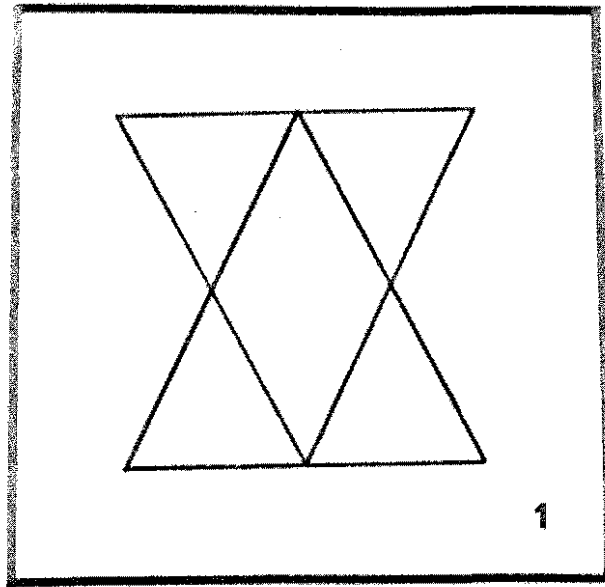
indicate that some functional interpretations of his ambiguous patterns (e.g., the pattern in Figure 6.1) are more likely than others. Thus, for the present experiment it was possible to choose some fragments which are compatible with these common interpretations (e.g., fragment 1a of Figure 6.1) and other fragments which are incompatible with them, the latter being parts of conflicting interpretations (e.g., fragment 1c of Figure 6.1). It was assumed that in the second case the subject would have to re-interpret the ambiguous pattern in recall in order to know where the fragment was situated before he commenced his drawing, but that in the first case no such re-interpretation would be required. In other words, it was assumed that structural representation would be necessary to enable a subject to reconstruct a pattern around an incompatible fragment, but that functional representation would be sufficient to enable him to make his reconstruction around a compatible fragment. Fragments were classified as "compatible" or "incompatible" on the basis of empirical criteria which are described below (6.2.3).

A visual imagery manipulation was also necessary to test the experimental hypothesis. This was again based on individual differences on the V.E.S. In the present experiment the intention from the start was to examine the performance of subjects at all score levels on the scale.

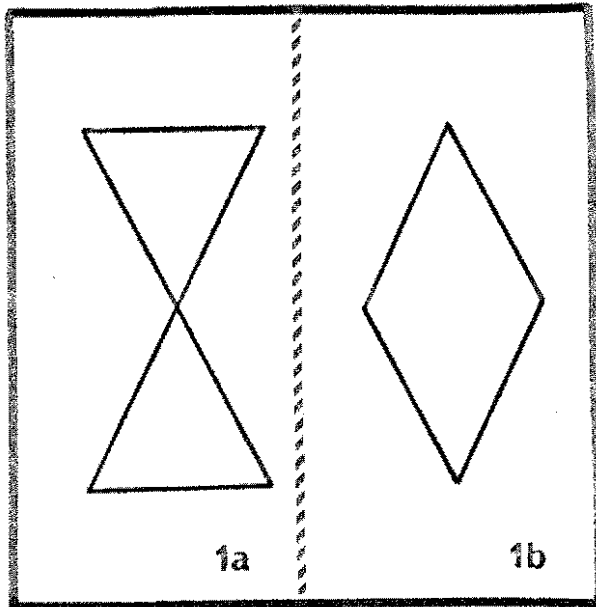
Within the paradigm described above, support for the experimental hypothesis would be indicated if no relationship were found to exist between V.E.S. scores and numbers of correct reconstructions around compatible fragments, but a positive relationship was found to exist between V.E.S. scores and numbers of correct reconstructions around incompatible fragments.

#### 6.2.2 Subjects

The subjects were 63 persons who responded to an advertisement which was posted around the university. This offered \$2.50 in return for



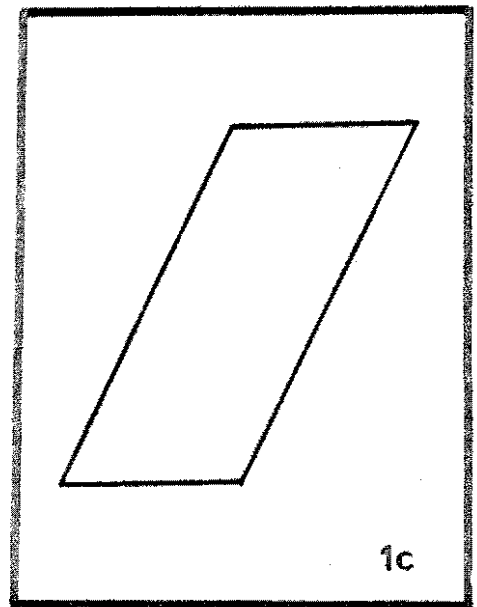
FIRST  
PATTERN



1a

1b

Compatible



1c

Incompatible

FRAGMENTS

FIGURE 6.1 A sample ambiguous pattern, and fragments of it.

answering a "thinking" questionnaire and for participating in a "visual memory" experiment. The composition of the group of subjects was similar to that of the group which participated in Experiment IV.

### 6.2.3 Materials

Four of Reed's (1974) ambiguous geometrical patterns were selected as basic stimuli. Reed's data on his positive fragments of these patterns were examined. A positive fragment which was recognised by more than two-thirds of his subjects (who, it will be recalled, had the option of rejecting it) was taken as being compatible with a common functional interpretation of the ambiguous pattern which had preceded it; a positive fragment which was recognised by less than one-third of Reed's subjects was deemed incompatible with common functional interpretations of the preceding pattern. The examination of Reed's data produced only four compatible fragments and five incompatible fragments.

More positive fragments were obtained from a Reed-type experiment (using negative, as well as positive fragments), which was run with a psychology laboratory class of 22 students. New fragments were abstracted from Reed's ambiguous patterns, and a new ambiguous pattern, together with a set of fragments, was constructed. With the compatibility and incompatibility of positive fragments defined on the same empirical criteria as above, this experiment produced six more compatible fragments, and three more incompatible fragments, giving a total of 10 in the former class, but only eight in the latter. To equate the numbers, two more incompatible fragments were selected by taking two of Reed's positive fragments which were recognised by slightly more than one-third of his subjects.

The compatible/incompatible classification of fragments was verified *post hoc* by:

- i) Comparing the mean number of correct reconstructions

achieved around compatible fragments with that achieved around incompatible fragments. If, as intimated above, all subjects are able to reconstruct patterns correctly around compatible fragments, but only reasonably efficient imagers are able to do so around incompatible fragments, there should be more correct reconstructions around the former than around the latter.

- ii) Comparing the mean time taken to commence correct drawings around compatible fragments after their presentation with the mean time taken to commence correct drawings around incompatible fragments after their presentation. If reconstruction around an incompatible fragment requires a re-interpretation of the pattern preceding it, but reconstruction around a compatible fragment requires no such re-interpretation, it should take appreciably longer to start a correct drawing around the former than around the latter.

Details of these comparisons are reported in the Results section.

The five sets of patterns and fragments are presented in Appendix 5a. One set is shown in Figure 6.1. Each pattern and each fragment was drawn with a black felt pen on a sheet of A4 bond paper, photographed, and processed as a slide. Fragments were shown in the same size, position, and orientation as they had been shown in the patterns from which they were taken.

#### 6.2.4 Apparatus and technical details

The subject sat at a glass-topped table. An image from a Carousel projector was thrown onto this table from below by means of a mirror. The image was projected onto a sheet of A4 bank paper which was placed on the

table within a cardboard frame. On any trial an ambiguous pattern was first projected onto the paper, followed by an interval during which a cardboard blank occupied the slide chamber, followed, in turn, by the projection of a fragment of the pattern. The subject attempted his reconstruction around the image of the fragment on the paper.

The presentation of slides in sets of three, and the presentation time for each slide (see below), were automatically controlled by a modular digital logic system. A trial was initiated by pressing a switch on the experimenter's table. A second switch, which by-passed the automatic control system, enabled a single cardboard blank to be dropped into the slide chamber of the projector between trials.

For the time measure used to verify the classification of fragments, an electronic timer was used; it was started by the onset of the projector's light (*via* a photo cell) when a fragment was projected, and was stopped by the release of a key by the subject when he started his drawing.

#### 6.2.5 Presentation time and order of presentation

As noted above, the presentation time for the ambiguous patterns was selected to enable one, and only one, functional interpretation to be made in the period in which they were displayed. This time was determined from a pilot study run with eight subjects. They were asked to derive as many interpretations as possible for each of the patterns used in the experiment, and were timed while they did so. The presentation time selected from these time data, 1.50 seconds, was almost midway between the mean time taken to make an initial interpretation and the mean time taken to derive additional interpretations. It was assumed that, allowing for individual differences, this would be ample time for a subject to derive one functional interpretation, but still not sufficient time for him to derive more than one, in a single presentation of a pattern.

The presentation of an ambiguous pattern was followed by an interval of three seconds during which a cardboard blank in the slide chamber blocked the projector's light. Finally, a positive fragment was displayed; this remained exposed until a subject had completed his drawing. The experimenter then terminated the trial by pressing the switch which by-passed the modular digital logic system. This caused a cardboard blank to be dropped into the slide chamber. The blank remained in the chamber throughout the inter-trial interval of 10 seconds.

The order of presentation was randomised separately for each subject, with the restrictions that at least two trials intervene between presentations of the same ambiguous pattern, and that no more than two compatible fragments or two incompatible fragments be presented in succession.

#### 6.2.6 Procedure

The V.E.S. was administered to each subject individually before the experiment began, but was not scored until it had been completed.

Subjects were also run individually in the experiment. Before it started a subject was required to copy three visual patterns, to ensure that he had no drawing problems as such.

The subject was then seated at the glass-topped table. He was told how a trial would proceed and was informed of the nature of his task. After being shown how to use the reaction-time key, he was told that he should take the time he needed before he commenced his drawing, but was also encouraged to start drawing (simultaneously releasing the reaction-time key) as soon as he could put in the missing parts of a pattern without further hesitation. Error in drawing was defined as: including lines which were not in the pattern, omitting lines which were in the pattern, and misplacing lines and joins.

It was stressed that no corrections were allowed once a drawing had been started. This constraint was to prevent trial-and-error reconstructions around incompatible fragments, based on previous functional interpretations.

Three practice trials were held with a single Witkin-type pattern and three different positive fragments of it. Before a trial commenced the experimenter said, "Finger down", as a signal for the subject both to press down the reaction-time key and to fix his gaze on the centre of the paper on the glass table.

After the subject had completed his attempt to draw the missing parts of a pattern around a fragment, he was requested to take a pencil of a different colour and to trace in the projected fragment itself. This was to make the scoring of drawings easier. In the inter-trial interval the subject handed the sheet of paper containing his reconstruction of a pattern to the experimenter, and put down a blank sheet in its place.

Following the practice trials, the 20 experimental trials were run following the same procedure.

#### 6.2.7 Results

The performances of two of the 63 subjects were not considered in the data analysis. Both these subjects were unable to make reconstructions of patterns around even the simplest of compatible fragments. Questioning revealed that they felt that the presentation time for the ambiguous patterns was too brief for them to see these patterns as meaningful figures.

The mean V.E.S. score for the remaining 61 subjects was 8.28, with a standard deviation of 3.14.

One point was allotted for each totally correct reconstruction. Scores for the two classes of fragment were analysed separately.

The means for the two measures used in verifying the classification of fragments are presented in Table 6.1.

TABLE 6.1 Mean number of correct reconstructions, and mean times (in seconds) taken to commence correct reconstructions

Class of Fragment	Mean No. Correct	Mean Time
Compatible	7.79	2.26
Incompatible	6.49	3.74

$t$ -tests for dependent groups revealed that the mean number of correct reconstructions around compatible fragments was significantly greater than the mean number of correct reconstructions around incompatible fragments ( $t = 6.653$ ;  $df$ ; 60;  $p < .001$ ), and that the mean time taken to commence correct reconstructions around compatible fragments was significantly less than the mean time taken to commence correct reconstructions around incompatible fragments ( $t = -5.930$ ;  $df$ ; 60;  $p < .001$ ). These results indicate that the classification of fragments was generally appropriate (but see Discussion section).

Mean numbers of correct reconstructions around compatible fragments and around incompatible fragments are plotted separately against V.E.S. intervals in Figure 6.2.<sup>2</sup> The data for individual subjects are tabled in Appendix 5b.

2

Again scores on the dependent variable were plotted against V.E.S. intervals, rather than against single score groups, because of the small number of subjects in some of the latter.

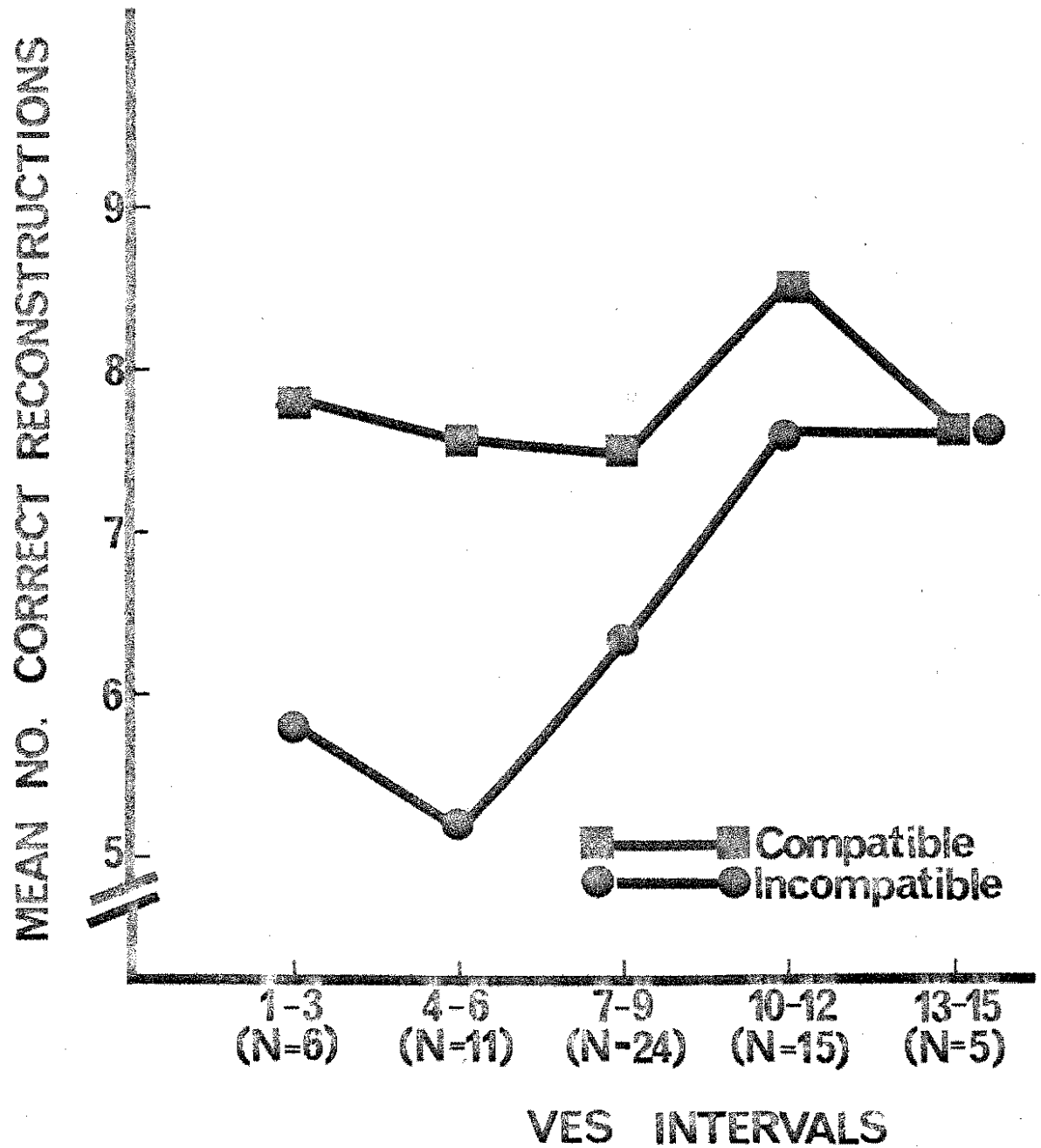


FIGURE 6.2. Mean number of correct reconstructions around compatible fragments, and around incompatible fragments, as functions of V.E.S. scores (grouped).

Both sets of data contributing to the curves in Figure 6.2 were tested for monotonic and bitonic trend using Ferguson's (1965) method of non-parametric trend analysis (see Chapter 5 and Appendix 4b). Each score group from one to 15 was taken as a separate treatment group.

The complete results of the tests for trend are presented in Appendix 5c. No trend was evident in the data for compatible fragments. However, there was a significant monotonic trend ( $p < .00006$ ) in the data for incompatible fragments.

#### 6.2.8 Discussion

The hypothesis tested in this experiment postulated that functional representation occurs in all normal human subjects and is effected by modes of recall other than visual imagery; and that structural representation is possible, but is dependent on visual imagery processes. The dual prediction made from this hypothesis in the context of the present paradigm was supported by the results; that is, there was no relationship between V.E.S. scores and the number of correct reconstructions around fragments which were compatible with common functional interpretations of the ambiguous patterns, but there was a strong positive relationship between scores on the imagery scale and the number of correct reconstructions around fragments which were incompatible with these interpretations.

One doubt remained about the strength of the support provided by the results for the notion that visual imagery is specialised for structural representation. It arose from the fact that, although success with incompatible fragments was related to visual imagery ability, "non-imagery" (i.e., subjects with V.E.S. scores of five or less) were not totally unable to reconstruct a pattern correctly around these fragments. There were twelve subjects within the 1-5 range on the V.E.S. and they averaged 5.08 correct drawings with the ten incompatible fragments.

This raises the question of whether there is some moderately effective alternative to visual imagery for structural representation.

However, a re-examination of the results indicated that the fifty percent success rate of the "non-imagers" with the incompatible fragments may have been due partly to a factor other than the ability for structural representation. The twenty experimental trials were halved with respect to their serial order and it became evident that nearly all the "non-imagers" correct reconstructions around incompatible fragments occurred in the second half of the trials. The proportions of correct reconstructions by the "non-imagers" around these fragments were .31 in the first half of the trials, and .71 in the second half. This was not the case for "good" imagers (eleven subjects with scores of twelve or more on the V.E.S.) for whom the respective proportions were .73 and .78.<sup>3</sup>

This great improvement by "non-imagers" with the incompatible fragments suggests that, during the experiment, they developed a strategy for dealing with such fragments. There was one aspect of the experimental procedure which may have given them the possibility of developing a strategy which was not related to structural representation. The ambiguous patterns were presented several times during the experiment. By the second half of the trials all subjects had seen each pattern once, and some more than once. After failing on a significant number of trials in the first half, "non-imagers" may have tried to perceive a pattern in a different way each time it appeared. Thus, despite the elaborate

---

3

The comparable proportions of correct reconstructions around compatible fragments were .71 and .76 for "non-imagers", and .74 and .82 for "good" imagers. Thus, the vast improvement shown by "non-imagers" with the incompatible fragments in the second half of the trials was not evident in the data for the compatible fragments.

precautions taken against subjects' doing so, the "non-imagers" may have accumulated a repertoire of functional interpretations of a pattern, against each member of which any fragment of the pattern could be tried. In other words, the "non-imagers' " correct reconstructions around incompatible fragments may have been made largely on the basis of functional representation. (Unfortunately, as the analysis of correct drawings according to when they occurred was made completely *post hoc*, questions about the strategy suggested for "non-imagers" were not asked in the experiment.)

It is unlikely that "good" imagers adopted the strategy of re-interpreting patterns each time they were displayed. The proportion of correct reconstructions made by these subjects was much the same in the first half of the trials as in the second half. Thus, they were quite successful with the incompatible fragments in the period before it was possible to build up a repertoire of functional interpretations of a pattern. Because of their initial success, "good" imagers had no real need to try to derive a new functional interpretation each time they saw a pattern.

The explanation offered for the unanticipated success rate of "non-imagers" with incompatible fragments receives some support from the results of an experiment reported in the next chapter. Discussion of the implications of the present experiment for the perceptual nature of visual imagery will be deferred until the next study has been described.

In conclusion, it should be noted that, if it were the case that the "non-imagers" had available some moderately efficient alternative to the visual image for structural representation, this would not seriously weaken the position which has been adopted here. That no relationship was found between V.E.S. scores and the number of correct reconstructions

around compatible fragments indicates that visual imagery has no special role with respect to stored information about how a subject has previously interpreted a visual pattern in functional terms. And the finding of a highly significant positive relationship between V.E.S. scores and the number of correct reconstructions around incompatible fragments indicates that, even if visual imagery is not the only means of retrieving, or reconstructing, stored information about distinctively visual features, it is still the most effective means of doing so.

## CHAPTER 7

VISUAL IMAGERY AS A PROCESS SPECIALISED  
FOR THE RECALL OF DETAILED VISUAL INFORMATION: II

## 7.1 GENERAL INTRODUCTION

Experiment V showed that there was a positive relationship between visual imagery ability and performance on a task which was hypothesised to require structural representation for its execution. However, there was one feature of the method of that experiment which gave subjects the opportunity of referring to functional representations in the second half of the trials. There were plausible reasons for believing that "non-imagers" took advantage of this opportunity while "good" imagers did not - and, hence, for postulating that the dependence of structural representation on visual imagery is even greater than is indicated by the previous data for incompatible fragments. However, this proposition would become even more plausible if alternative evidence of the reliance of structural representation on visual imagery processes could be provided. Experiment VI, reported below, was designed for this purpose.

The experiment used a different paradigm from that employed previously. Patterns were presented a fragment at a time, so that subjects were precluded from making a functional interpretation of a complete pattern at the time of perception. Instead, they were required to make their interpretations at the time of recall. Thus, in the present experiment the strategy of referring to representations of stored functional interpretations (i.e., functional representations) was not possible.

In addition to the "interpretation-in-recall" task, the experiment included a recognition task. Its purpose was to determine if any differences in performance on the recall task were matched by differences in the ability to store visual information. From the standpoint which has been adopted in the present theorising, it would not be expected that storage ability would be related to imagery ability. The visual image has been envisaged here as a medium specialised for the recall of detailed visual information. It could be argued, however, that the image's special role with respect to this kind of information extends to storage - that is, that only "imagers" recall information about visual structure because only these subjects have such information stored. Although the present author is unhappy with the idea that information can be stored as a visual image, this idea is quite common in the literature on imagery. For example, Paivio, while acknowledging the role of the image in recall, also refers to, "... symbolic representations that are stored in long-term memory as concrete memory images" (1971, p. 53); and, indeed, the notion that the visual image is an especially efficient medium for storage, as well as a medium for recall, is implicit in all the literature on the role of visual imagery in verbal paired-associate learning.

## 7.2 EXPERIMENT VI: STRUCTURAL REPRESENTATION WITHOUT FUNCTIONAL REPRESENTATION

### 7.2.1 Introduction

In this experiment, the subject was presented with simple dot patterns. An example is shown in Figure 7.1(a). The dots could be organised visually into lines, so that a functional interpretation of the pattern they formed could be represented by a line drawing (see Figure

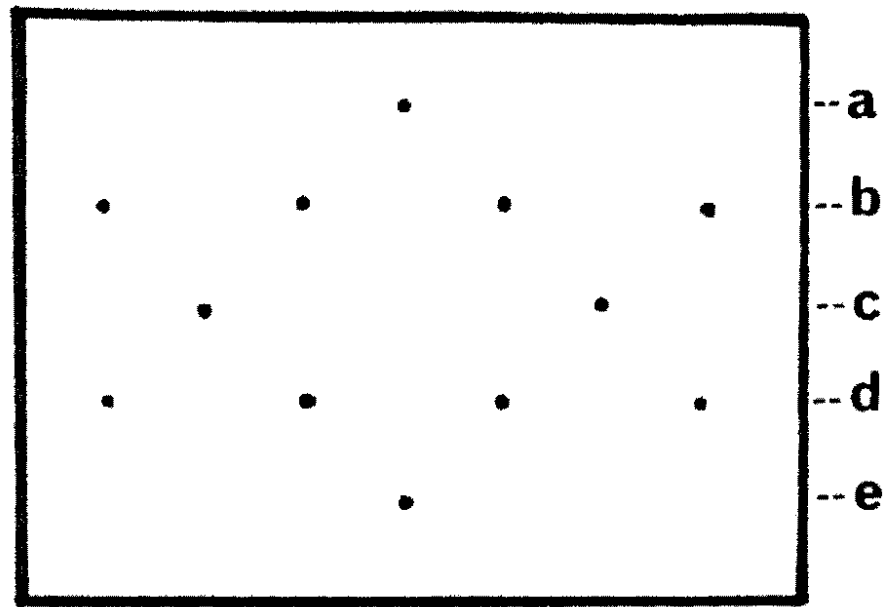
7.1(b). However, as was indicated previously, the subject did not see a complete pattern before the test phase of the experiment. Rather, he was shown the pattern a fragment at a time - specifically, a row at a time (see Figure 7.1(a), where the separate rows are marked a-e). After a subject had seen all the fragments which constituted a dot pattern, he was required firstly to combine them in recall and to represent his interpretation of the pattern they formed by a line drawing, and, secondly, to choose the correct pattern from a recognition set of dot patterns.

It was argued that the task of constructing and interpreting a pattern in recall (subsequently abbreviated as "the recall task") could only be performed if the subject had available a structural representation of the combined fragments of the pattern. He could not refer to a functional representation of a whole pattern before he attempted the task because he had no opportunity to make a functional interpretation of the pattern to serve as the stored basis for such a representation.<sup>1</sup> Thus, it was assumed that an appropriate visual construction could only be achieved by the normal mechanisms of perception (principally those concerned with gestalt principles of proximity, common fate, *etcetera*) operating on an available record of the visual features of a pattern (i.e., a structural representation).

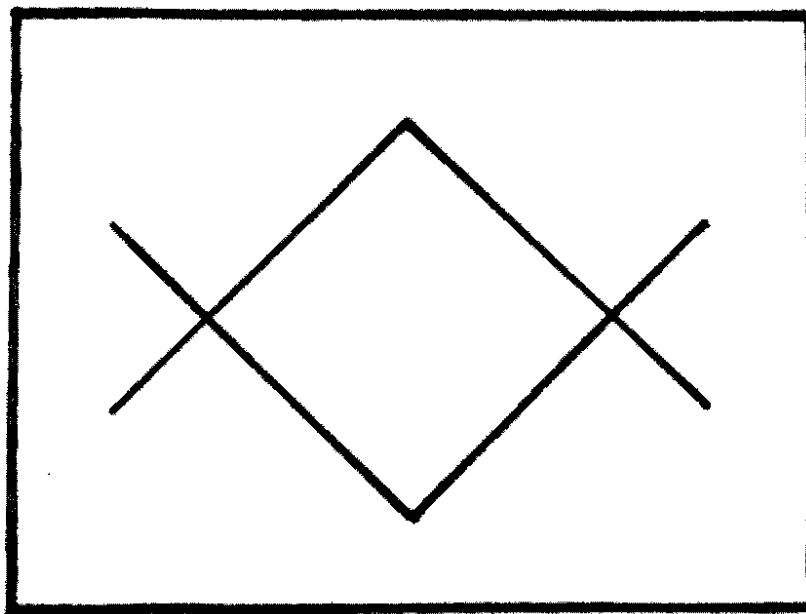
Convergent support for the proposition that structural representation is achieved most efficiently by visual imagery processes

---

<sup>1</sup> An interpretation of each fragment containing more than one point (dot) was, of course, possible. However, as these fragments were rows of a pattern, a subject could not interpret them as anything other than horizontal lines. Far from being helpful to performance in the recall task, functional representation based on interpretations of the separate fragments as horizontal lines is actually antagonistic to it. A premature mental joining of dots horizontally eliminates the possibility that, in the complete gestalt, they may be points of vertical or diagonal lines.



**(a) PATTERN**



**(b) POSSIBLE INTERPRETATION**

FIGURE 7.1 (a) Sample dot pattern (actual size).  
(b) A correct interpretation of the pattern.

would be indicated if, as in the task with incompatible fragments, imagery ability were found to be related to performance on the present recall task. This proposition could be seen as receiving greater support if, with the possibility of referring to functional representations removed, "non-imagers" performed more poorly on this task than they performed overall on the task with incompatible fragments. Although the tasks of the present experiment and the previous experiment differ (the present task introducing a new element by requiring subjects to combine separate items of information in recall), such a finding would be consistent with the explanation offered previously for the "non-imagers' " fifty percent success rate with incompatible fragments.

The recognition task of the experiment was included to clarify the recall *versus* storage issue raised above. To perform this task, the subject did not need to interpret a pattern in memory. The members of a recognition set were dot patterns, rather than line drawings representing possible and impossible interpretations of a pattern. Thus, in order to make a correct choice, the subject had only to have in storage information about the arrangement of the dots in each row of a pattern.

It was assumed that if the visual image is also specialised for the storage of visual information, this should be reflected by a positive relationship between imagery ability and recognition performance, but that if the image is specialised only for the recall of this kind of information - that is, if "non-imagers" have the visual information stored, but have a problem in retrieving and interpreting it - there should be no relationship between these two factors.

### 7.2.2 Subjects

As the results of this experiment were to be related to those of Experiment V, it was decided to use as many of the subjects who had

participated in that study as were still available (after an interval of over two months). It was possible to use 51 of the original 61 subjects in the present experiment. In addition, a "good" imager (V.E.S. score, 14) from another experiment agreed to participate. She replaced a "good" imager (V.E.S. score, 13) who had left Canberra.

The mean V.E.S. score of the 52 subjects was 8.44, with a standard deviation of 3.24.

### 7.2.3 Materials

The basic stimuli for the experiment consisted of 18 dot patterns. They had survived a pilot study in which 24 complete dot patterns were shown to each of 10 subjects. As the experimenter presented each pattern to a pilot subject she asked simply, "What's this?" There were six patterns for which at least one pilot subject was unable to give a meaningful interpretation. These were discarded. A few of the remaining patterns were ambiguous, that is, more than one interpretation was given for them. However, these patterns were retained and allowance was made for ambiguity in scoring the recall task (see Results section).

The patterns were composed of black filled dots made with a felt pen on a 4" x 3" unlined card. Each was constructed within a 5(rows) x 7(columns) matrix of points in which the rows and the columns were each separated by a  $\frac{1}{2}$ " space.

Each of the 18 patterns retained after the pilot study was divided into rows. The dots on each of the five rows were drawn on a separate 4" x 3" unlined card, and occupied the same position on this card as they occupied on the card containing the complete pattern. Points of the matrix which were not filled with the black pattern (stimulus) dots were marked by light pencil dots. The latter were included to draw the subject's attention to the spatial position of the stimulus dots.

Thus, the stimulus material consisted of 18 decks of five cards. Each card in a deck contained the black dots comprising one row of a pattern, together with spatial markers.

A recognition set comprised the correct pattern and three distractors. All members of a set were constructed as dot patterns, but empty locations in the matrix were not marked. Each distractor had at least one row which was identical with a row in the correct pattern; changes were made either by re-arranging the order of the remaining rows or by altering the number and/or position of dots within a row. One pattern and its recognition set are presented in Figure 7.2. The remainder are included in Appendix 6a.

#### 7.2.4 Order of presentation

The cards in a deck were ordered randomly, with the constraint that the rows of a pattern could not be ordered in a top to bottom or bottom to top sequence; for example, the rows in Figure 7.1(a) could be ordered in any sequence except a, b, c, d, e or e, d, c, b, a.<sup>2</sup> To control for the possibility that some orderings of rows are more difficult than others, the fragments of each pattern were presented in the same order to all subjects.

The order of presentation for the 18 decks of cards containing the pattern fragments was randomised independently for each subject.

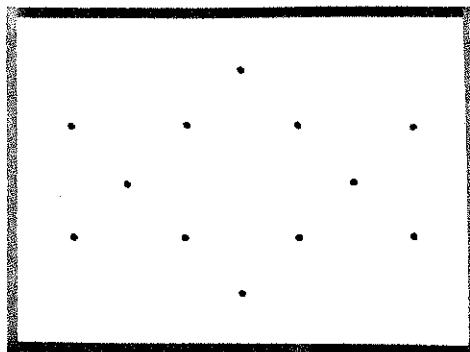
#### 7.2.5 Procedure

The general method of presenting patterns was outlined verbally by the experimenter. The verbal description was illustrated with the

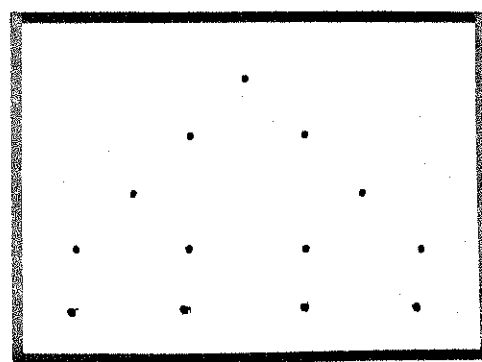
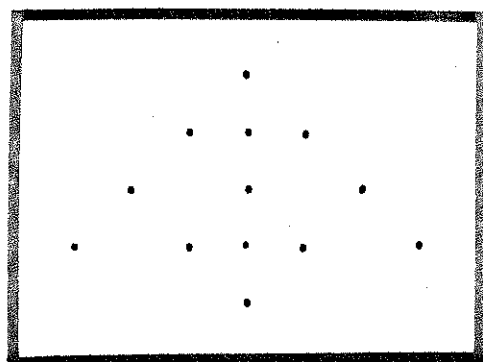
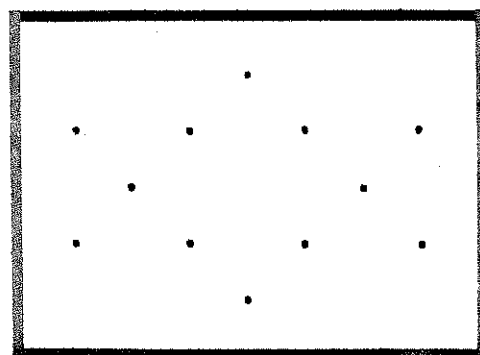
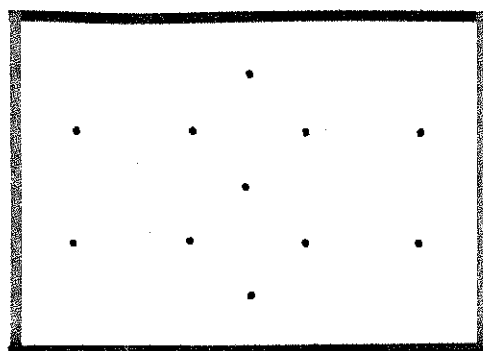
---

2

Fragments containing rows were not marked a-e in the experiment. They are marked in this way in Figure 7.1(a) purely for present illustrative purposes.



**PATTERN**



**RECOGNITION**

**SET**

FIGURE 7.2 A dot pattern and its recognition set (5/8 actual size).

aid of a complete pattern and five fragments which together formed it. The experimenter explained that the patterns could come from several categories (letters, numerals, pictorial representations, geometrical shapes, *etcetera*). Then the recall and recognition tasks were described. It was stressed that, in making his line drawing, the subject was not permitted to put down individual dots and then join them up; his interpretation had to be made "in his head" and not in direct perception. Error in drawing was defined for the subject as: omitting some stimulus dots in the line drawing, drawing lines which could be constructed only by including dots which were not in the fragments, and placing lines in positions which did not correspond with the positions of the stimulus dots. Each type of error was illustrated with an example drawn by the experimenter.

After receiving these instructions, the subject was shown a second complete pattern together with the five fragments which formed it in combination. He was invited to examine the fragments to see how they could be put together to make up the whole pattern. This examination was followed by two practice trials on the recall task and two practice trials on the recognition task.

The 18 experimental trials then commenced. On any trial the subject was handed a deck of cards, face down. He turned the first card, examined it, then placed it to one side face down; turned the second card, examined it, and placed it face down on top of the first card, and so on, until he had seen all five fragments of a pattern. The subject himself controlled the presentation rate. After he had seen all the fragments, he took a 4" x 3" piece of unlined paper and made a line drawing to represent his interpretation of the pattern they formed. He was permitted to take as much time as he thought necessary before he started his drawing.

When the subject had finished the line drawing, it was removed. He was shown the four members of a recognition set in a simultaneous presentation and was asked to make his choice of the correct one. The next trial then started.

#### 7.2.6 Results

One point was allotted for each correct line drawing. Where a pattern was ambiguous, a representation of any possible interpretation of it was taken as correct. For example, the pattern in Figure 7.1(a) can be interpreted in the manner shown in Figure 7.1(b), that is, as an upright V and an inverted V overlapping, or it can be interpreted as a Star of David, or as a six-pointed star without the horizontal lines of the Star of David (*etcetera*). Drawings representing any of these interpretations were accepted.

One point was also given for each correct choice made on the recognition task. Recall and recognition scores were analysed separately.

The mean recall score was 9.62, with a standard deviation of 2.84. The mean recognition score was 16.19, with a standard deviation of 1.48. Individual recall and recognition scores, together with V.E.S. scores, are presented in Appendix 6b.

Recall scores are plotted against V.E.S. intervals in Figure 7.3. Each separate score group on the V.E.S. was again taken as a treatment group and the recall data were tested for trend using Ferguson's (1965) method of non-parametric trend analysis. The tests disclosed a significant monotonic trend ( $p < .00006$ ) in these data, with no bitonic component (see Appendix 6c for details).

An examination of the recall scores of the 10 "non-imagers" (subjects with V.E.S. scores of five or less) who participated in the

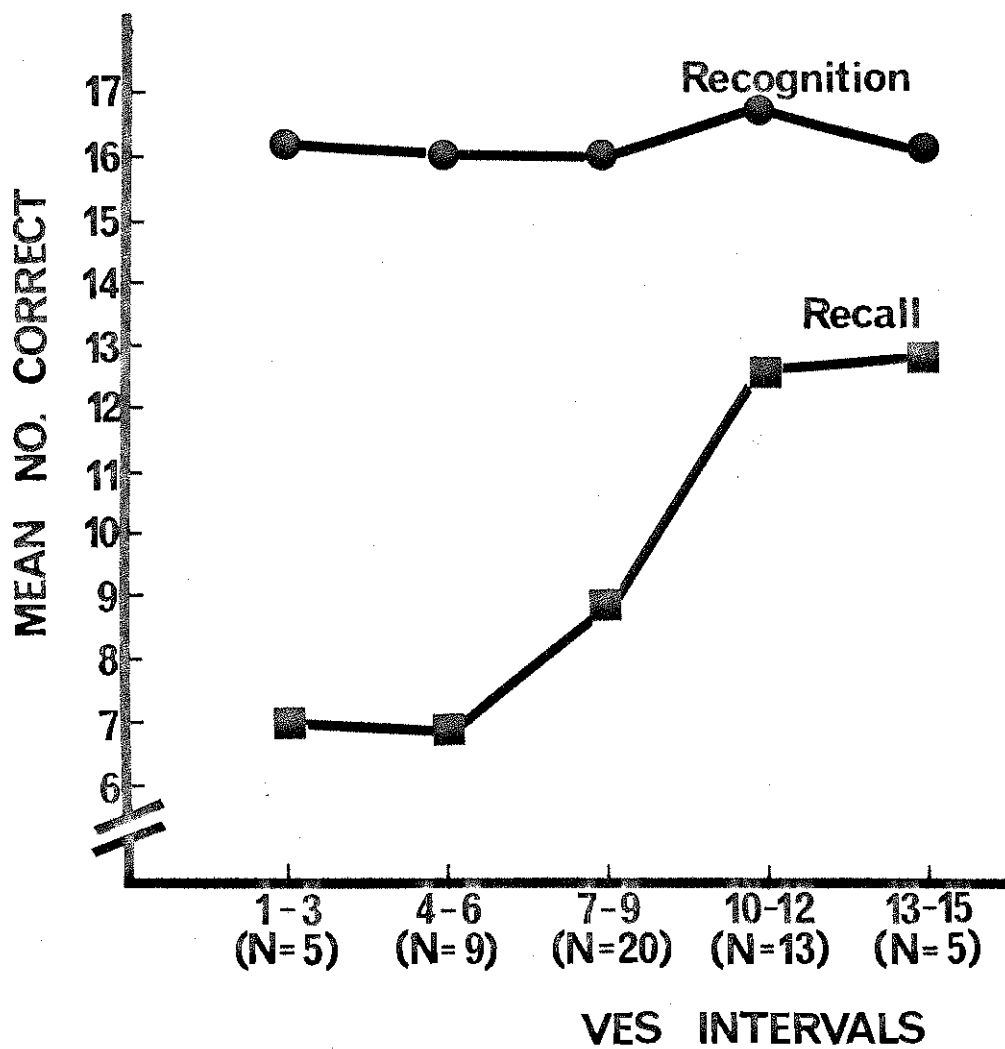


FIGURE 7.3 Mean number of correct recall drawings, and mean number of correct recognition choices, as functions of V.E.S. scores (grouped).

experiment<sup>3</sup> revealed that they averaged 6.6, or approximately 37 percent, correct line drawings. The 10 "good" imagers had a mean of 12.8, or approximately 71 percent, correct drawings.

Thus, the positive relationship between visual imagery ability and performance which was found in the data for incompatible fragments in the last experiment, was replicated in this study. And, while "good" imagers maintained their previous level of performance in the present recall task, the performance of "non-imagers" was poorer here than it was overall with the incompatible fragments.

Recognition scores are also plotted against V.E.S. intervals in Figure 7.3. Analyses for trend showed that there were no significant trends in the recognition data (see Appendix 6c for details).

#### 7.2.7 Discussion

The results of this experiment add weight to the theoretical argument which has been advanced concerning the existence of two types of representation in recall and the role of visual imagery in relation to each.

The recall results roughly parallel the results for the incompatible fragments of Experiment V. However, the present data indicate an even stronger dependence of structural representation on visual imagery than was indicated by the previous data. "Non-imagers" performed more poorly on the recall task here than they performed overall with the incompatible fragments (though, interestingly,

---

3

Two of the 12 "non-imagers" from the previous experiment could not be contacted before this experiment. Also, two of the 11 "good" imagers from the last experiment could not be contacted, but it was possible to replace one of them.

they achieved approximately the same level of success as they achieved with these fragments in the first ten trials of Experiment V).

It might be argued that the poorer performance of "non-imagers" on the present recall task, than on the related task of the last experiment, is reflecting a generally greater difficulty of the former task, rather than providing stronger evidence for the special role of visual imagery in structural representation. This is, of course, possible. But "good" imagers performed at approximately the same level here as they did with the incompatible fragments. This suggests that the drop in the performance of "non-imagers" was related more to the removal of the possibility of their using a strategy which was available to them in the latter half of the preceding experiment, namely that of referring to alternative functional representations. On the previous interpretation of the results for incompatible fragments, one would expect that precluding subjects from referring to functional representations of patterns would affect the performance of "non-imagers", but not that of "good" imagers.

The failure to find a relationship between V.E.S. scores and recognition scores supports the notion that the specialised role of the visual image with respect to distinctively visual information is limited to its recall. Of course, the fact that recognition scores were generally very high may imply that the recognition sets were not capable of discriminating among subjects with varying capacities for the accurate storage of visual information. Alternatively, however, the generally high recognition scores may imply that the storage of such information - at least when it is relatively simple - is highly reliable. Despite the former possibility, that is, that the recognition sets were incapable of reflecting a greater storage accuracy in "imagers" than in "non-imagers", the recognition performance of the latter subjects suggests that they had in storage quite accurate information concerning the visual features of the patterns.

Thus, the recognition results suggest that the storage of information which corresponds in some way with visual features is a normal and reliable concomitant of visual perception. However, the recall results indicate that the subsequent retrieval of such information is not nearly so reliable; this is dependent to a large extent on a person's imagery ability. "Good" imagers are quite readily able to reconstruct and use this information, but "non-imagers" have a very limited capacity for doing so.

Although the retrieval of visual information is difficult for "non-imagers", it is not totally impossible for them. The recall average of the "non-imagers" of the present experiment, while low, was well above zero. It seems that "non-imagers" do not normally retrieve information about visual appearances in recalling objects but that, when they are specifically required to use it, they can sometimes make it available (though not with great reliability). Their method of doing so is not known.

To summarise: This experiment was designed to provide additional evidence for the dependence of structural representation on visual imagery. The procedure for its recall task precluded the use of a strategy which could eliminate the need for structural representation, and which, apparently, was employed by "non-imagers" in the latter half of the last experiment. In this circumstance, the performance of "non-imagers" was very poor, while that of "good" imagers remained at approximately the level they had previously attained. In addition, there was a positive relationship between imagery ability and recall performance. Finally, the difficulty experienced by "non-imagers" in the recall task was not due to a problem in storing the relevant information.

Because the "non-imagers" made some correct line drawings, it still cannot be concluded that visual imagery is the sole mode of structural representation. However, the present results indicate that performance on tasks requiring the representation of the visual features of a pattern is even more strongly related to imagery ability than was apparent from the data of the previous experiment. Thus, it can now be asserted with some confidence that visual imagery is the only really reliable and efficient process for retrieving and representing visual information in recall.

### 7.3 GENERAL DISCUSSION OF THE RESULTS OF EXPERIMENT V AND EXPERIMENT VI

The results of the last two studies provide validation of the constructs of structural representation and functional representation. These were proposed as theoretically distinct types of recall for stimuli originally presented *via* the visual system. The data also indicate that, while functional representation is a normal component of the conscious remembrance of objects or visual patterns, structural representation is an "extra" whose presence is dependent to a large extent on a subject's visual imagery ability.

The findings indicating that structural representation is possible run counter to the theories of Reed (1973, 1974, 1975) and Sutherland (1968) concerning memory for visual patterns. As discussed previously, these theories propose that subjects store a visual pattern only in terms of an abstract description which corresponds with a particular functional interpretation, and that they can recall or recognise only those aspects of the pattern which are parts of this original interpretation.

Reed's (1974) data, which at first glance appear to support the view of Sutherland and Reed, resulted from a paradigm which was loaded against subjects' producing evidence of a capacity for re-interpreting patterns in recall, and hence, of a capacity for structural representation. In the last two experiments of the present thesis it was found that some subjects were capable of achieving not only a *re*-interpretation (Experiment V), but also an *original* interpretation (Experiment VI) of a pattern in recall. These findings suggest that some modification of the Sutherland-Reed thesis is necessary.

The finding that "non-imagers" had a record of detailed visual information stored, although they could not reliably retrieve it, has a wider significance than its support for the present argument that the visual image is specialised only for the recall of distinctively visual features of a stimulus. This finding suggests that the conscious remembering of past visual experience is not so much a problem of how visual information is stored as a problem of how, and in what mode, it is retrieved.

Thus, the results of the last two experiments have implications for current theories of memory for visual patterns, and for the relative importance of storage and retrieval processes for the conscious memory of visual information. However, in the present context, the greatest significance of these results is in relation to the perceptual nature of visual imagery. This is discussed in the next chapter, where the findings of all three experiments of this part of the thesis are integrated.

## CHAPTER 8

### VISUAL IMAGERY AS A PERCEPTUAL PROCESS

#### 8.1 GENERAL INTRODUCTION

In this chapter the results of the preceding experiments are reviewed generally (8.2) and are then interpreted in the context of particular questions. To date, the results of Experiments V and VI have been considered primarily in functional terms. In section 8.3 these results, together with the results of Experiment IV, are considered in relation to the main question of the thesis, namely that of whether or not visual imagery, as subjective visualisation of absent objects, is perceptual in nature. This question is answered in the affirmative, and section 8.4 proceeds to a consideration of the specific ways in which imagery might be perceptual. Finally (8.5) we look briefly at the results in the context of the issue of whether the visual image - in the sense in which it has been defined throughout the present thesis - has functional significance, or whether it is, as Neisser (1967) once suggested, a "cognitive luxury".

#### 8.2 REVIEW OF EXPERIMENTS IV, V AND VI

The major findings of the last three experiments are described below in neutral terms, that is, in terms which are uncommitted to any specific theoretical orientation.

Experiment IV showed that subjects' imagery ability was not related to the time taken to transmit information about absent letters, so long as the mode of output did not require externally-oriented visual

perceptual activity (i.e., in the tapping and speaking conditions of the experiment). However, when the output mode involved visual monitoring of symbols on a response sheet (i.e., in the pointing condition), "imagers" (both "middle" and "good") were significantly slower than "non-imagers" (and "middle" imagers were slower again than "good" imagers).

In Experiment V no relationship was found between imagery ability and performance on the task of reconstructing ambiguous patterns around fragments which were compatible with usual interpretations of the patterns. But where the fragments were incompatible with likely interpretations of the patterns there was a significant positive relationship between imagery ability and performance on the reconstruction task.

Finally, Experiment VI showed that subjects presented with separate and relatively meaningless fragments (rows) of a dot pattern were able to combine these fragments in recall and to make a line drawing representing the complete pattern formed by them - but that their degree of success in doing so was strongly related to their visual imagery ability. However, Experiment VI also showed that there was no relationship between imagery ability and performance on a recognition test which required only that subjects have in storage information about the arrangement of dots in each individual fragment of a pattern (i.e., which did not require subjects to interpret the complete pattern in memory).

These findings are of interest in themselves, that is, irrespective of any particular theoretical interpretation which might be placed on them. However, they resulted from experiments which were designed to test particular theoretical propositions, and have been discussed earlier in theoretical terms. In subsequent sections of this chapter we shall be considering the data above within the framework which has been established previously.

### 8.3 IS VISUAL IMAGERY PERCEPTUAL?

The findings of the last three experiments suggest very strongly that visual imagery is a perceptual process and, concomitantly, that the visual image is a perceptual phenomenon. The most obvious explanation of the finding that "imagers" took significantly longer than "non-imagers" to transmit information about a mentally-represented letter, while concurrently engaging in externally-oriented perceptual activity (Experiment IV), is that visual imagery makes specific use of some of the apparatus of visual perception.

Furthermore, the results of Experiments V and VI suggest that a stimulus perceived on an earlier occasion may be re-interpreted at the time of recall by means of visual imagery. For example, in recalling the pattern shown in Figure 6.1, the "good" imagers of Experiment V appeared to be able to interpret it as two overlapping parallelograms although, as Reed's (1974) data indicate, this is a highly unlikely initial interpretation; and in the recall task of Experiment VI, "good" imagers appeared readily able to combine previously-presented single items - which, in themselves, were relatively meaningless - and to derive thereby meaningful interpretations such as a Star of David.

Thus, the data of the last three experiments indicate that visual imagery uses some of the apparatus of visual perception and that in visual imagery, as in visual perception, functional interpretations can be derived. The first proposition will come as no surprise to some theorists who have insisted, though with little supporting evidence, that "seeing" an absent object must involve the apparatus of visual perception (e.g., Hebb, 1968; Konorski, 1967). However, the second proposition is more controversial. It is generally accepted that interpretations are made only in the presence of the stimulus input which is directly available in perception.

## 8.4 IN WHAT WAYS IS VISUAL IMAGERY

### PERCEPTUAL?

Let us now consider a little more closely the ways in which visual imagery is perceptual. Obviously, it is not possible to give a highly detailed account of the perceptual nature of imagery; such an account presupposes the existence of a detailed theory of visual perception itself and, to date, only very sketchy theories of this process are available. However, there are some generally-accepted propositions concerning visual perception, and it is in relation to these that the present discussion will proceed.

Visual perception is no longer considered a photographic process, that is, a direct and passive registration of the external world. Rather, it is now commonly regarded as an active, constructive process. It seems to involve two stages. In the first stage, pre-conscious processes internalise the pattern of light falling on the retina, or proximal stimulus, and construct a selective model of it. Some writers (e.g., Neisser, 1967) have put forward ideas concerning the nature of this model, which may be termed a "sensory representation", or an "icon" (cf. Neisser, 1967). For present purposes, however, there is no need to commit ourselves to any specific notion of its nature. It suffices to note that what is constructed at this stage is a model of the proximal stimulus and not yet a detailed model of the external scene - that is, the result of this first stage of processing does not directly determine our awareness of the external world.

The second stage of perception involves the construction of a representation of the external scene. This requires the application of processes of interpretation to the sensory representation. These processes result in our awareness of the external scene. It is the *perceptual*

representation constructed at this stage which has been referred to previously as a "perceptual organisation". A perceptual organisation has two aspects, both of which enter our awareness. We are aware of the functional significance of a perceived object (that is, that it is a square, a chair, or Robert Redford), and we are aware that it has certain characteristics of visual structure (brightness, colour, texture). The perceptual organisation may be envisaged as occupying a particular place in the visual processing system, the perceptual representational space, the contents of which determine the nature of our visual awareness at any moment.

With this general sketch in mind, we can now proceed with the discussion of the ways in which visual imagery could be perceptual. One way is suggested by the introspective reports of the "imagers" of Experiment IV, namely that the visual image occupies the same representational space as is occupied by a perceptual organisation (or perceptual representation). These subjects reported that they could not "look at" the letter being recalled and see the symbols on the pointing response sheet at the same time. Their reports suggest that their images of the letters and their perceptual organisations of the contents of the response sheet were competing for the occupation of a single representational space.

If visual imagery were perceptual only in the sense suggested above, the perceptual apparatus would be minimally implicated in it. However, the results of Experiments V and VI imply that more than the perceptual representational space is involved. First, these results suggest that structural representation, that is the representation in recall of information corresponding with features of visual structure, can be effected in visual imagery, in addition to the representation of information corresponding with the manner in which an object has been interpreted in functional terms at the time of perception. (It is

difficult to conceive how "imagers" could interpret patterns in recall if information corresponding with features of visual structure were not available.) Both structural and functional aspects also characterise the nature of our awareness in perception itself. Therefore, it is a reasonable supposition that what have been referred to previously as "imagery processes" are, in fact, some of the constructive processes of visual perception. However, despite an apparent identity of some mechanisms used in visual imagery and visual perception, there remains a distinction between the two processes; in visual imagery these mechanisms make a construction from stored information, rather than from the stimulus input which is available in perception.

Second, the reason for concluding that structural representation occurs in visual imagery is that imaging subjects were able to interpret patterns in recall. Although the interpretation-in-recall tasks of Experiments V and VI were devised originally to investigate whether or not structural representation is achieved in visual imagery, the apparent fact that interpretations of patterns can be made in recall by "imagers" is of considerable interest in its own right. It suggests not only that detailed visual information is represented by the visual image, but also that this information can be used to gain new knowledge of a pattern, in much the same way as the visual information provided by direct sensory input is used in perception itself.

It is suggested, then, that imagery is perceptual in three related ways:

- i) The visual image occupies the same representational space as the organisation, or representation, which is constructed in visual perception itself.

- ii) Some of the processes which construct a perceptual organisation also construct the visual image, as the latter presents to awareness both kinds of information which are present in perception, that is, both structural and functional information.
- iii) The structural information which is available in imagery can be used to derive functional interpretations, in much the same way as stimulus information can be used to derive interpretations at the time of perception.

The last suggestion is contrary to recent cognitive theory (e.g., Reed, 1973, 1974, 1975; Sutherland, 1968) which prefers to regard the original functional interpretation made in perception as virtually immutable (unless, of course, the object in question is seen again on a later occasion). However, this suggestion is in line with common observation; people frequently report that they now view differently something which they have seen previously, that is, that they are now placing a different interpretation on it from the one they derived originally. Many "Aha!" experiences appear to be of this kind.

#### 8.5 IS THE VISUAL IMAGE A COGNITIVE LUXURY?

The results of the experiments of the present thesis suggest that the answer to this question depends very much on the nature of the task the subject is asked to perform, and on the conditions under which he is required to carry it out.

Where a task requires concurrent mental representation and externally-oriented visual perceptual activity, the visual image is a severe disadvantage, rather than a luxury, as is indicated by the poorer performance of "imagers" than of "non-imagers" in the visual interference (pointing) condition of Experiment IV.

Where visual interference is not a problem, whether or not the image is a luxury depends on what sort of stored information is required for the execution of the experimental task. If, to perform the task, the subject need have available only functional information, that is, information about the conclusion he has previously reached regarding the identity of an object, or more general information about how it was functionally interpreted at the time of perception, the image is, in a sense, a luxury; it is not necessary for conveying this kind of information to consciousness, though it may do so. Experiment III showed that where subjects were required only to name objects depicted in previously-seen pictures (i.e., to give the identity of the objects), "non-imagers" who were instructed to verbalise in rehearsal performed just as well as "good" imagers who were instructed to image. In the non-interference (i.e., tapping and speaking) conditions of Experiment IV there was no difference between the performance of "imagers" and that of "non-imagers", but the task of the experiment required only information about a normal functional interpretation of a letter, that is, an interpretation of it *as* a letter. And in Experiment V "non-imagers" were as successful as "imagers" in reconstructing patterns around fragments when the fragments were parts of common interpretations of the patterns.

However, when a task requires subjects to make interpretations in the recall of patterns, the visual image is by no means a luxury. It is the only really efficient medium for consciously representing the information about visual structure which permits interpretations to be made in recall. When the subjects of Experiment V had to re-interpret patterns in functional terms in order to perform the reconstruction task, "imagers" had a distinct advantage over "non-imagers", and the advantage increased with increases in imagery ability. And in Experiment VI, where subjects were required to derive original functional interpretations in

recall, "imagers" again had an advantage over "non-imagers" who, in general, performed very poorly.

It is often noted (e.g., Neisser, 1970, 1972; Richardson, 1969) that experiments using individual differences in "imagery-as-experience" as a basis for manipulating visual imagery have produced inconsistent results. Sometimes these differences have been found to be related to task performance, and sometimes they have not. If the experiments producing contradictory results were to be analysed with respect to the conditions of carrying out their tasks (i.e., with respect to whether or not visual perception is necessary to task performance), and with respect to the tasks' informational requirements, it might become possible to reconcile the inconsistencies. (This suggestion is made on the presumption that the individual differences measures in question are appropriate.)

## CHAPTER 9

### CONCLUDING COMMENTS

#### 9.1 INDIVIDUAL DIFFERENCES IN VISUAL IMAGERY

There has been considerable pessimism concerning the possibility of using individual differences in "imagery-as-experience" as a tool for studying visual imagery (e.g., see Neisser, 1970). However, it was found in Experiments I and II that such differences would provide a relatively good method for studying the nature of visual imagery, and they were so used in this investigation. Problems with the individual differences measure employed in the first two experiments, namely the visual section of the revised Betts' Q.M.I. (Sheehan, 1967), led to the construction of a new measure of subjects' ability to generate images, the Visual Elaboration Scale (V.E.S.). The pattern of the results obtained in Experiments III - VI provided a validation of the V.E.S., and also of the general technique of using differences in "imagery-as-experience" in experimental work.

Thus, previous problems encountered in using individual differences in studies of visual imagery appear not to stem from the irrelevance of the individual differences themselves, but, rather, appear to reside largely in the instruments which are used to measure them.<sup>1</sup>

---

<sup>1</sup> Another problem is that insufficient attention has been given to devising tasks on which "imagers" and "non-imagers" might reasonably be expected to perform differently (see Chapter 8).

For example, vividness scales, such as the Q.M.I. and the Vividness of Visual Imagery Questionnaire (Marks, 1973), i) require subjects to give ratings on a dimension which (in subjects' minds) may be a dimension of modes of recall other than visual imagery and, ii) require subjects to provide their own standards for responding. Informing subjects that, say, a "moderately clear and vivid" mental experience should be given a rating of 3 does not solve the second problem; subjects still have to decide for themselves what kind of experience falls into this category. The V.E.S. was designed specifically to overcome problems such as these (see Chapter 3).

## 9.2 ARE LOW SCORERS ON THE V.E.S. REALLY NON-IMAGERS?

In preceding theoretical analyses it has been assumed that very low scorers on the V.E.S. are non-imagers, rather than weak imagers. There is no direct proof of the validity of this assumption. However, protocols and taped post-experiment interviews suggest strongly that the very low scorers on the V.E.S. were persons who are unable to generate visual images or who, at the very least, were not imaging during the experiments. For example, the low scorers who participated in Experiment IV did not report, as did higher scorers, that looking at the pointing response sheet "broke up" mental pictures of the letters being recalled; and the reports of the imagery-instructed low scorers of Experiment III indicated that they were simply unable to obey their instructions.

It is sometimes claimed that non-imagers do not exist, and that subjects who classify themselves as such do so only because they misunderstand the questions put to them by researchers (e.g., Bower, 1972).

If "imagery" is taken to mean "the recall of material presented originally through the visual system", this claim is obviously correct - we all remember something of our perceptual experiences. But if the term "imagery" is taken to refer to the subjective experience of visualising absent objects, Bower's contention is questionable. Although it does not provide direct proof of the claim that there are non-imagers, the present study suggests that there are some persons who, to all intents and purposes, are non-imagers in the second sense outlined above. These apparent non-imagers constituted roughly twenty percent of the subject population.

### 9.3 WHAT IS THE NATURE OF THE STORED STRUCTURAL INFORMATION WHICH IS RETRIEVED IN VISUAL IMAGERY?

It was argued previously (Chapter 5) that the use of the processes of visual perception in visual imagery is concerned primarily with retrieving and reconstructing structural information, rather than with retrieving the functional information which is also conveyed to consciousness by means of imagery. However, the question of the nature of the stored structural information which is retrieved (and which may be re-interpreted) has not been discussed.

It is evident that such structural information is stored as the result of visual perceptual activity. In the last chapter we noted that two constructions are made in visual perception - a model of the proximal stimulus, or sensory representation; and a perceptual organisation, or representation of the external scene, which has both structural and functional aspects. It appears likely that it is information corresponding with one of these constructions which is stored and later retrieved in imagery.

In perception the constructive and interpretative processes which result in our awareness of the external scene are applied to a sensory representation. Therefore, one is tempted to hypothesise that the processes which result in visual awareness of an absent object are involved in retrieving and reconstructing a stored sensory representation. However, there are problems with this hypothesis. It represents the "pictorial" view of imagery of which Pylyshyn (1973) is so critical - that is, the view that people store "raw" sensory data which are totally re-perceived in visual imagery (see Chapter 1). Pylyshyn advances two arguments against this notion, namely that the storage of such data would over-tax the storage capacity of the brain, and that storage in these terms would create retrieval difficulties. Another argument which might be advanced against the hypothesis is based on studies of visual masking (e.g., Sperling, 1963) and post-stimulus cue-ing (e.g., Averbach and Coriell, 1961; Sperling, 1960). The limitations on subjects' performance observed in these studies appear inconsistent with the storage of a complete sensory record of the stimulus array (although they are not inconsistent with the storage of a fragmentary sensory record of the items read out).

As noted above, the obvious alternative candidate for the stored structural information which is retrieved, and sometimes re-interpreted, in visual imagery is information corresponding with the structural aspect of a perceptual organisation - that is, information concerning how a subject previously organised a stimulus in structural terms, or how an object *looked* (to him) at the time of perception. Unlike the previous hypothesis, this hypothesis does not imply that a completely original perceptual organisation is constructed in imagery; it implies that an organisation which is similar in structural and functional aspects to one which has been constructed in perception is *reconstructed* in

imagery - but that it can take on a new functional aspect in addition to its original one. However, this hypothesis raises a problem of its own: it is difficult to know what mechanisms could be applied to the imaginal reconstruction to derive the new interpretation. (One might, perhaps, conceive of these as pictorial equivalents of Chomsky-type linguistic transformations.)

No judgement can be made on which of these hypotheses is correct (or, indeed, on whether they exhaust the possibilities of the structural information which might be stored). In the current theoretical climate, the second hypothesis appears more attractive than the first. However, despite the apparently serious problems of the first hypothesis, one is inclined to feel that it should not be written off entirely.

#### 9.4 WHY DO "GOOD" IMAGERS MAKE ERRORS IN RECALL?

Previous discussions have emphasised the potential advantage afforded by visual imagery in retrieving and representing information about visual structure, in addition to more general functional information. If "good" imagers have access to distinctively structural information, one might expect that they would make only certain types of error in recall, namely, i) errors resulting from a failure to perceive a complete scene originally and ii) errors resulting from a gradual loss of visual information over time (i.e., omissions of detail). It is clear, however, that "imagers" make other kinds of error. For example, Bartlett (1932) reports that visualisers confabulate: his visualising subjects added features to the original stimulus and changed features of it.

However, the fact that even "good" imagers make recall errors other than errors of omission is not a serious problem. Nor does it mean

that "imagers" do not, after all, have structural information available in recall. It appears that the nature of any internal construction which a subject makes is determined not only by the data which are available to him, but also by his own cognitive structures, or "schemata" (cf. Bartlett, 1932). These schemata can introduce bias and distortion into perception itself, where structural information is evidently present (as when, for example, the small bush on the side of the road is seen as a dwarf). Thus, it is reasonable to suppose that they can sometimes introduce bias and distortion into "imagers' " recall of stimuli, despite the fact that these subjects have structural information available.

#### 9.5 HOW DO "NON-IMAGERS" INTERPRET STIMULI IN RECALL?

The present study has not been concerned directly with the performance of "imagers" and "non-imagers" as such, but, rather, with what the *differences* in performance between these groups tell us about the nature of visual imagery. However, an interesting problem is raised by the fact that, although it was difficult for "non-imagers" to re-interpret stimuli in recall, it was not completely impossible for them to do so.

The investigation of what "non-imagers" do in recalling visual stimuli was outside the scope of the empirical work of this thesis. But, in an attempt to provide some insight into the matter, subjects were questioned casually at the end of Experiment VI (the dot pattern experiment). "Imagers" tended to report that their successes with the dot patterns were based on visualising the fragments together. However, "non-imagers" tended to report that on their few successful trials they "just knew" that a pattern was, say, a diamond or an arrow. Their reports were

reminiscent of the unhelpful comments made by the "non-imagers" of Experiment IV.

Thus, even the beginnings of a solution to the problem raised above escape us. Apart from the obvious fact that it contains functional information (cf. Experiments III, IV and V), visual memory in "non-imagers" remains an enigma.

APPENDIX 1  
EXPERIMENT I

## APPENDIX 1a.

SENTENCES PAIRS USED IN EXPERIMENT 1.<sup>1</sup>

1. a) The theory has both answers and opinions.  
b) The library has both newspapers and letters.
2. a) These positions need minds with plenty of ideas.  
b) These women need friends with plenty of dollars.
3. a) There is a fault in his knowledge of the method.  
b) There is an engine in his square of the building.
4. a) The hypothesis contained perceptions and deductions.  
b) The poster contained bouquets and pianists.
5. a) To the unbeliever, this attitude is a hindrance.  
b) To the acrobat, this bar is a hurdle.
6. a) The proxy required aptitude and deceit to carry out his task.  
b) The doorman required missiles and tomahawks to carry out his task.

---

<sup>1</sup>  
Sentence a) is always the abstract (low item imagery) sentence.

## APPENDIX 1b.

## SCORES FOR RECALL OF CONCRETE AND ABSTRACT NOUNS

Group 1. "Good" imagers with imagery instructions.

S	Av. Q.M.I. rating	Noun recall	
		Concrete	Abstract
1	1.0	11	6
2	1.0	9	2
3	1.0	10	3
4	1.0	11	8
5	1.0	11	6
6	1.2	12	7
7	1.4	8	6
8	1.4	11	7
9	1.0	11	9
10	1.6	11	7
$\bar{X}$	1.16	10.5	6.1

Group 2. "Good" imagers with verbalisation instructions.

S	Av. Q.M.I. rating	Noun recall	
		Concrete	Abstract
1	1.0	7	3
2	1.0	8	0
3	1.0	9	7
4	1.2	8	4
5	1.0	8	1
6	1.4	10	5
7	1.4	6	4
8	1.4	9	5
9	1.4	10	4
10	1.6	10	3
$\bar{X}$	1.24	8.5	3.6

## APPENDIX 1b. (continued)

Group 3. "Poor" imagers with imagery instructions.

S	Av. Q.M.I. rating	Noun recall	
		Concrete	Abstract
1	4.4	11	8
2	4.2	10	3
3	3.8	12	4
4	3.8	8	2
5	3.6	9	3
6	4.6	9	3
7	4.0	8	6
8	3.8	10	2
9	3.8	9	7
10	3.6	10	2
$\bar{x}$	3.96	9.6	4.0

Group 4. "Poor" imagers with verbalisation instructions.

S	Av. Q.M.I. rating	Noun recall	
		Concrete	Abstract
1	4.4	12	7
2	4.0	11	0
3	3.8	11	2
4	3.6	11	4
5	3.6	11	2
6	4.0	9	1
7	4.4	8	5
8	4.0	7	6
9	3.8	6	7
10	3.6	9	8
$\bar{x}$	3.92	9.5	4.2

APPENDIX 2

EXPERIMENT II

## APPENDIX 2a.

## QUESTIONS FOR PICTURE RECALL

(The first question in each pair is the "position" question, the second the "detail" question. A "detail" question was asked only if the "position" question was answered correctly.)

Picture 1. (Aeroplane)

- i) a) What was at the left of the aeroplane? (Crescent moon)
- b) What was inside the crescent moon?

Or

- ii) a) What was in the middle of the aeroplane? (Kite)
- b) Where was the kite's tail?

Or

- iii) a) What was at the right of the aeroplane? (Target or bull's eye)
- b) How many circles enclosed the central dot of the target or bull's eye?

Picture 2. (Box)

- i) a) What was at the left of the box? (Cup or mug)
- b) How was the mug decorated?

Or

- ii) a) What was in the middle of the box? (Apple)
- b) Where was the apple set relative to the other two objects on the box?

Or

- iii) a) What was at the right of the box? (Key)
- b) Which way were the key's teeth pointing?

Picture 3. (Flag)

- i) a) What was at the left of the flag? (Flower)
- b) How many petals did the flower have?

Or

## APPENDIX 2a. (continued)

Picture 3. (Flag) (continued)

- ii) a) What was in the middle of the flag? (Shield)
- b) Name anything that was on the shield.

Or

- iii) a) What was at the right of the flag? (Star of David/Star)
- b) How many points did the star have?

Picture 4. (Jersey)

- i) a) What was the outline shape at the top of the jersey? (Square)
- b) What was inside the square?

Or

- ii) a) What was the outline shape in the middle of the jersey?  
(Triangle)
- b) In what orientation was the triangle?

Or

- iii) a) What was the outline shape at the bottom of the jersey? (Circle)
- b) What was inside the circle?

Picture 5. (Fence)

- i) a) What was at the top of the fence? (Notice or poster)
- b) What was at the top of the notice?

Or

- ii) a) What was in the middle of the fence? (Love heart)
- b) In which direction was the arrow pointing?

Or

- iii) a) What was at the bottom of the fence? (Bucket)
- b) Where was the bucket's handle?

Picture 6. (Tower)

- i) a) What was at the top of the tower? (T.V. antenna)
- b) How many cross-bars did the antenna have?

Or

## APPENDIX 2a. (continued)

Picture 6. (Tower) (continued)

- ii) a) What was in the middle of the tower? (Clock)
- b) What was the time on the clock?

Or

- iii) a) What was at the bottom of the tower? (Door)
- b) Where was the doorknob?

## APPENDIX 2b.

## SCORES FOR "POSITION" AND "DETAIL" RECALL OF PICTURES

Group 1. "Good" imagers with imagery instructions.

S	Av. Q.M.I. rating	Picture recall	
		Position	Detail
1	1.0	4	2
2	1.0	6	5
3	1.0	4	4
4	1.0	5	4
5	1.0	4	3
6	1.2	6	5
7	1.4	5	3
8	1.4	6	5
9	1.0	5	5
10	1.6	3	3
$\bar{X}$	1.16	4.8	3.9

Group 2. "Good" imagers with verbalisation instructions.

S	Av. Q.M.I. rating	Picture recall	
		Position	Detail
1	1.0	3	1
2	1.0	6	6
3	1.0	5	4
4	1.2	2	2
5	1.0	4	3
6	1.4	3	2
7	1.4	6	3
8	1.4	5	4
9	1.4	5	5
10	1.6	6	4
$\bar{X}$	1.24	4.5	3.4

## APPENDIX 2b. (continued)

## Group 3. "Poor" imagers with imagery instructions

S	Av. Q.M.I. rating	Picture recall	
		Position	Detail
1	4.4	5	1
2	4.2	5	5
3	3.8	5	4
4	3.8	2	1
5	3.6	5	5
6	4.6	5	4
7	4.0	5	3
8	3.8	5	3
9	3.8	5	4
10	3.6	5	3
$\bar{x}$	3.96	4.7	3.3

## Group 4. "Poor" imagers with verbalisation instructions.

S	Av. Q.M.I. rating	Picture recall	
		Position	Detail
1	4.4	4	3
2	4.0	6	4
3	3.8	2	1
4	3.6	4	4
5	3.6	6	6
6	4.0	5	4
7	4.4	5	3
8	4.0	5	2
9	3.8	5	2
10	3.6	6	2
$\bar{x}$	3.92	4.8	3.1

APPENDIX 3  
EXPERIMENT III

## APPENDIX 3.

## SCORES FOR "POSITION" RECALL OF PICTURES

Group 1. "Good" imagers with  
imagery instructions

S	V.E.S. score	Recall
1	13	4
2	13	3
3	12	5
4	13	5
5	12	6
6	14	3
7	13	5
8	13	2
9	12	5
10	12	3
$\bar{X}$	12.7	4.1

Group 3. "Poor" imagers ("non-imagers")  
with imagery instructions

S	V.E.S. score	Recall
1	3	1
2	4	1
3	4	2
4	2	4
5	5	2
6	2	2
7	5	2
8	5	2
9	4	2
10	2	2
$\bar{X}$	3.6	2.0

Group 2. "Good" imagers with  
verbalisation instructions

S	V.E.S. score	Recall
1	15	6
2	12	6
3	12	4
4	14	3
5	13	5
6	12	5
7	13	3
8	12	3
9	13	4
10	13	4
$\bar{X}$	12.9	4.3

Group 4. "Poor" imagers ("non-imagers")  
with verbalisation instructions

S	V.E.S. score	Recall
1	3	4
2	5	4
3	5	4
4	5	4
5	4	5
6	2	6
7	4	4
8	2	3
9	5	6
10	1	4
$\bar{X}$	3.6	4.4

APPENDIX 4

EXPERIMENT IV

## APPENDIX 4a.

## TIMES TAKEN TO TRANSMIT INFORMATION IN EACH OUTPUT

MODE<sup>1</sup>

S	V.E.S. score	Output times (seconds)		
		Tapping	Speaking	Pointing
1	8	7.16	4.76	16.96
2	12	13.23	10.96	18.29
3	8	9.60	5.35	18.99
4	8	8.60	10.20	26.82
5	8	8.42	6.98	20.32
6	13	6.12	7.52	12.99
7	8	8.51	8.77	16.21
8	5	7.78	8.17	13.70
9	2	8.73	4.37	13.53
10	11	11.37	11.47	16.07
11	4	14.36	11.93	22.85
12	13	10.74	5.32	16.65
13	12	6.69	7.34	16.09
14	7	9.53	8.05	15.79
15	9	9.78	9.29	21.18
16	10	4.85	4.00	9.43
17	14	8.85	8.61	14.92
18	7	5.44	4.78	10.69
19	5	7.19	6.76	13.41
20	6	10.18	7.73	19.52
21	13	14.50	12.96	23.00
22	4	8.91	7.30	13.54
23	6	8.23	9.05	17.90
24	9	11.54	7.66	16.53
25	3	7.72	6.41	13.79
26	7	7.30	6.08	12.36
27	9	11.51	9.51	18.91
28	10	13.97	8.11	18.74
29	11	10.71	7.36	14.02
30	11	5.98	4.43	9.12

<sup>1</sup> Each score represents the average time over three trials in an output mode.

## APPENDIX 4a. (continued)

S	V.E.S. score	Output times (seconds)		
		Tapping	Speaking	Pointing
31	8	11.41	10.54	20.21
32	12	8.20	6.14	15.86
33	5	6.40	7.32	9.01
34	5	7.49	8.02	11.37
35	13	8.15	8.05	15.71
36	11	10.77	10.54	23.17
37	7	12.41	12.20	25.92
38	6	10.12	9.68	23.62
39	2	6.88	8.41	9.58
40	9	5.12	5.08	14.88
41	12	7.31	7.06	15.89
42	8	9.85	7.14	26.15
43	6	10.40	7.96	21.37
44	7	6.11	5.73	14.26
45	15	9.73	9.48	17.65
46	6	9.95	7.90	14.72
47	12	10.66	8.45	26.82
48	4	5.52	6.23	8.90
49	12	6.73	5.51	18.35
50	12	6.67	5.58	13.77
$\bar{X}$	8.50	8.94	7.77	16.79

## APPENDIX 4b.

## NON-PARAMETRIC TREND ANALYSIS

Ferguson's (1965) non-parametric trend analysis provides a test of relationships between two variables  $X$  and  $Y$ . It is non-parametric in the sense that it is applied when one (or both) of the variables is (are) ordinal. It is capable of distinguishing between monotonic (one branch), bitonic (two branch), tritonic (three branch) - *etcetera* - functions, but gives no information about the specific forms of the functions.

The analysis is based on ranks and employs the sampling distribution of the statistic  $S$ , as used in the definition of Kendall's coefficient of rank correlation, tau (Kendall, 1948).

$S$  describes disarray in a set of ranks paired on  $X$ ,  $Y$ . To compute this statistic the values of the  $X$  variable are ranked from lowest to highest as are the values of the  $Y$  variable. Each pair of ranks is then compared with every other pair. For each comparison of pairs of ranks a weight of +1, -1, or 0 is assigned according to the following rule:

- +1 if the order of the  $X$  ranks is the same as that of the corresponding  $Y$  ranks.
- 1 if the order of the  $X$  ranks is opposite to that of the corresponding  $Y$  ranks.
- 0 if the  $X$  ranks and/or the corresponding  $Y$  ranks are equal.

For example, for a comparison of the paired ranks  $X:3$ ,  $Y:20$  and  $X:7$ ,  $Y:25$ , the weight assigned is +1; for a comparison of the paired ranks  $X:7$ ,  $Y:20$  and  $X:3$ ,  $Y:25$ , or a comparison of the paired ranks  $X:3$ ,  $Y:25$  and  $X:7$ ,  $Y:20$ , the weight is -1; and for a comparison of the paired ranks  $X:3$ ,  $Y:25$  and  $X:3$ ,  $Y:25$ , or of the paired ranks  $X:3$ ,  $Y:20$  and  $X:3$ ,  $Y:25$ , or of the paired ranks  $X:3$ ,  $Y:20$  and  $X:7$ ,  $Y:20$ , the weight is 0.  $S$  is the sum of the weights over all comparisons of  $X$ ,  $Y$  pairs.

## APPENDIX 4b. (continued)

Commonly (particularly where  $X$  is an experimentally manipulated variable) there are many ties on  $X$  and the data may be regarded as a set of samples of  $Y$  which are ordered in relation to  $X$ . Under these circumstances, there are tabular procedures for calculating  $S$  (see Ferguson, 1965).

The significance of the relation between  $X$  and  $Y$  can be calculated by referring  $S$  (or the corresponding tau) to special tables for  $N < 10$  (Kendall, 1948). However, for  $N \geq 10$ , the sampling distribution of  $S$  (or tau) approximates the normal distribution (Kendall, 1948, pp. 38-39), and in these cases the significance of  $S$  can be tested by referring the ratio  $z = S/\sigma_S$  to standard tables of the normal distribution (with a correction of  $S$  for continuity). The expressions for computing the standard error of  $S$  (with, and without ties on the ranks of the two variables) are given by Ferguson (1965, p. 11, p. 13).

Where samples of  $Y$  for different levels of  $X$  are independent (i.e., based on different subjects), as in the present research, Ferguson's trend analysis proceeds as described above, with one difference. The values of the dependent variable  $Y$  are ranked as before according to their natural order, but the values of the independent variable,  $X$ , are ranked according to their orthogonal polynomial weights for the number of different levels of  $X$ , and the desired trend. For monotonic trend these ranks for  $X$  in fact follow natural order, but for other trends they do not. For example, take the following values of  $Y$ . These have been sorted into three samples corresponding to increasing levels of  $X$ . (This example is taken from Ferguson, 1965.)

Sample I:	3	7	11	16	22	29	31	36	
Sample II:	3	4	7	18	19	32			
Sample III:	22	38	46	47	47	50	53	54	56

## APPENDIX 4b. (continued)

To test for monotonic trend we first consult the tables of orthogonal polynomials (Fisher and Yates, 1963, pp. 98-108), and discover that, for three levels of an independent variable and a test for a single branch function, the polynomial weights are -1, 0, +1. These are ranked 1, 2, 3. Thus, the data can be represented by a set of paired ranks, as follows:

Sample I: X: 1 1 1 1 1 1 1 1  
 Y: 1.5 4.5 6 7 10.5 12 13 15

Sample II: X: 2 2 2 2 2 2  
 Y: 1.5 3 4.5 8 9 14

Sample III: X: 3 3 3 3 3 3 3 3 3  
 Y: 10.5 16 17 18.5 18.5 20 21 22 23

Here the X ranks are ordered with respect to other X ranks; only comparisons of pairs of Y ranks are necessary. As the X ranks are in natural order, a weight of +1 is assigned if a pair of Y ranks is in natural order, a weight of -1 is assigned if a pair of Y ranks is in inverse order, and a weight of 0 is assigned if the ranks of a pair are equal. The value of  $S$  is:  $S = 14 + 10 + 9 + 9 + 4 + 3 + 3 + 1 + 9 + 9 + 9 + 9 + 9 + 7$   
 $= 105$

The value of 14 is obtained by comparing the first Y rank for Sample I, 1.5, with all Y ranks for Samples II and III. The rank 1.5 in Sample I is not compared with other Y ranks for that sample, because all such values in Sample I are tied on X (and so comparisons of them are assigned a weight of 0 - see above). The value of 10 is obtained by comparing the second Y rank for Sample I with all Y ranks for Samples II and III - and so on, until the final value of 7 is obtained by comparing the last Y rank in Sample II with each Y rank in Sample III.

## APPENDIX 4b. (continued)

To test for bitonic trend in the same data, we again consult the Fisher and Yates tables for orthogonal polynomials. For three levels of an independent variable, and a test for a two branch function, the values of the polynomial are 1, -2, 1, which are ranked 2.5, 1, 2.5. Again the values of the dependent variable are ranked according to their natural order. The data for bitonic trend are represented as follows:

Sample I:	X:	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
	Y:	1.5	4.5	6	7	10.5	12	13	15	
Sample II:	X:	1	1	1	1	1	1			
	Y:	1.5	3	4.5	8	9	14			
Sample III:	X:	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Y:	10.5	16	17	18.5	18.5	20	21	22	23

Here the X ranks for Samples I and II are in inverse order, so a weight of -1 is assigned to a pair of Sample I and Sample II Y ranks which are in natural order, a value of +1 is assigned if the Y pair from these samples is also in inverse order, and a weight of 0 if the two Y ranks are equal. However, the X ranks for Samples II and III are in natural order, so weights for comparisons of Y ranks for Sample II with Y ranks for Sample III are assigned as for monotonic trend. The value of the  $S$  for bitonic trend is:

$$S = -5 - 1 + 0 + 0 + 4 + 4 + 4 + 6 + 9 + 9 + 9 + 9 + 7$$

$$= 64$$

The value of -5 is obtained by comparing the first Y rank of 1.5 for Sample I with each Y rank for Sample II, and assigning weights as described above. No comparison of pairs is necessary for Samples I and III, because these samples are tied on X. The value of -1 in the equation is obtained by

## APPENDIX 4b. (continued)

comparing the second Y rank for Sample I, with each Y rank for Sample II, and so on, until the final value of 7 is obtained by comparing the last Y rank for Sample II with each Y rank for Sample III.

For  $N \geq 10$ , the standard error of  $S$  is computed (Ferguson, 1965, p. 11, p. 13). The value of this error term depends on the number of ties on each variable, and so will differ between tests for monotonic and bitonic trend; there are more ties on the X variable in the test for the latter trend than in the test for the former.  $S$  is corrected for continuity and  $z$  obtained by dividing the corrected  $S$  by the standard error.

For complete details, see Ferguson.

In Experiment IV, there were 14 levels of X (14 V.E.S. score groups, from 2 to 15 inclusive) and 50 ranked observations on the dependent (Y) variable for each mode of output. The results of the tests for trend carried out on the data for the experiment are presented below. Each  $S$  value reported has been corrected for continuity.

## TESTS FOR RELATIONSHIPS BETWEEN V.E.S. SCORES AND TAPPING TIMES

- i) Monotonic trend:  $S = 111$   $\sigma_S = 118.87$   $z = 0.93$
- ii) Bitonic trend:  $S = -70$   $\sigma_S = 117.37$   $z = -0.60$

## TESTS FOR RELATIONSHIPS BETWEEN V.E.S. SCORES AND SPEAKING TIMES

- i) Monotonic trend:  $S = 63$   $\sigma_S = 118.86$   $z = 0.53$
- ii) Bitonic trend:  $S = 16$   $\sigma_S = 117.37$   $z = 0.14$

## APPENDIX 4b. (continued)

## TESTS FOR RELATIONSHIPS BETWEEN V.E.S. SCORES AND POINTING TIMES

- i) Monotonic trend:  $S = 169$   $\sigma_S = 118.87$   $z = 1.42^1$   
 ii) Bitonic trend:  $S = -292$   $\sigma_S = 117.37$   $z = -2.49^*$  ( $p=.013$ )

## TESTS FOR RELATIONSHIPS BETWEEN V.E.S. SCORES AND DIFFERENCES BETWEEN TAPPING AND SPEAKING TIMES

- i) Monotonic trend:  $S = 47$   $\sigma_S = 118.86$   $z = 0.40$   
 ii) Bitonic trend:  $S = -138$   $\sigma_S = 117.37$   $z = -1.18$

## TESTS FOR RELATIONSHIPS BETWEEN V.E.S. SCORES AND DIFFERENCES BETWEEN POINTING AND TAPPING TIMES

- i) Monotonic trend:  $S = 142$   $\sigma_S = 118.86$   $z = 1.19$   
 ii) Bitonic trend:  $S = -298$   $\sigma_S = 117.36$   $z = -2.54^*$  ( $p=.011$ )

## TESTS FOR RELATIONSHIPS BETWEEN V.E.S. SCORES AND DIFFERENCES BETWEEN POINTING AND SPEAKING TIMES

- i) Monotonic trend:  $S = 121$   $\sigma_S = 118.87$   $z = 1.02$   
 ii) Bitonic trend:  $S = -316$   $\sigma_S = 117.37$   $z = -2.69^*$  ( $p=.007$ )

1

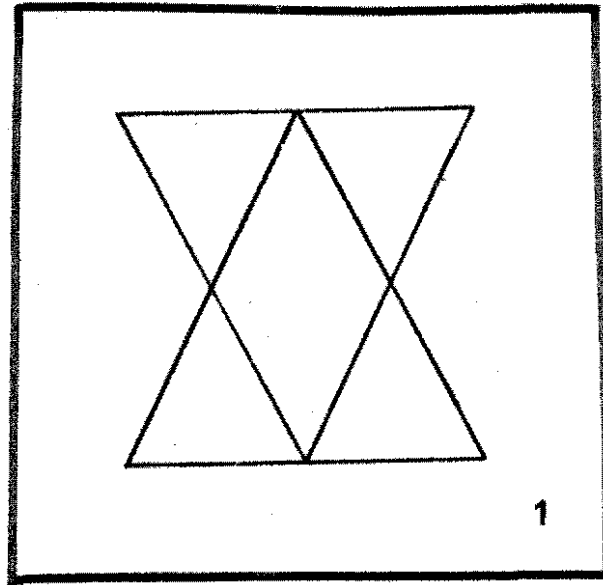
The probabilities quoted beside the asterisked  $z$  values are for two-tailed tests. Although the  $z$  value for the monotonic trend on the pointing data is not significant on a two-tailed test, it does approach significance on a one-tailed test ( $p=.078$ ).

APPENDIX 5

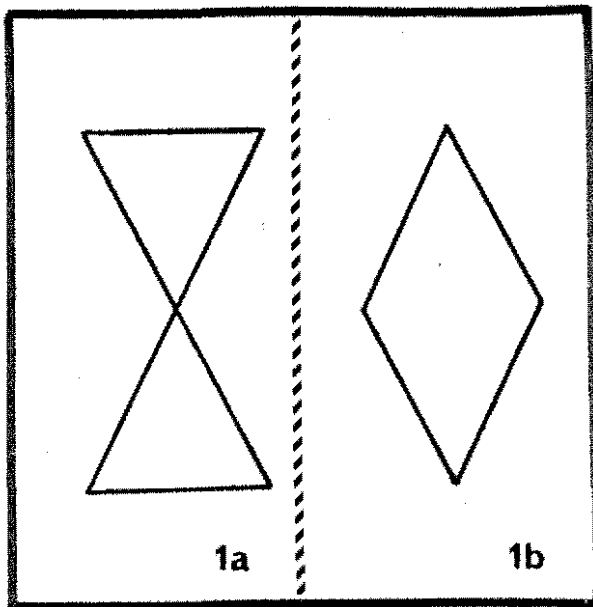
EXPERIMENT V

APPENDIX 5a.

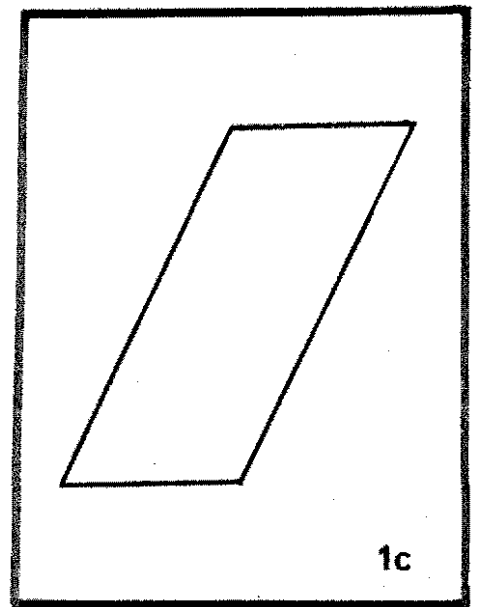
AMBIGUOUS PATTERNS AND POSITIVE FRAGMENTS



FIRST  
PATTERN



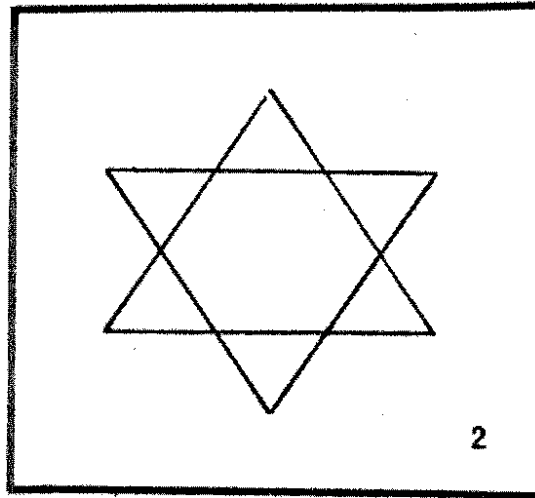
Compatible



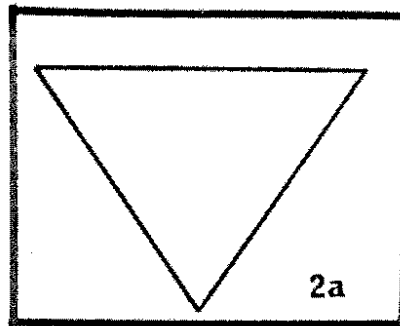
Incompatible

FRAGMENTS

APPENDIX 5a. (continued)

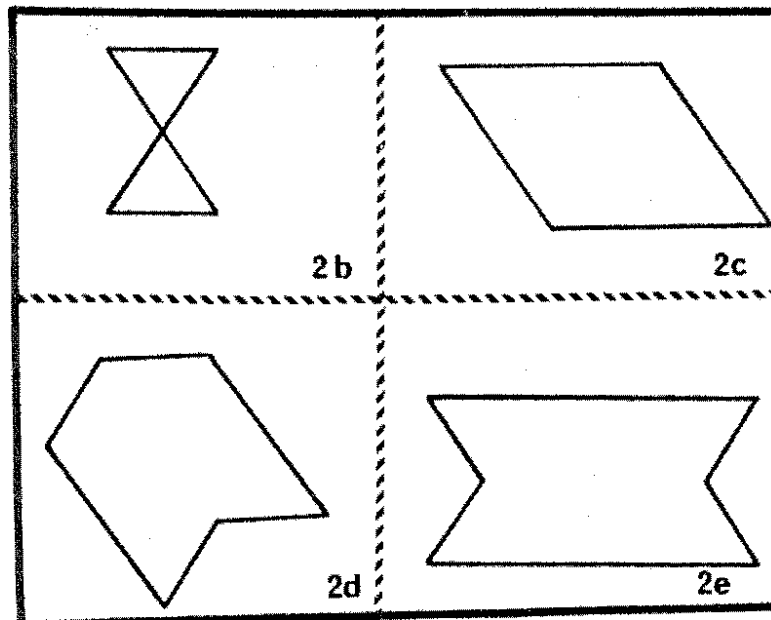


SECOND  
PATTERN



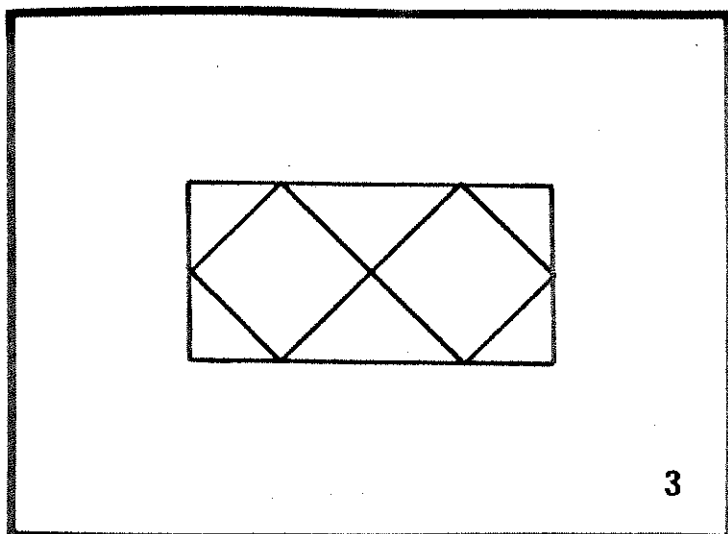
FRAGMENTS

Compatible



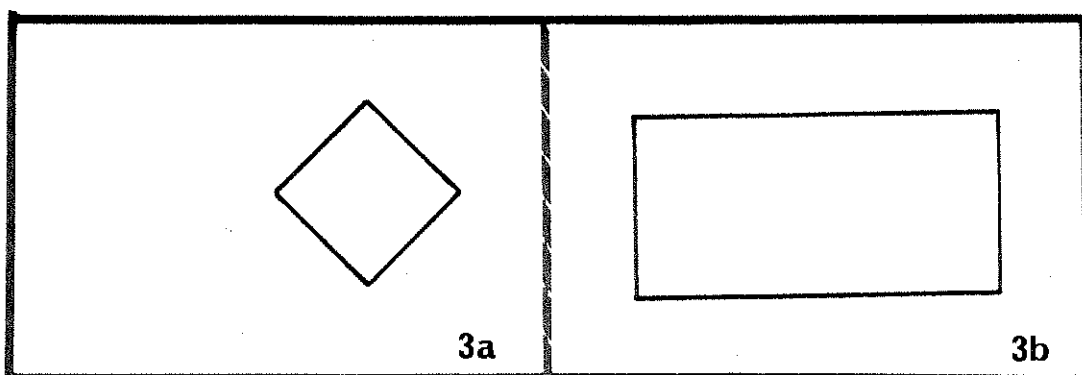
Incompatible

APPENDIX 5a. (continued)

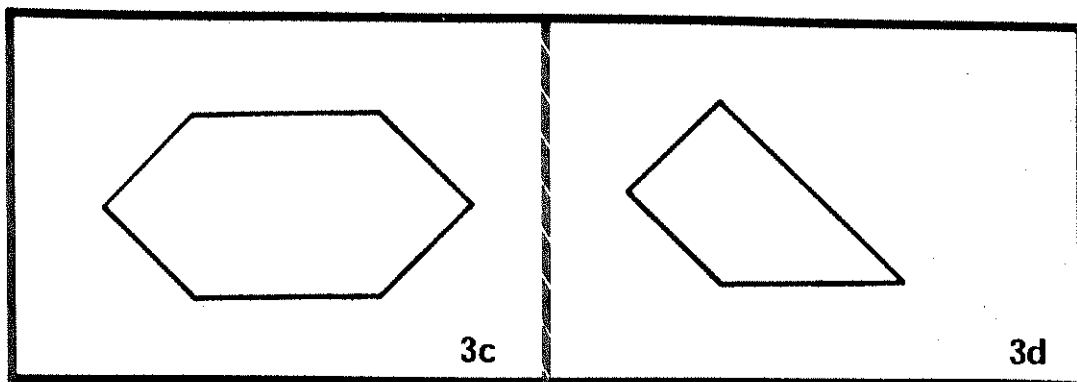


**THIRD  
PATTERN**

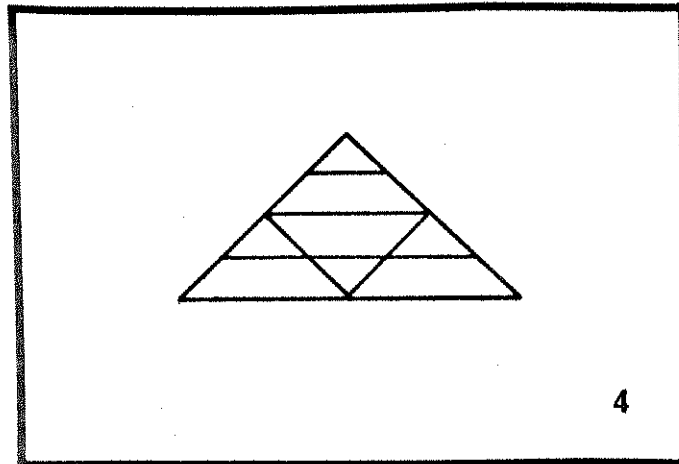
**FRAGMENTS**



**Compatible**

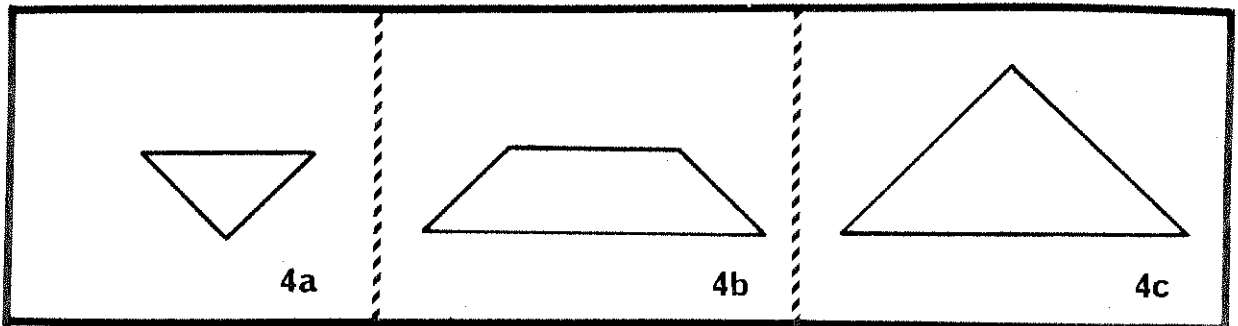


**Incompatible**

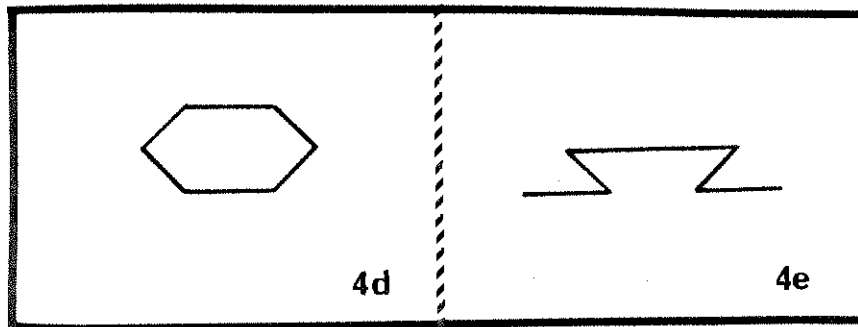


FOURTH  
PATTERN

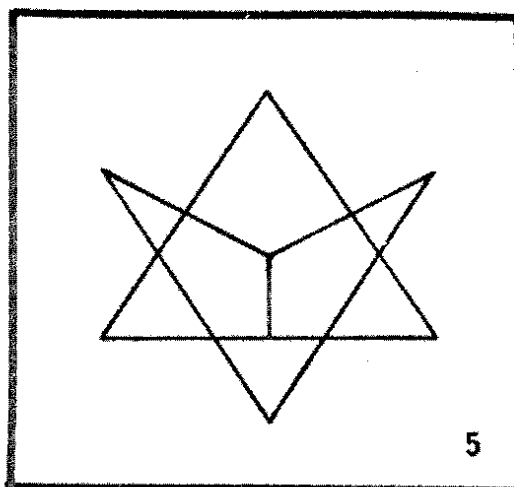
FRAGMENTS



Compatible

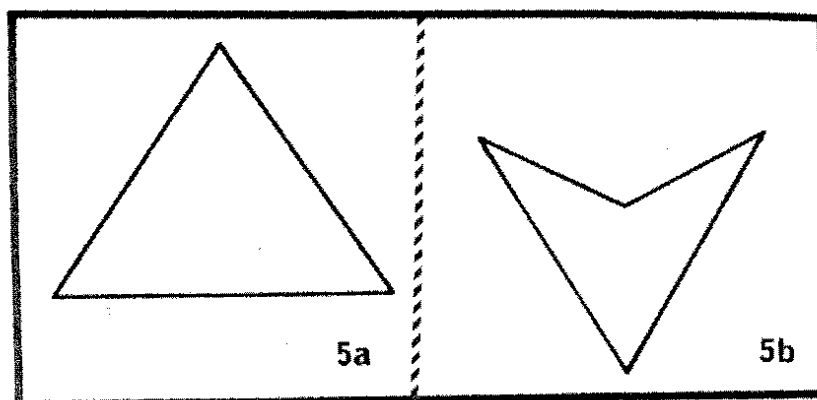


Incompatible

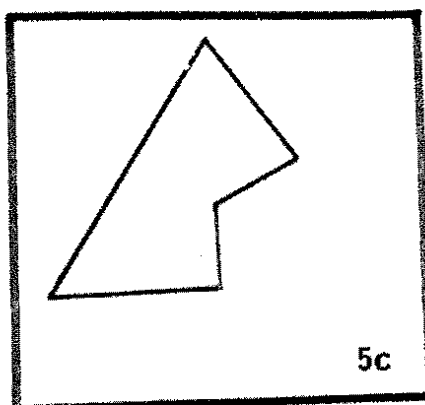


FIFTH  
PATTERN

FRAGMENTS



Compatible



Incompatible

## APPENDIX 5b.

## RECONSTRUCTION SCORES

S	V.E.S. score	Fragments	
		Compatible	Incompatible
1	9	8	7
2	9	7	7
3	12	7	7
4	7	8	6
5	7	6	6
6	7	10	7
7	5	7	3
8	11	10	9
9	6	8	10
10	6	9	4
11	10	8	8
12	3	8	7
13	8	5	5
14	7	9	6
15	11	8	7
16	8	10	8
17	5	7	4
18	6	8	5
19	4	6	5
20	13	9	8
21	3	8	6
22	8	9	9
23	8	6	6
24	7	5	3
25	9	8	7
26	9	8	6
27	6	8	5
28	3	8	6
29	5	7	6
30	9	6	5
31	9	8	8
32	12	7	7
33	1	7	7
34	7	8	6

S	V.E.S. score	Fragments	
		Compatible	Incompatible
35	11	10	8
36	13	9	8
37	13	6	8
38	5	8	4
39	10	6	5
40	6	9	7
41	11	10	8
42	5	6	4
43	10	9	7
44	12	9	7
45	9	6	8
46	12	7	8
47	9	8	5
48	11	10	9
49	15	7	7
50	9	6	5
51	12	9	8
52	7	10	7
53	13	7	7
54	9	8	7
55	9	5	7
56	8	6	5
57	11	9	8
58	12	9	8
59	9	9	6
60	2	8	5
61	2	8	4
$\bar{x}$	8.28	7.79	6.49

## APPENDIX 5c.

## RESULTS OF TESTS FOR TREND

The number of levels of X (see Appendix 4b) was 14 (V.E.S. score groups 1-15, excluding 14). The number of ranked observations on Y (the dependent variable) was 61.

TESTS FOR RELATIONSHIPS BETWEEN V.E.S. SCORES AND NUMBER OF CORRECT RECONSTRUCTIONS AROUND COMPATIBLE FRAGMENTS

- i) Monotonic trend.  $S = 186$   $\sigma_s = 155.42$   $z = 1.19$
- ii) Bitonic trend.  $S = 66$   $\sigma_s = 153.46$   $z = 0.42$

TESTS FOR RELATIONSHIPS BETWEEN V.E.S. SCORES AND NUMBER OF CORRECT RECONSTRUCTIONS AROUND INCOMPATIBLE FRAGMENTS

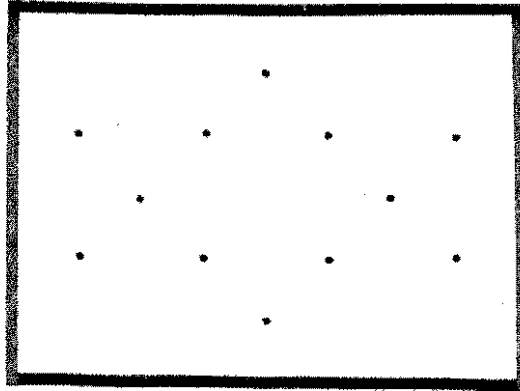
- i) Monotonic trend.  $S = 719$   $\sigma_s = 156.04$   $z = 4.60^*$  ( $p < 0.00006$ )
- ii) Bitonic trend.  $S = 255$   $\sigma_s = 154.07$   $z = 1.65$

APPENDIX 6

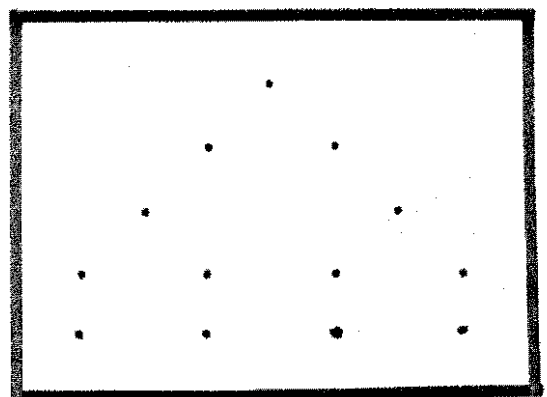
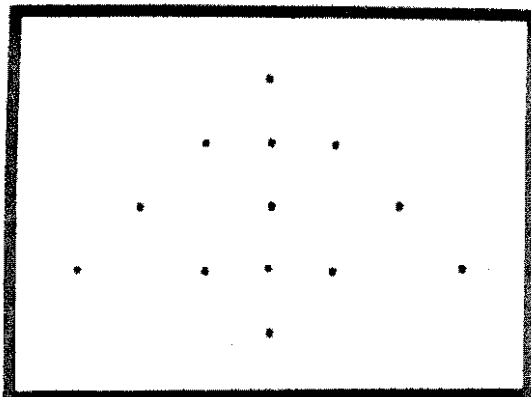
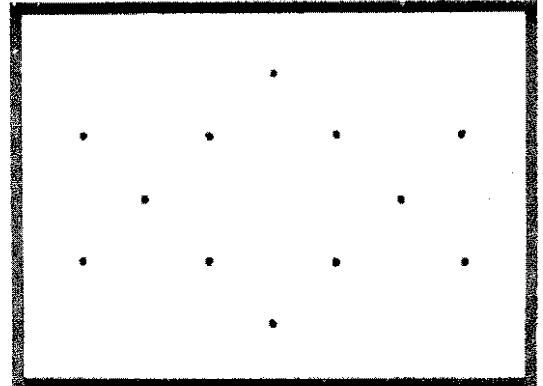
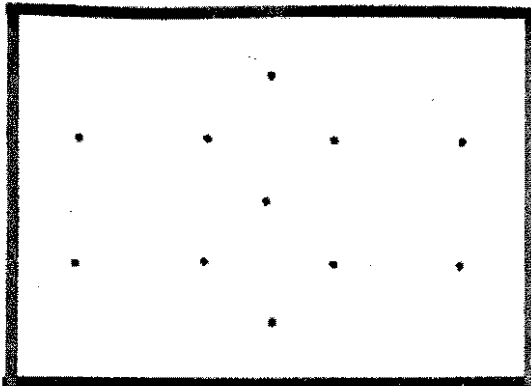
EXPERIMENT VI

APPENDIX 6a.

DOT PATTERN AND RECOGNITION SETS

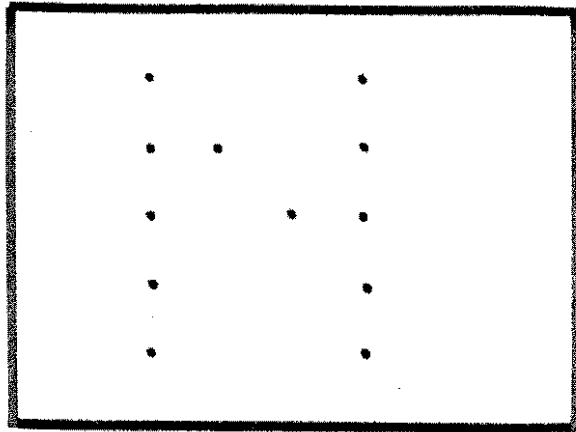


PATTERN

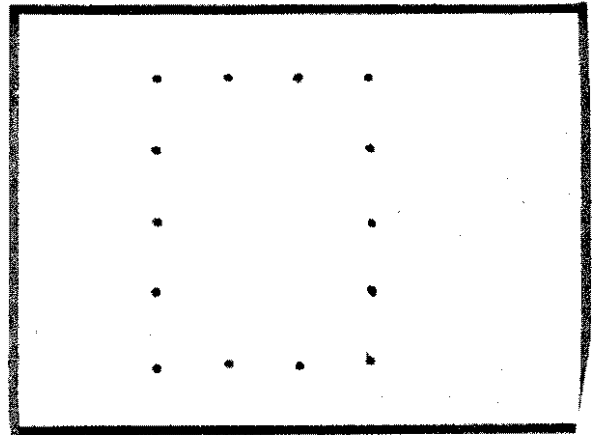
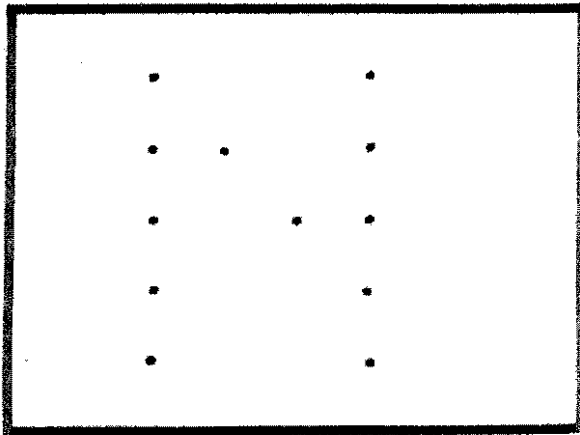
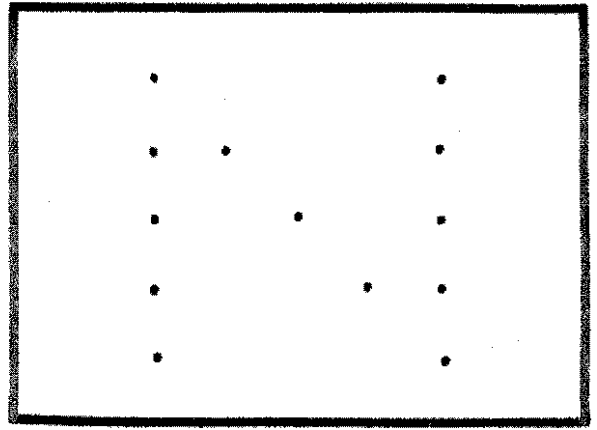
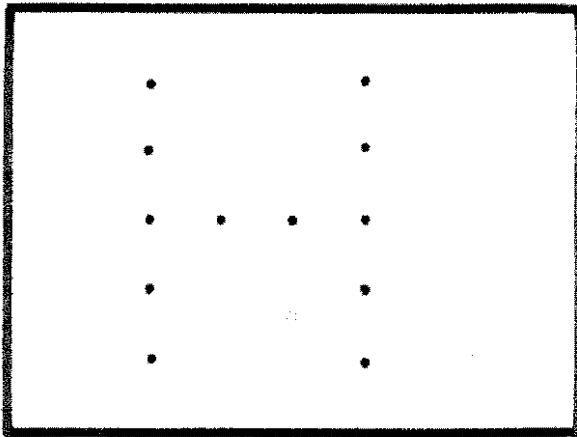


RECOGNITION

SET

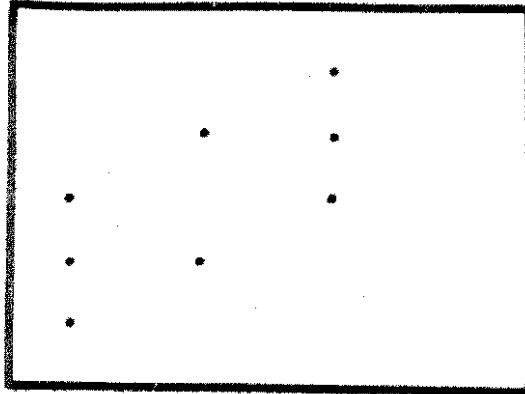


PATTERN

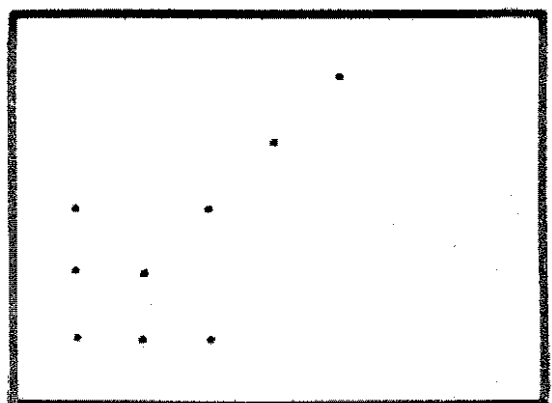
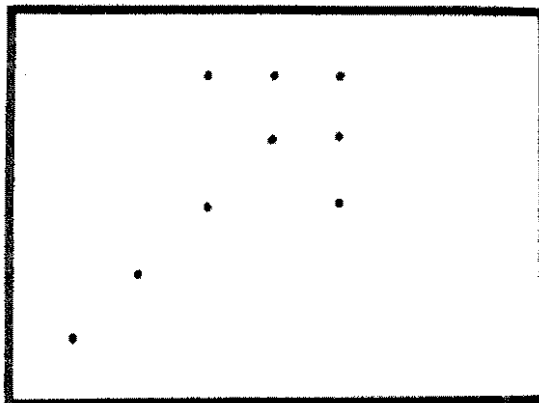
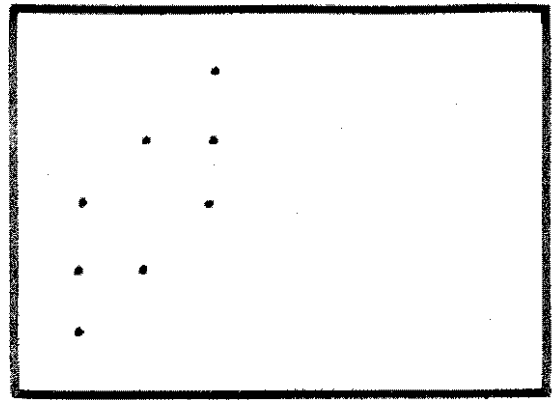
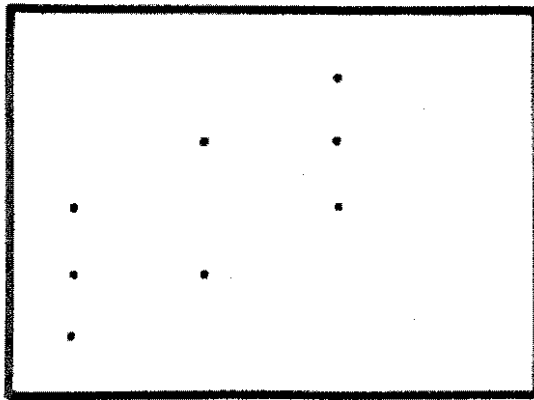


RECOGNITION SET

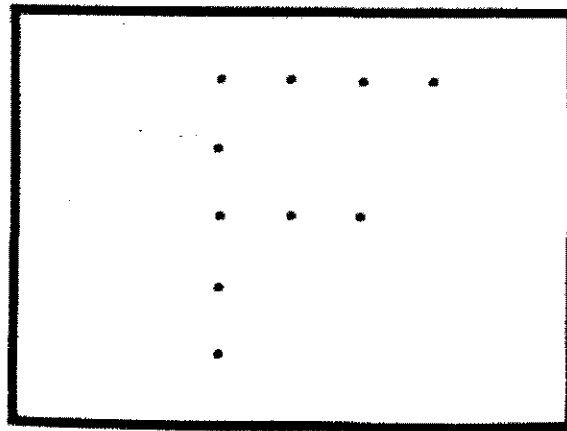
## APPENDIX 6a. (continued)



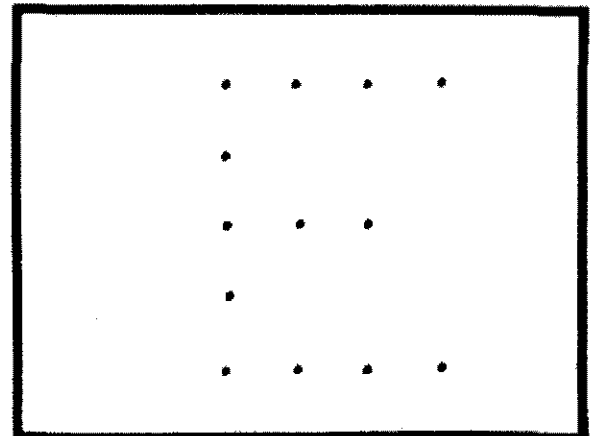
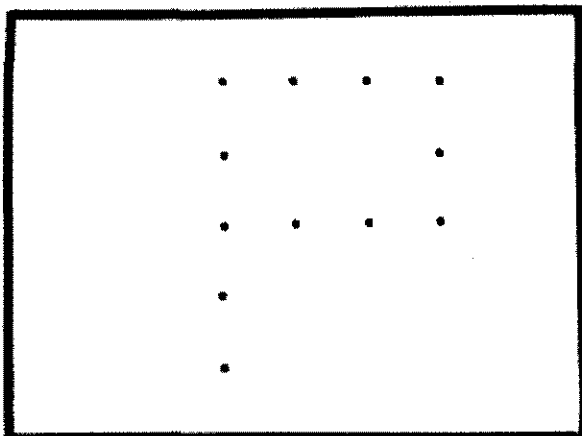
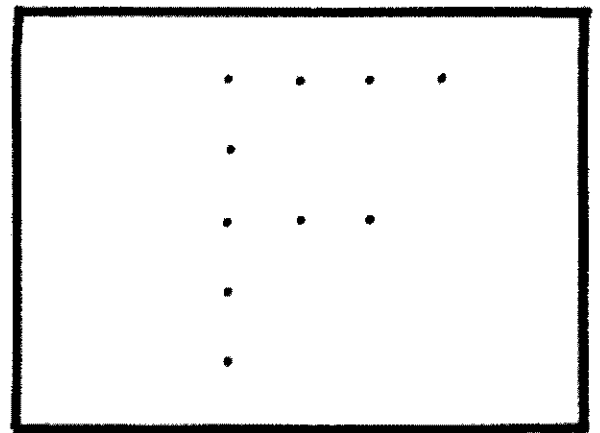
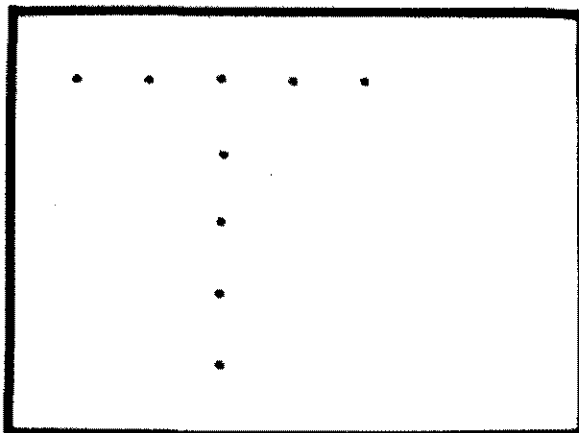
PATTERN



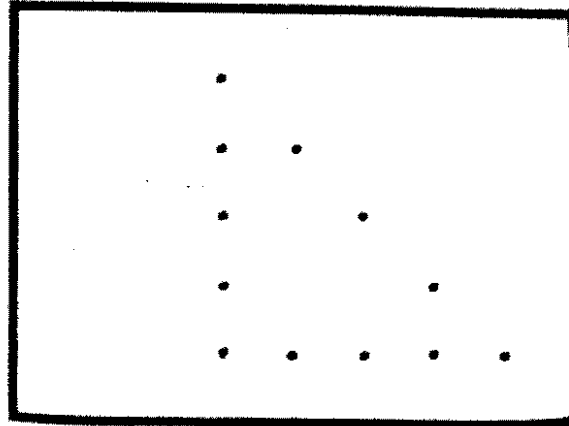
RECOGNITION SET



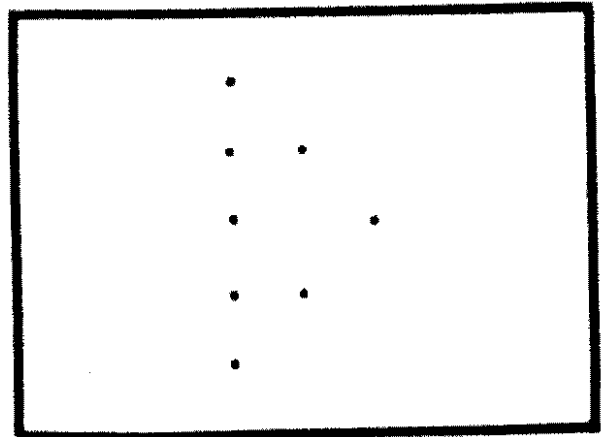
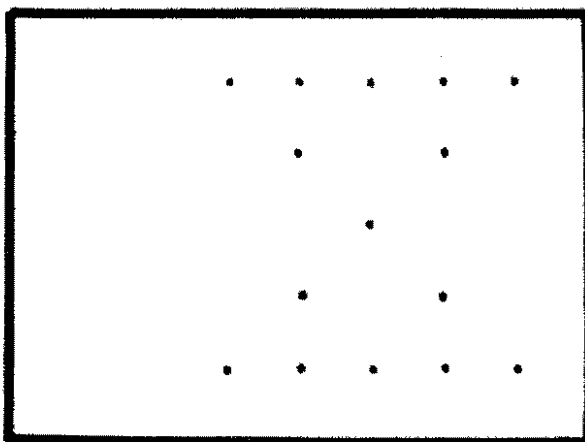
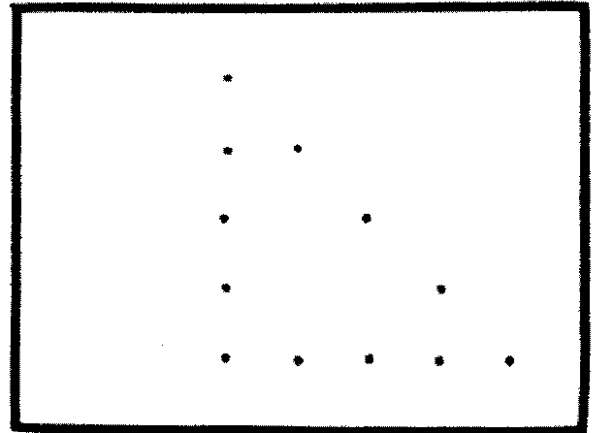
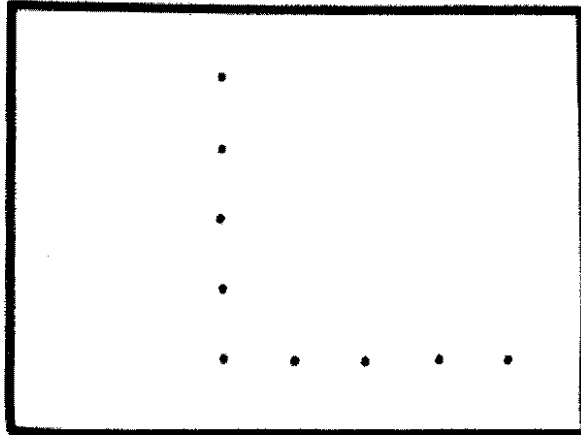
**PATTERN**



**RECOGNITION SET**

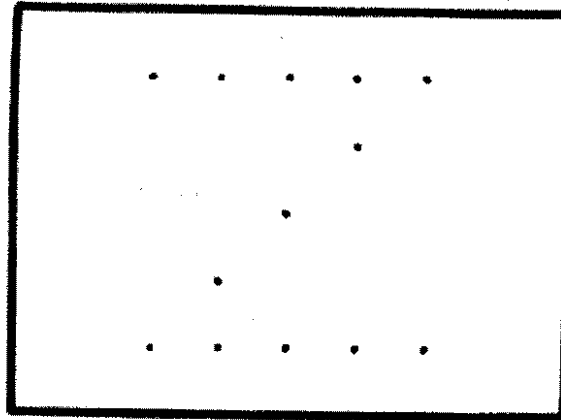


**PATTERN**

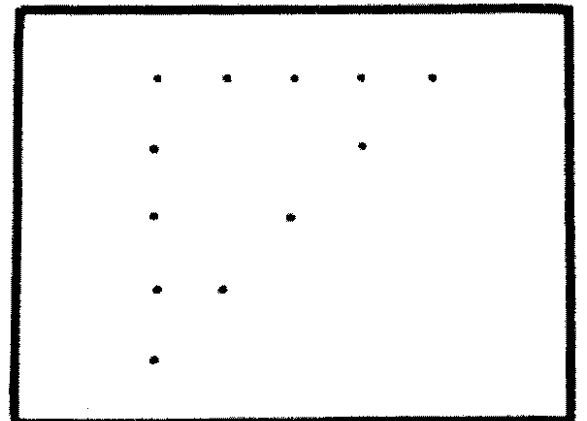
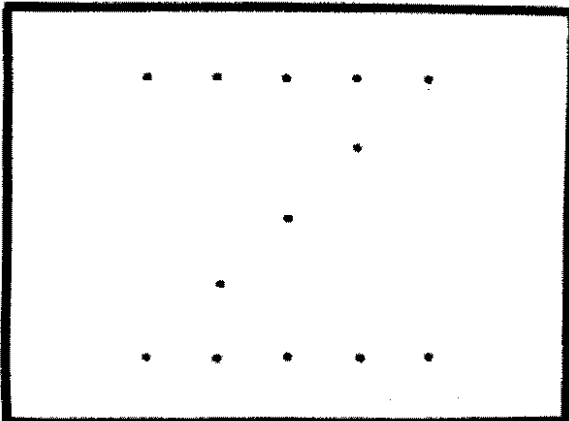
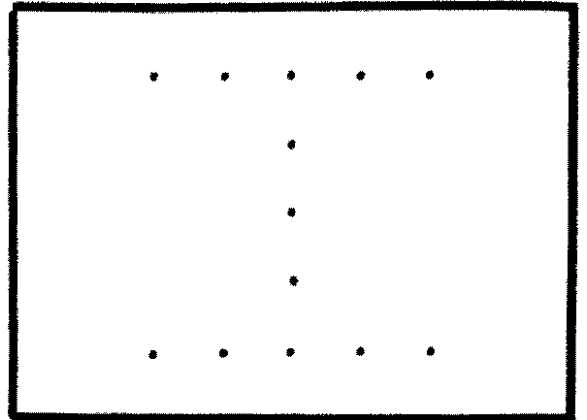
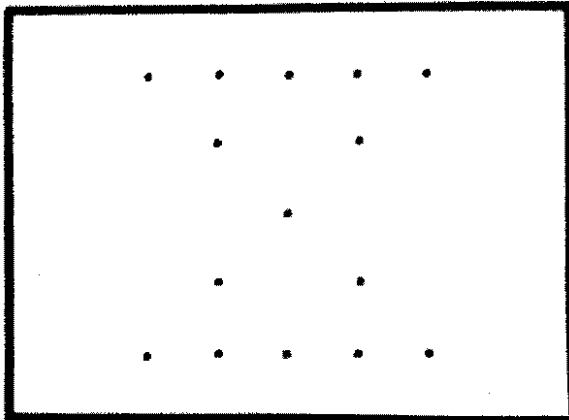


**RECOGNITION SET**

APPENDIX 6a. . (continued)

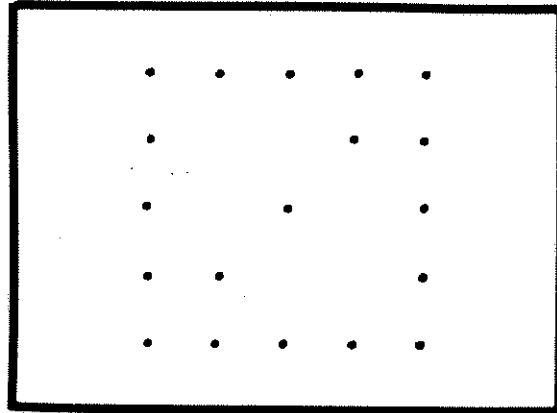


**PATTERN**

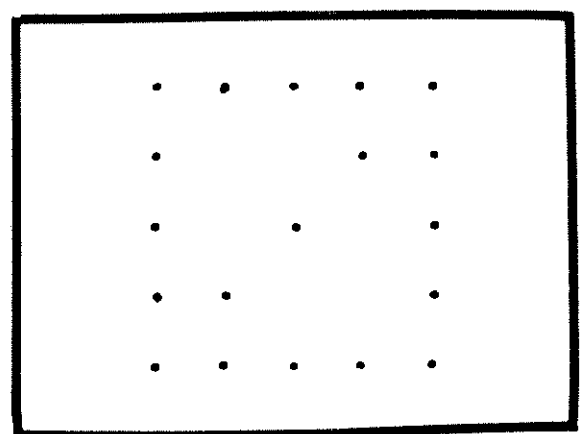
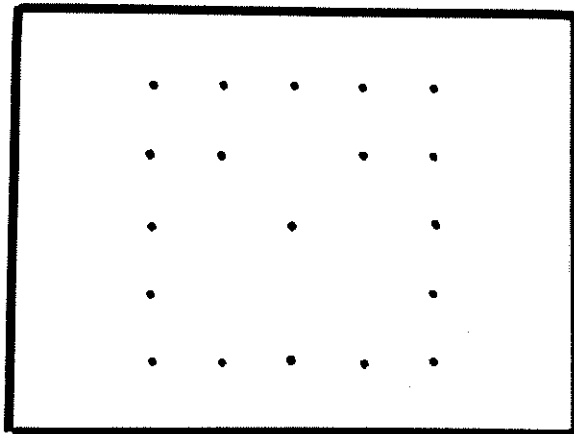
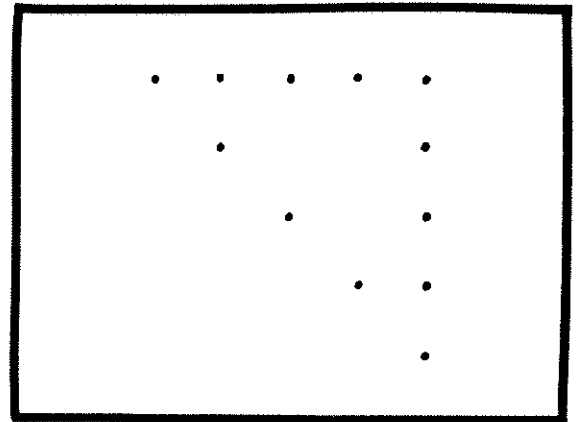
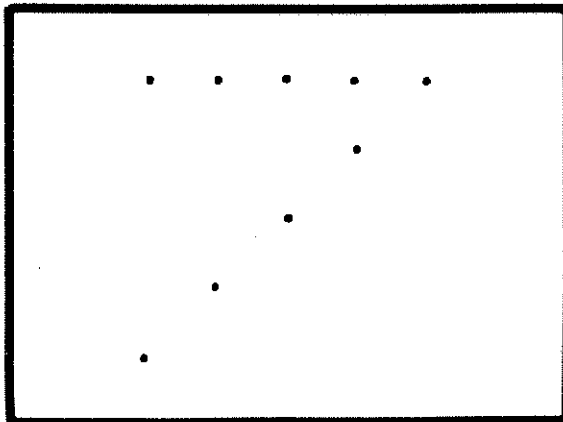


**RECOGNITION SET**

APPENDIX 6a. (continued)

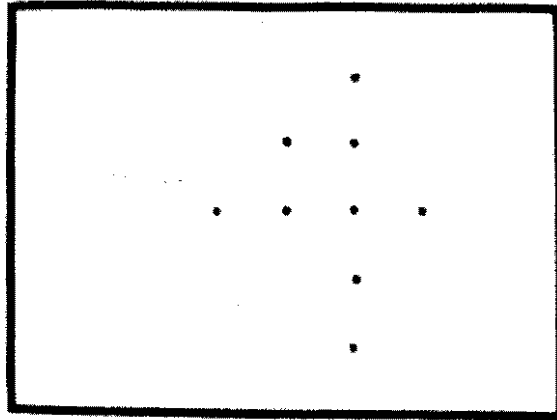


**PATTERN**

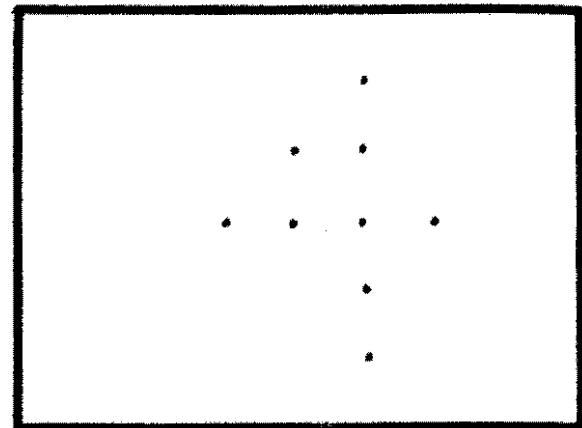
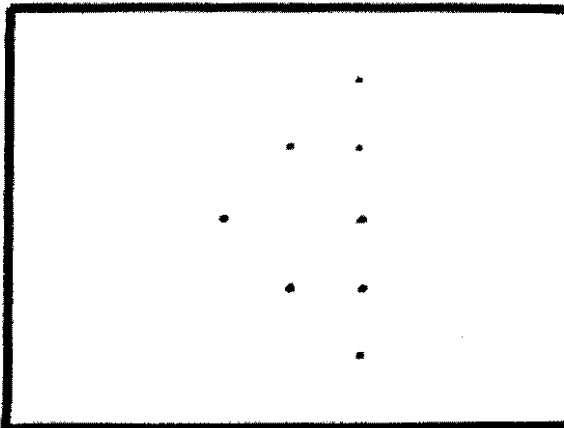
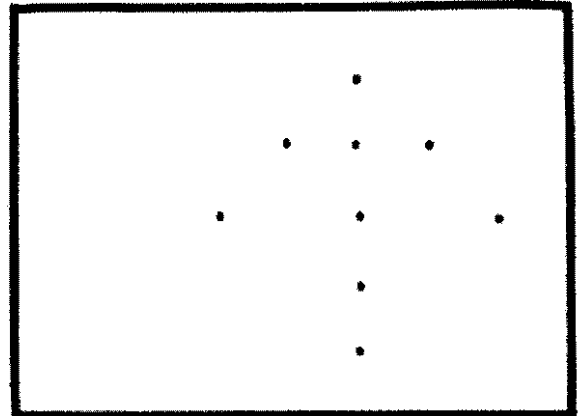
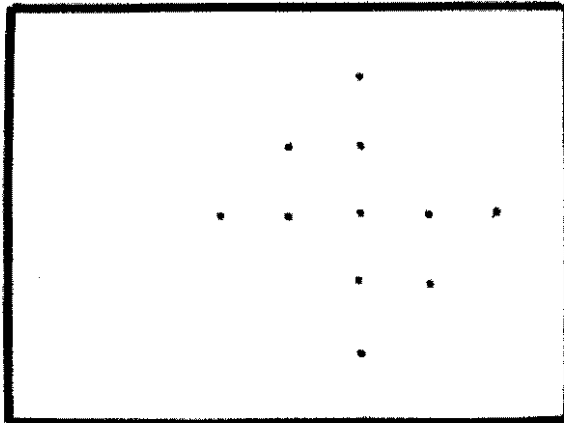


**RECOGNITION SET**

APPENDIX 6a. (continued)

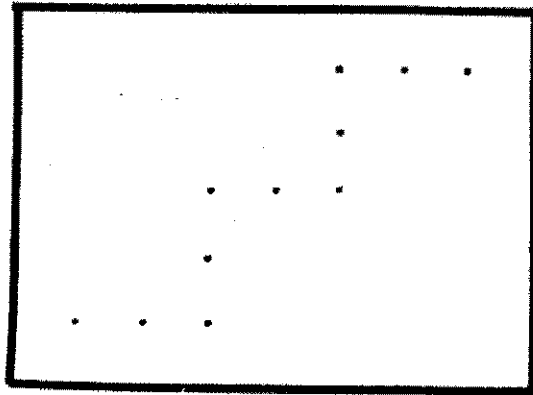


**PATTERN**

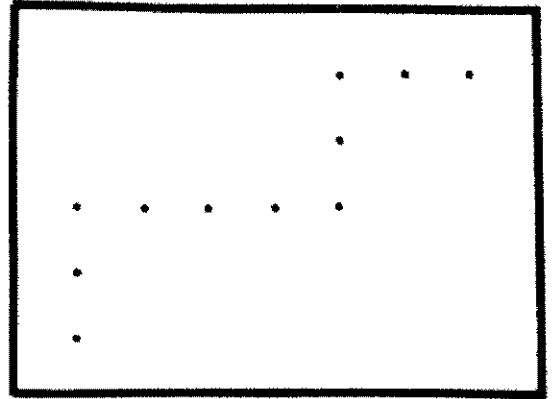
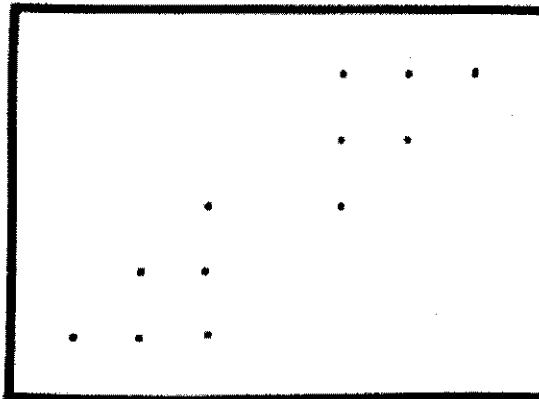
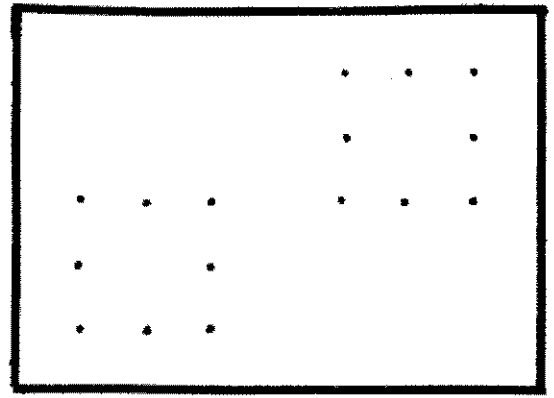
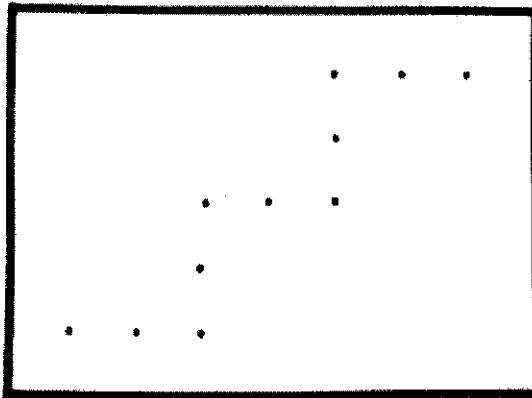


**RECOGNITION SET**

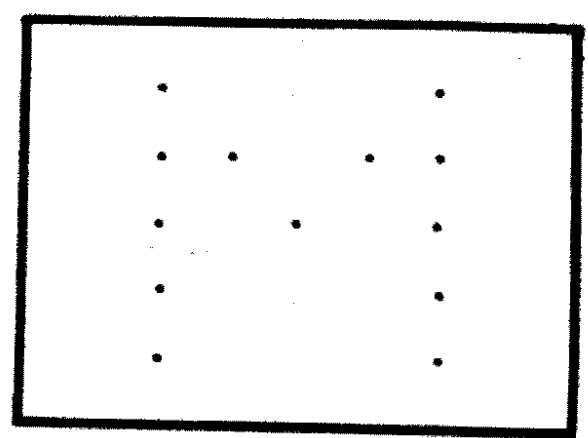
APPENDIX 6a. (continued)



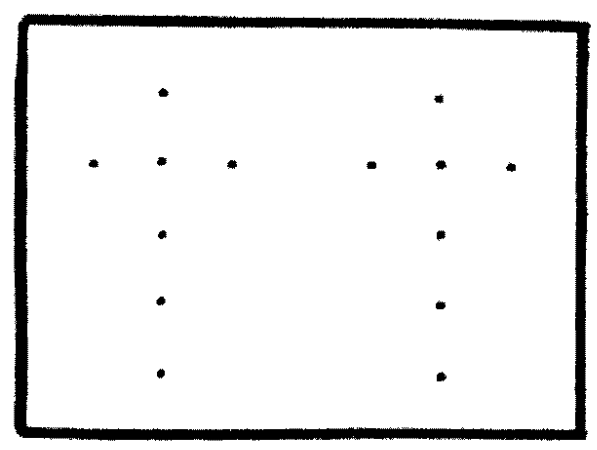
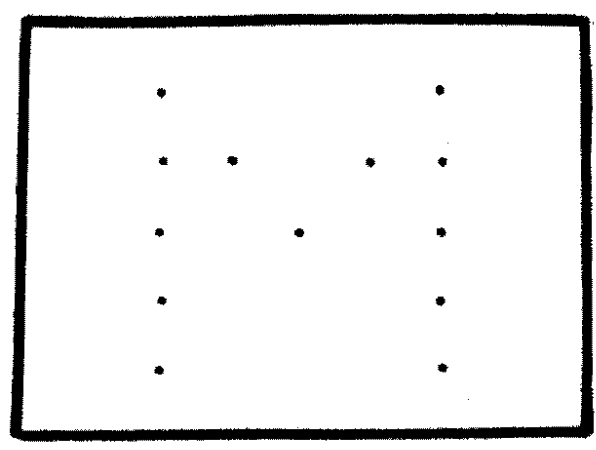
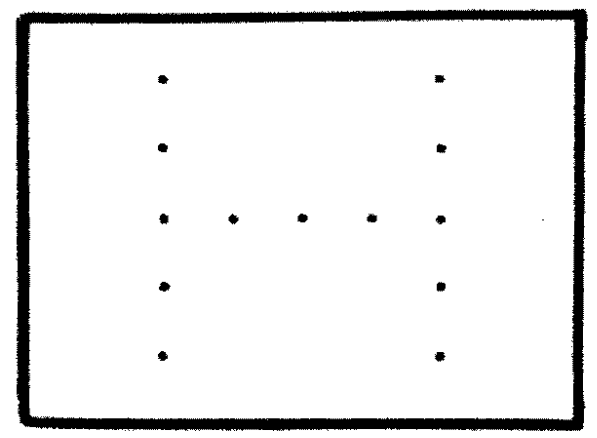
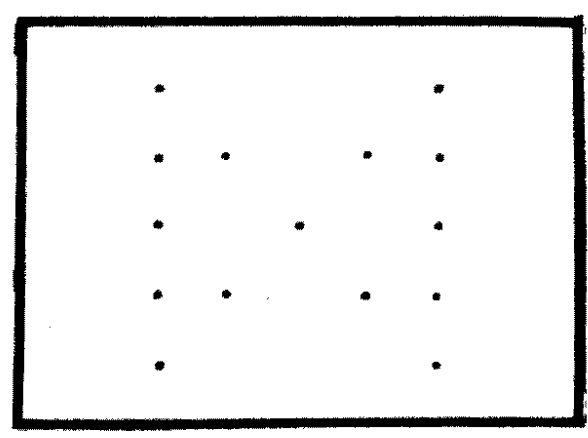
PATTERN



RECOGNITION SET

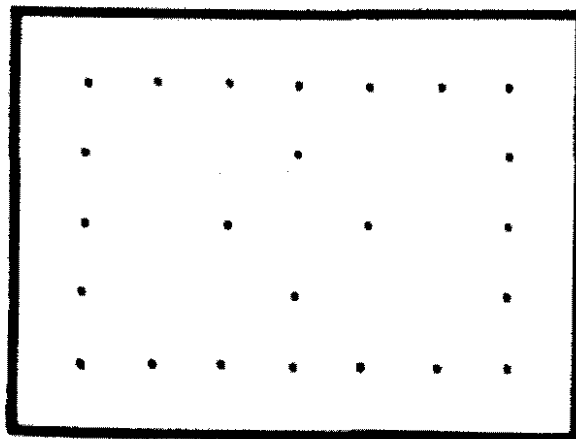


PATTERN

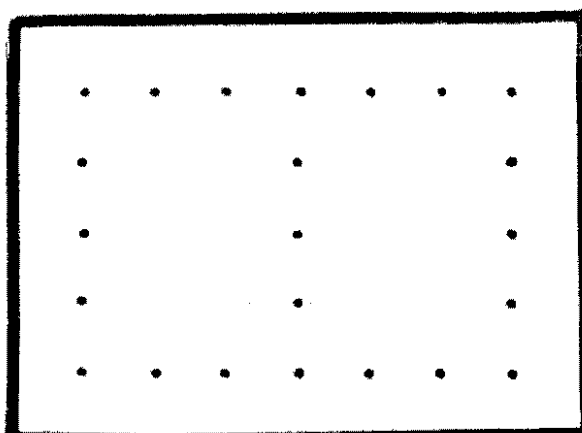
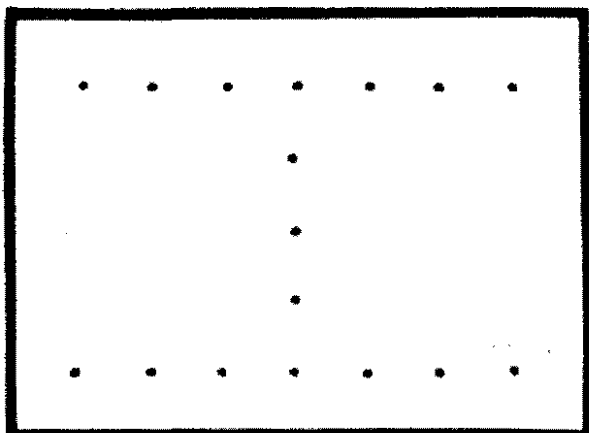
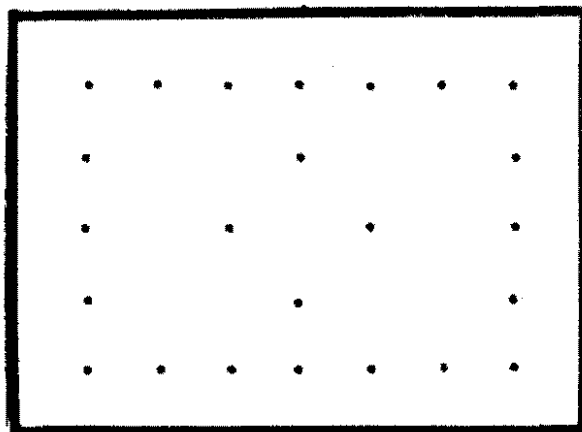
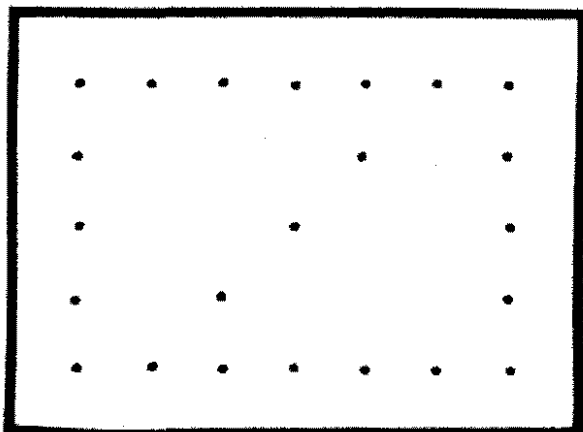


RECOGNITION SET

APPENDIX 6a. (continued)

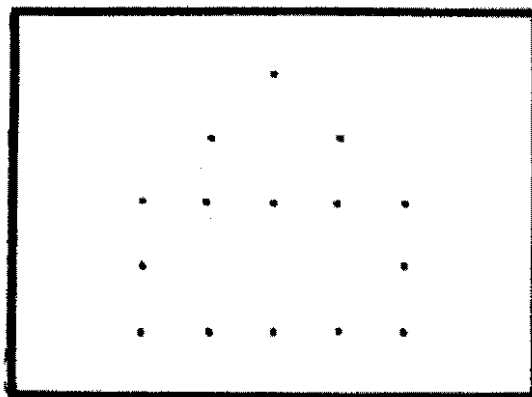


**PATTERN**

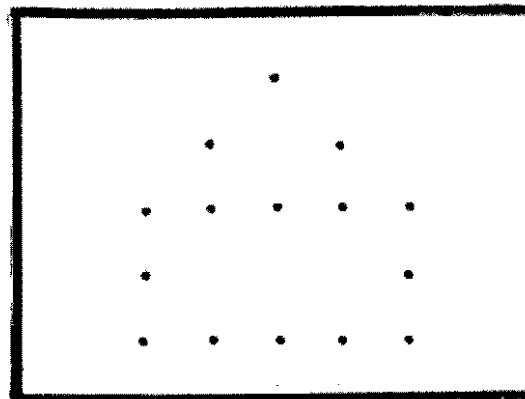
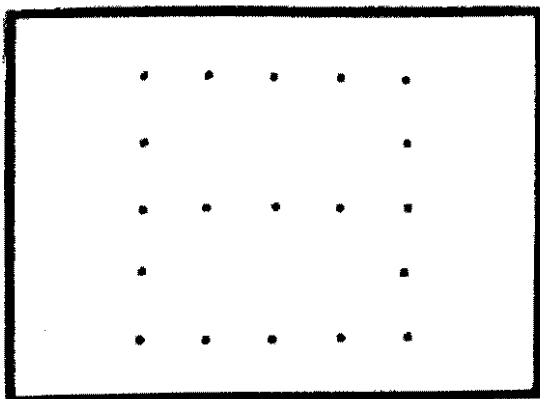
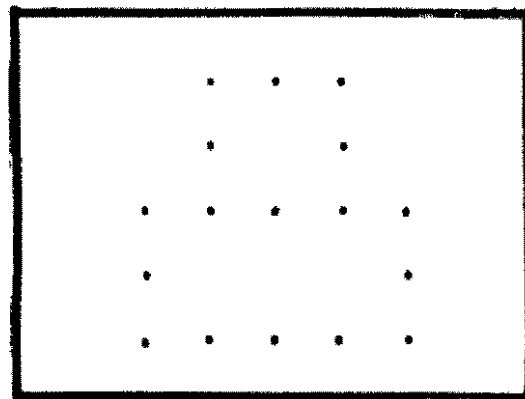
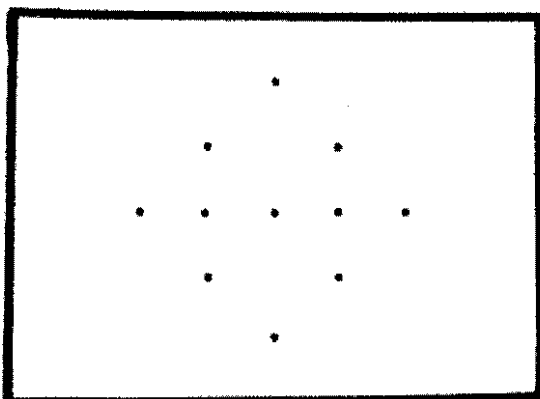


**RECOGNITION SET**

APPENDIX 6a. (continued)

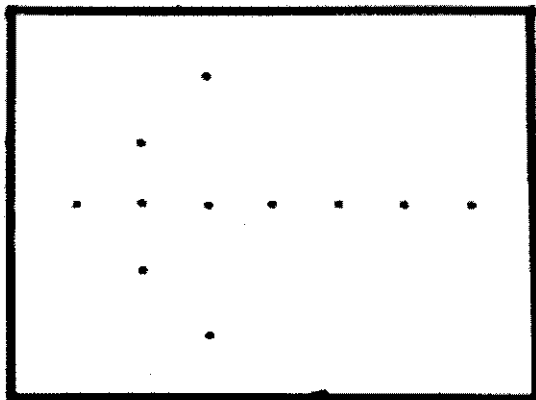


PATTERN

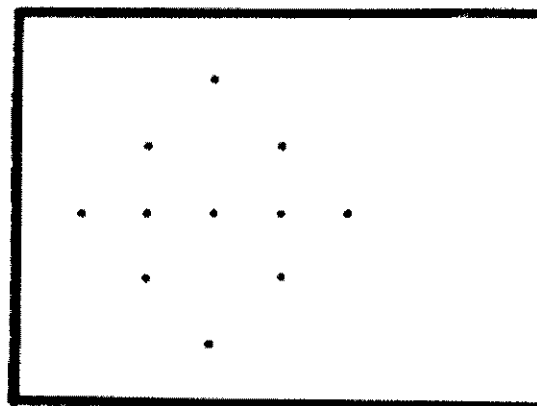
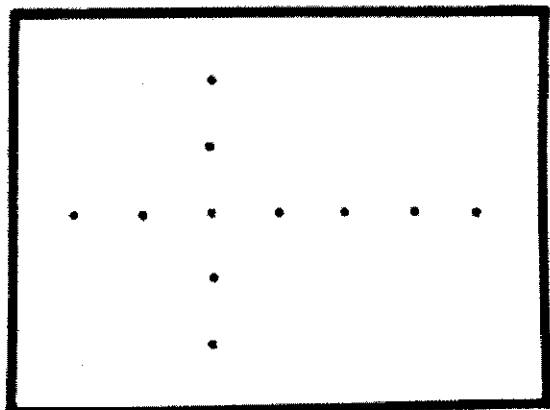
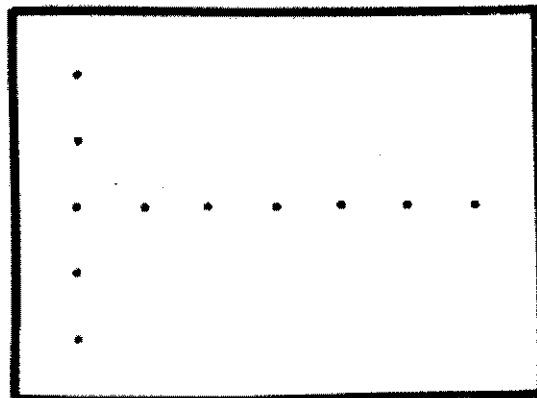
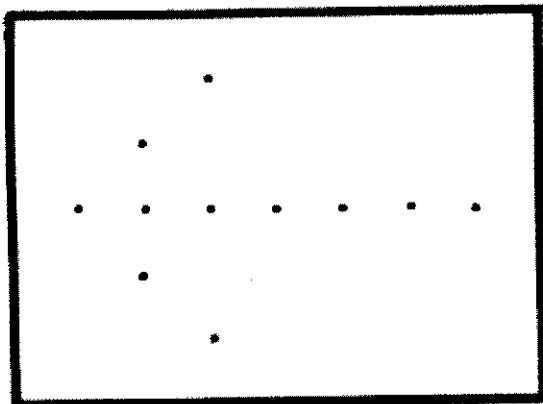


RECOGNITION SET

APPENDIX 6a. (continued)

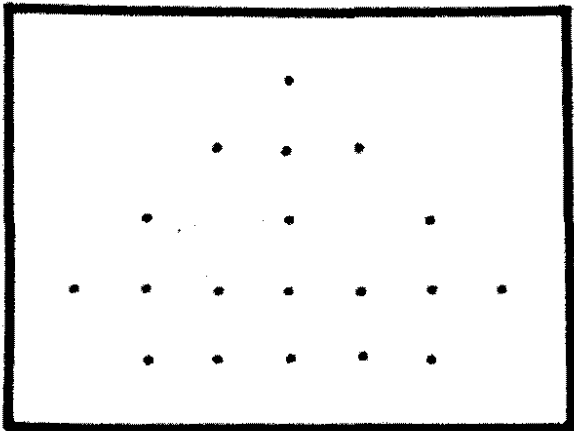


**PATTERN**

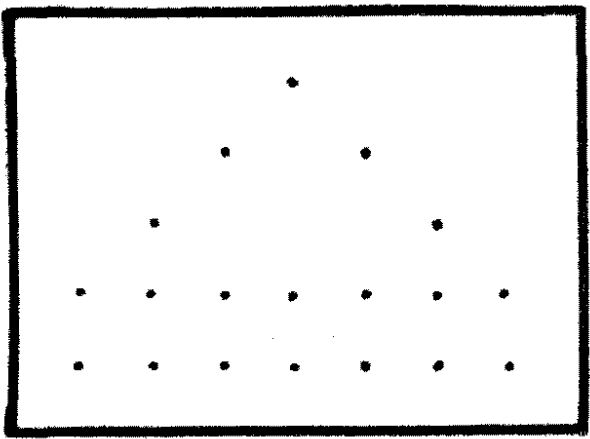
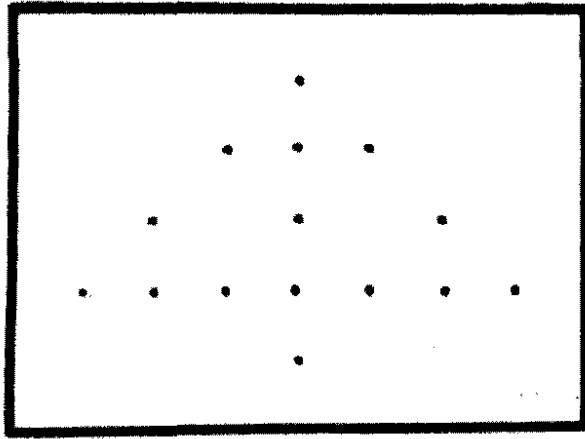
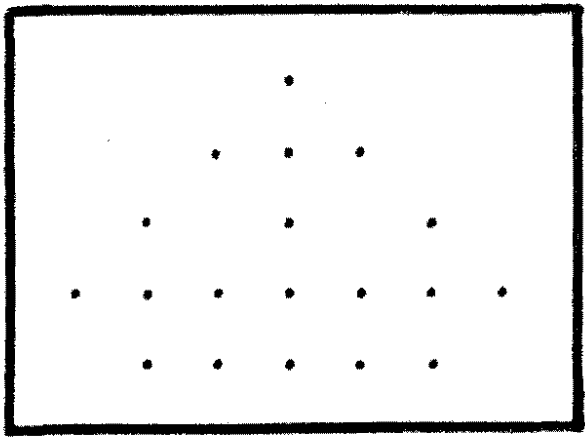
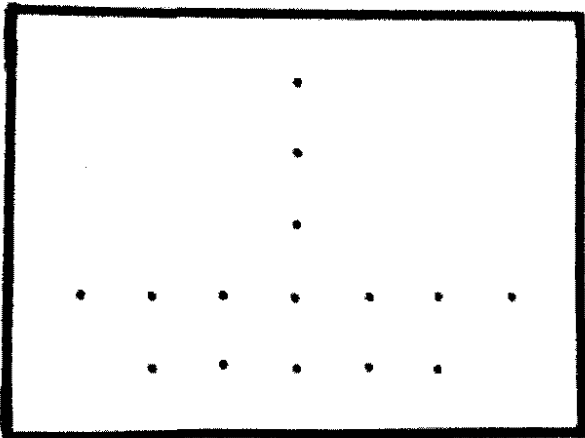


**RECOGNITION SET**

APPENDIX 6a. (continued)

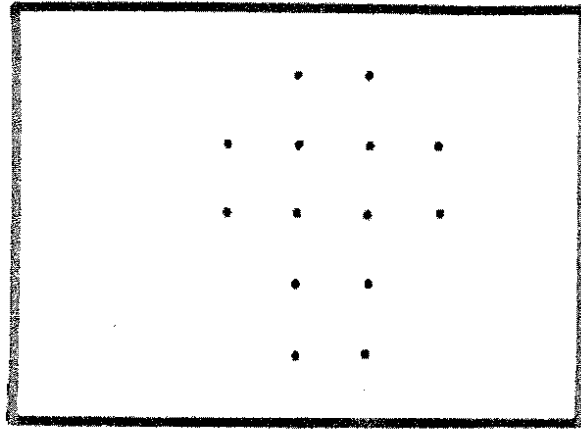


PATTERN

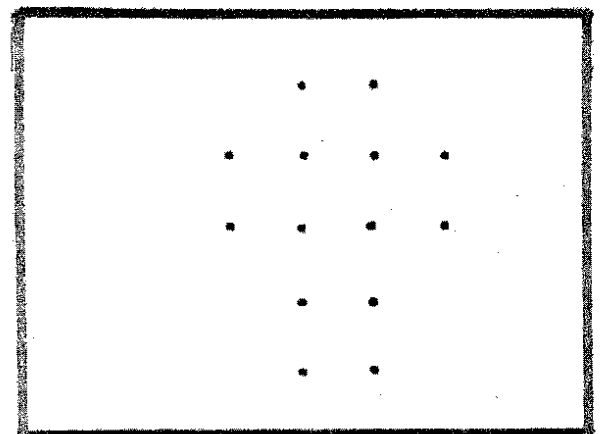
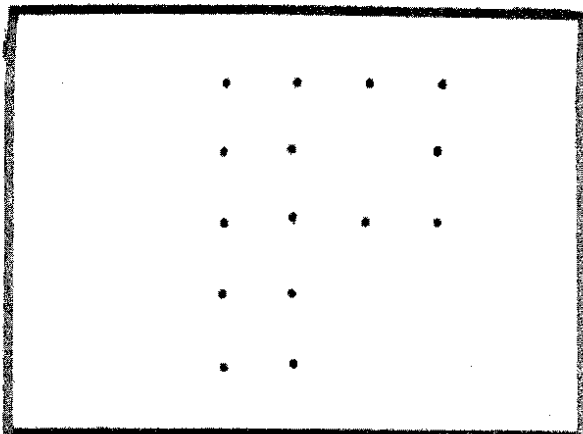
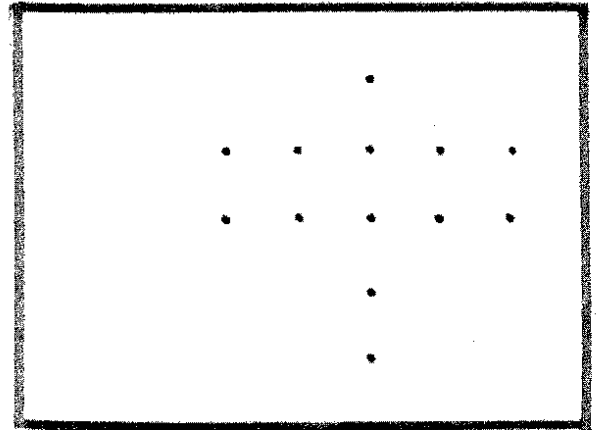
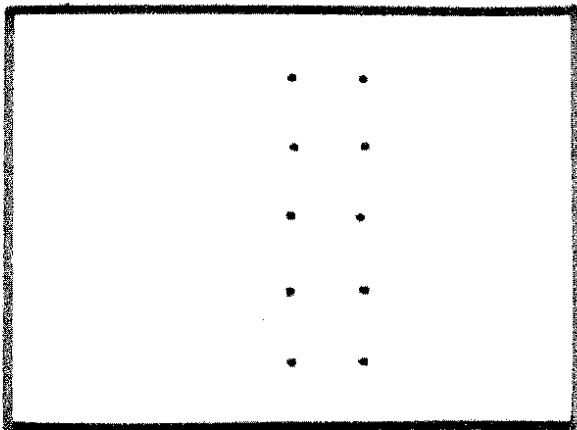


RECOGNITION SET

APPENDIX 6a. (continued)

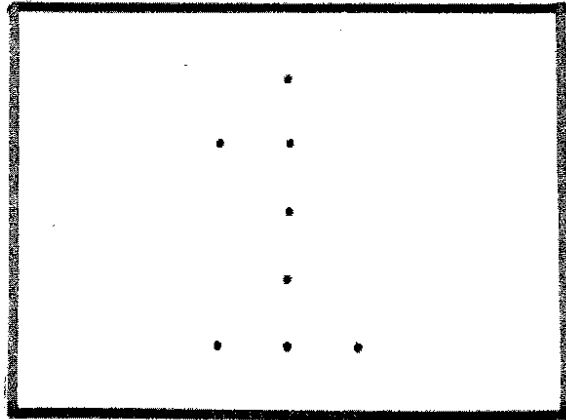


PATTERN

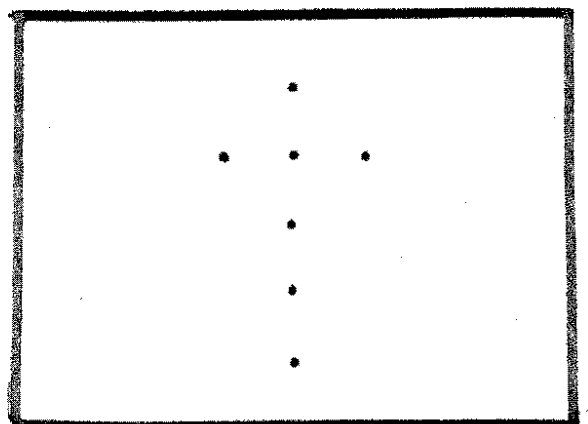
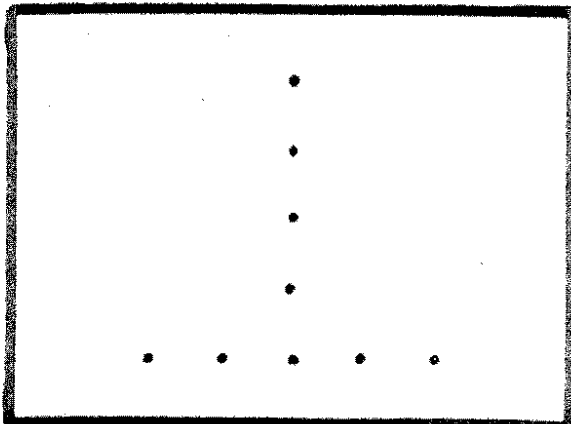
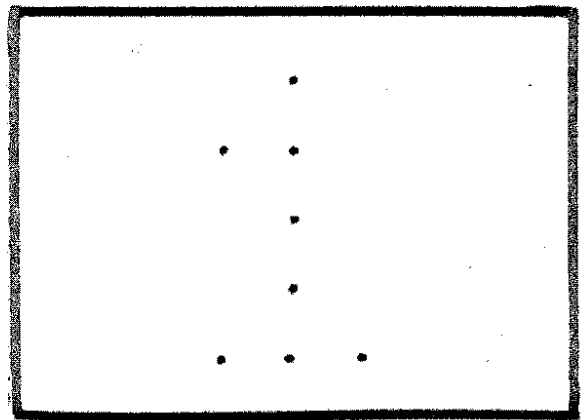
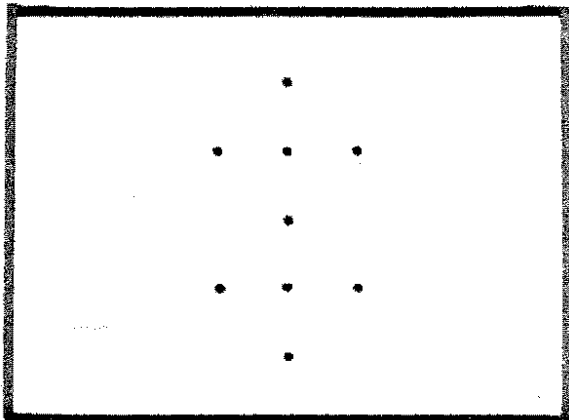


RECOGNITION SET

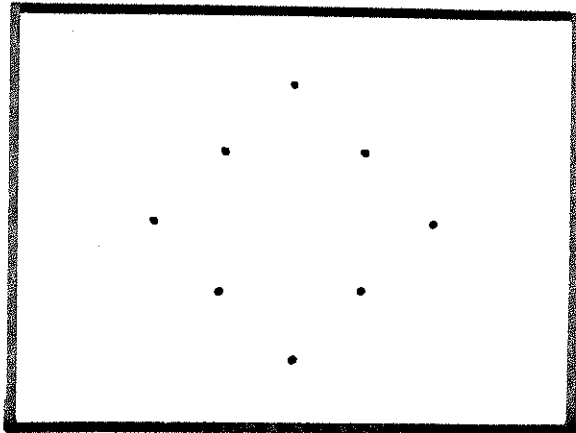
APPENDIX 6a. (continued)



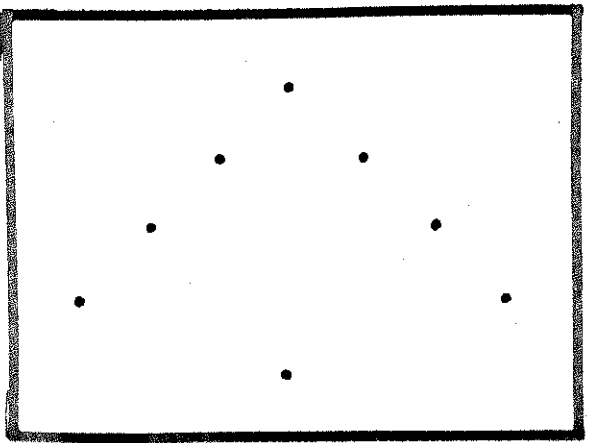
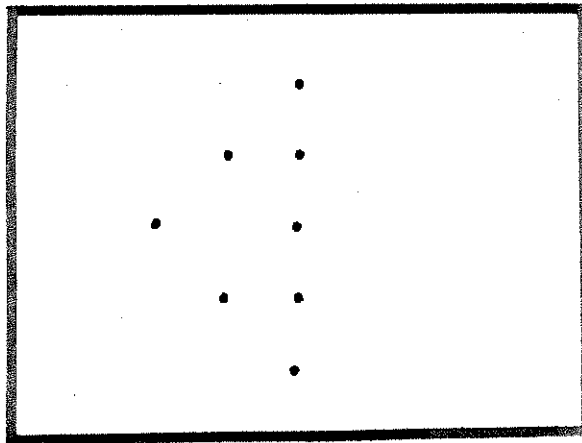
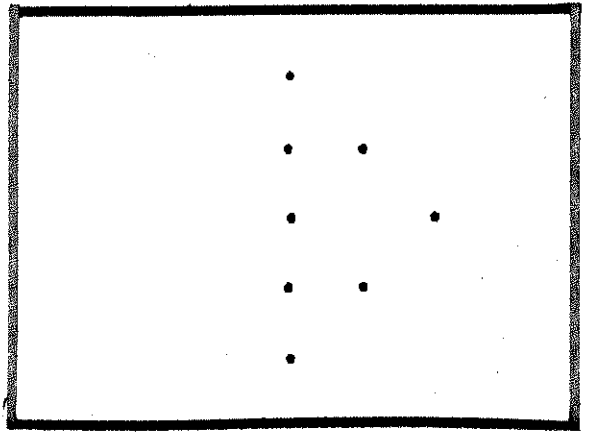
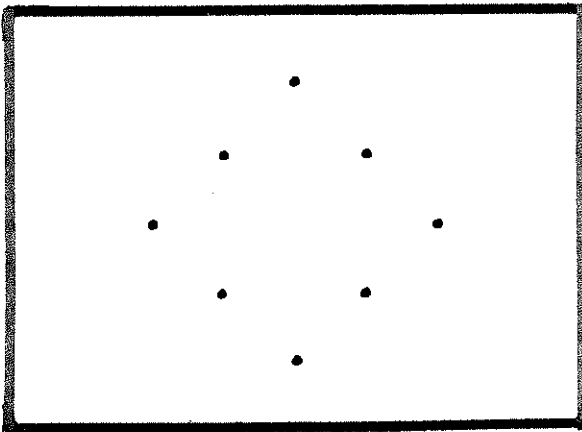
PATTERN



RECOGNITION SET



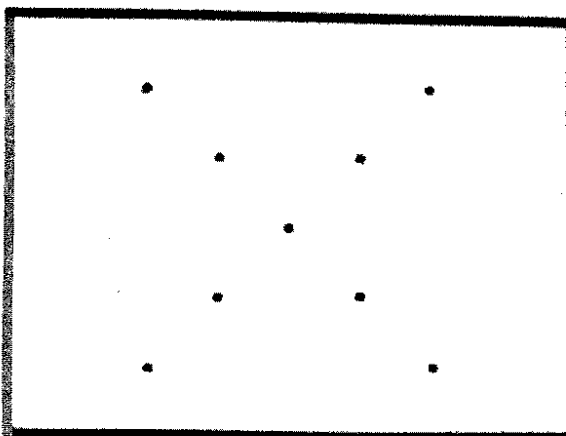
PATTERN



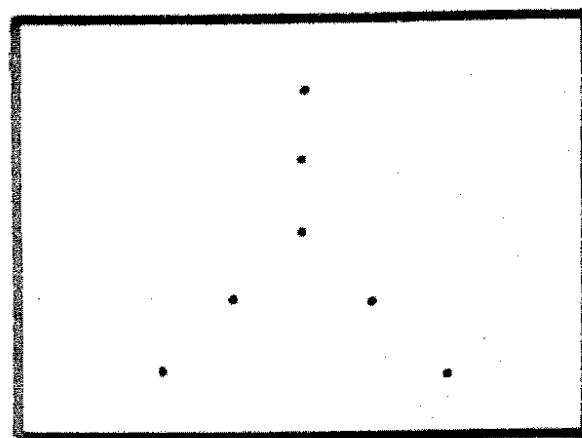
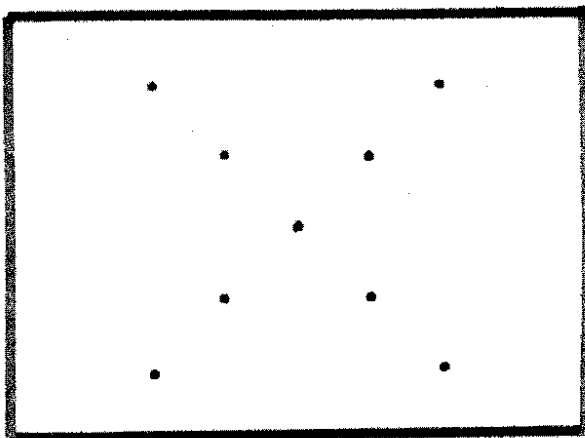
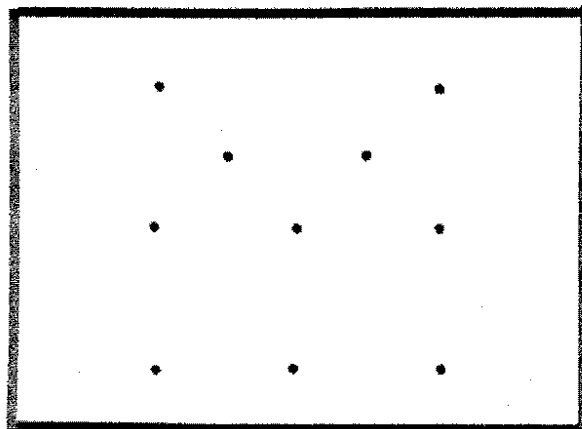
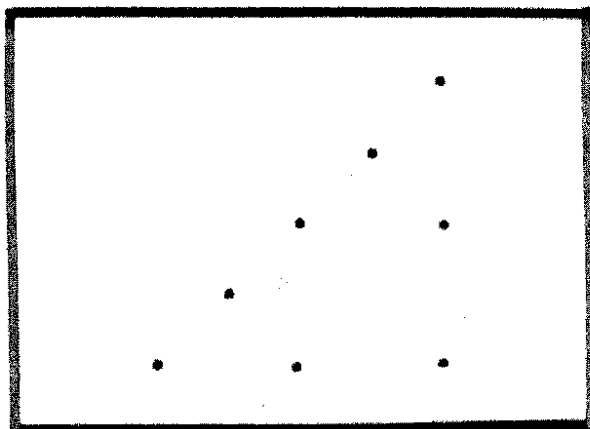
RECOGNITION

SET

## APPENDIX 6a. (continued)



PATTERN



RECOGNITION SET

## APPENDIX 6b.

## SCORES FOR RECALL AND RECOGNITION

S	V.E.S. score	Recall	Recognition
1	13	15	16
2	5	9	18
3	5	2	15
4	9	11	18
5	7	7	15
6	9	6	16
7	6	6	12
8	11	13	17
9	11	12	14
10	12	10	13
11	11	13	18
12	8	9	18
13	2	5	17
14	7	8	15
15	5	4	17
16	12	13	17
17	8	10	17
18	12	13	18
19	9	8	15
20	15	10	15
21	9	10	17
22	6	9	18
23	11	13	17
24	9	8	15
25	7	6	15
26	14	14	17
27	12	13	17
28	9	8	14
29	1	8	16
30	3	6	15
31	2	8	15
32	9	9	15
33	4	9	18
34	9	10	17
35	6	9	17

## APPENDIX 6b. (continued)

S	V.E.S. score	Recall	Recognition
36	10	11	17
37	3	8	18
38	10	13	16
39	13	13	17
40	7	8	16
41	5	7	14
42	9	10	16
43	8	9	17
44	9	10	18
45	8	10	15
46	6	7	15
47	13	12	15
48	11	12	18
49	12	15	18
50	9	8	15
51	11	13	18
52	7	10	15
$\bar{x}$	8.44	9.62	16.19

## APPENDIX 6c.

## RESULTS OF TESTS FOR TREND

The number of levels of X (see Appendix 4b) was 15 (V.E.S. score groups 1-15, inclusive). The number of ranked observations on Y (the dependent variable) was 52.

TESTS FOR RELATIONSHIPS BETWEEN V.E.S. SCORES AND NUMBER OF CORRECT  
RECALL DRAWINGS

- i) Monotonic trend:  $S = 791$   $\sigma_s = 124.44$   $z = 6.35^*$  ( $p \ll .00006$ )
- ii) Bitonic trend:  $S = 205$   $\sigma_s = 122.66$   $z = 1.67$

TESTS FOR RELATIONSHIPS BETWEEN V.E.S. SCORES AND NUMBER OF CORRECT  
RECOGNITION CHOICES

- i) Monotonic trend:  $S = 100$   $\sigma_s = 121.88$   $z = 0.81$
- ii) Bitonic trend:  $S = 78$   $\sigma_s = 120.15$   $z = 0.64$

## REFERENCES

- Antrobus, J.S., Antrobus, J.S., & Singer, J.L. Eye movements accompanying daydreaming, visual imagery, and thought suppression. *Journal of Abnormal and Social Psychology*, 1968, 69, 244-252.
- Aserinsky, E., & Kleitman, N. Two types of ocular motility occurring in sleep. *Journal of Applied Physiology*, 1955, 8, 1-10.
- Averbach, E., & Coriell, A.S. Short-term memory in vision. *Bell System Technical Journal*, 1961, 40, 309-328.
- Bartlett, F.C. *Remembering*. Cambridge: Cambridge University Press, 1932.
- Betts, G.H. The distribution and functions of mental imagery. *Columbia University Contributions to Education Series*, 1909, 26, 1-99.
- Bower, G.H. Mental imagery in associative learning. In L.W. Gregg (Ed.), *Cognition in learning and memory*. New York: Wiley, 1972.
- Bradshaw, J.L. Pupil size and problem solving. *The Quarterly Journal of Experimental Psychology*, 1968, 20, 116-122.
- Brooks, L.R. The suppression of visualization by reading. *The Quarterly Journal of Experimental Psychology*, 1967, 19, 289-299.
- Brooks, L.R. Spatial and verbal components of the act of recall. *Canadian Journal of Psychology*, 1968, 22, 349-368.
- Brown, B.B. Visual recall ability and eye movements. *Psychophysiology*, 1968, 4, 300-306.
- Bruner, J.S. On cognitive growth. I. In J.S. Bruner, R.R. Olver, & P.M. Greenfield (Eds.), *Studies in cognitive growth*. New York: Wiley, 1966.
- Bugelski, B.R. Images as mediators in one trial paired-associate learning. *Journal of Experimental Psychology*, 1968, 77, 328-334.
- Chowdhury, K.R., & Vernon, P.E. An experimental study of imagery and its relation to abilities and interests. *British Journal of Psychology*, 1964, 55, 355-364.

- Coltheart, M., & Glick, M.J. Visual imagery: a case study. *The Quarterly Journal of Experimental Psychology*, 1974, 26, 438-453.
- Cooper, L.A., & Shepard, R.N. Chronometric studies of the rotation of mental images. In W.G. Chase (Ed.), *Visual information processing*. New York: Academic, 1973.
- Craik, F.I.M., & Lockhart, R.S. Levels of processing: a framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, 1972, 11, 671-684.
- Dement, W., & Wolpert, E.A. The relation of eye movements, body motility and external stimuli to dream content. *Journal of Experimental Psychology*, 1958, 55, 543-553.
- Doob, L.W. The ubiquitous appearance of images. In P.W. Sheehan (Ed.), *The function and nature of imagery*. New York: Academic, 1972.
- Ferguson, G.A. *Nonparametric trend analysis*. Montreal: McGill University Press, 1965.
- Fisher, R.A., & Yates, F. *Statistical tables*. Sixth Edition. Edinburgh: Oliver & Boyd, 1963.
- Furth, H.C. *Piaget and knowledge*. Englewood Cliffs, New Jersey: Prentice-Hall, 1969.
- Gibson, J.J. *The senses considered as perceptual systems*. Massachusetts: Houghton, 1966.
- Gordon, R. An investigation into some of the factors that favour the formation of stereotyped images. *British Journal of Psychology*, 1949, 39, 156-167.
- Griffith, D., & Johnston, W.A. An information-processing analysis of visual imagery. *Journal of Experimental Psychology*, 1973, 100, 141-146.

- Griffiths, K. *A study of the strategies underlying the discrimination of rotated figures.* Unpublished honours thesis, Australian National University, Canberra, 1975.
- Hebb, D.O. Concerning imagery. *Psychological Review*, 1968, 75, 466-477.
- Holt, R.R. Imagery: the return of the ostracized. *American Psychologist*, 1964, 19, 254-264.
- Kahneman, D., Peavler, W.S., & Onuska, L. Effects of verbalization and incentive on the pupil response to mental activity. *Canadian Journal of Psychology*, 1968, 22, 186-196.
- Kaplan, A. *The conduct of inquiry.* San Francisco: Chandler, 1964.
- Kendall, M.G. *Rank correlation methods.* London: Griffin, 1948.
- Kintsch, W. Abstract nouns: imagery versus lexical complexity. *Journal of Verbal Learning and Verbal Behavior*, 1972, 11, 59-65.
- Konorski, J. *Integrative activity of the brain.* Chicago: The University of Chicago Press, 1967.
- Kosslyn, S.M. Scanning visual images: some structural implications. *Perception and Psychophysics*, 1972, 63, 149-162.
- Kosslyn, S.M. Information representation in visual images. *Cognitive Psychology*, 1975, 7, 341-370.
- Kuhlman-Hollenberg, C. Functions of visual imagery in the learning and concept formation of children. *Child Development*, 1970, 41, 1003-1015.
- Lea, G. Chronometric analysis of the method of loci. *Journal of Experimental Psychology*, 1975, 104, 95-104.
- Lenox, J.R., Lange, A.F., & Graham, K.R. Eye movement amplitudes in imagined pursuit of a pendulum with the eyes closed. *Psychophysiology*, 1970, 6, 773-777.

- Marks, D.F. Individual differences in the vividness of visual imagery and their effect on function. In P.W. Sheehan (Ed.), *The function and nature of imagery*. New York: Academic Press, 1972.
- Marks, D.F. Visual imagery differences in the recall of pictures. *British Journal of Psychology*, 1973, 64, 17-24.
- Natsoulas, T. The subjective experiential element in perception. *Psychological Bulletin*, 1974, 81, 611-631.
- Neisser, U. *Cognitive psychology*. New York: Appleton-Century-Crofts, 1967.
- Neisser, U. Visual imagery as process and experience. In J.S. Antrobus (Ed.), *Cognition and affect*. Boston: Little, Brown, 1970.
- Neisser, U. Changing conceptions of imagery. In P.W. Sheehan (Ed.), *The function and nature of imagery*. New York: Academic, 1972.
- Paivio, A. Mental imagery in associative learning and memory. *Psychological Review*, 1969, 76, 241-263.
- Paivio, A. On the functional significance of imagery. *Psychological Bulletin*, 1970, 73, 385-392.
- Paivio, A. *Imagery and verbal processes*. New York: Holt, Rinehart & Winston, 1971.
- Paivio, A., & Foth, D. Imaginal and verbal mediators and noun concreteness in paired-associate learning: the elusive interaction. *Journal of Verbal Learning and Verbal Behavior*, 1970, 9, 384-390.
- Paivio, A., & Yuille, J.C. Mediation instructions and word attributes in paired-associate learning. *Psychonomic Science*, 1967, 8, 65-66.

- Paivio, A., Yuille, J.C., & Madigan, S. Concreteness, imagery and meaningfulness values for 925 nouns. *Journal of Experimental Psychology Monograph Supplement*, 1968, 76, (1, Part 2).
- Palermo, D.S. Imagery in children's learning: discussion. *Psychological Bulletin*, 1970, 73, 415-421.
- Peterson, M.J. The retention of imagined and seen spatial matrices. *Cognitive Psychology*, 1975, 7, 181-193.
- Piaget, J. *Play, dreams and imitation in childhood*. (Trans.) New York: Norton, 1951. (Originally published in French in 1946.)
- Piaget, J., & Inhelder, B. *Mental imagery in the child*. (Trans.) London: Routledge & Kegan Paul, 1971. (Originally published in French in 1966.)
- Pylyshyn, Z.W. What the mind's eye tells the mind's brain: a critique of mental imagery. *Psychological Bulletin*, 1973, 80, 1-24.
- Reed, S.K. *Psychological processes in pattern recognition*. New York: Academic, 1973.
- Reed, S.K. Structural descriptions and the limitations of visual images. *Memory and Cognition*, 1974, 2, 329-336.
- Reed, S.K., & Johnsen, J.A. Detection of parts in patterns and images. *Memory and Cognition*, 1975, 3, 569-575.
- Reese, H.W. Imagery and contextual meaning. *Psychological Bulletin*, 1970, 73, 404-414.
- Reyher, J., & Morishige, H. Electroencephalogram and rapid eye movements during free imagery and dream recall. *Journal of Abnormal Psychology*, 1969, 74, 576-582.
- Richardson, A. *Mental imagery*. London: Routledge and Kegan Paul, 1969.

- Segal, S.J., Fusella, V. Influence of imaged pictures and sounds on detection of auditory and visual signals. *Journal of Experimental Psychology*, 1970, 83, 458-464.
- Segal, S.J., & Gordon, P.E. The Perky effect revisited: paradoxical thresholds or signal detection error? *Perceptual and Motor Skills*, 1969, 28, 791-797.
- Sheehan, P.W. A shortened form of Betts' Questionnaire Upon Mental Imagery. *Journal of Clinical Psychology*, 1967, 23, 386-389.
- Sheehan, P.W., & Neisser, U. Some variables affecting the vividness of imagery in recall. *British Journal of Psychology*, 1969, 60, 71-80.
- Short, P.L., & Walter, W.G. The relationship between physiological variables and stereognosis. *Electroencephalography and Clinical Neurophysiology*, 1954, 6, 29-44.
- Simpson, H.M., & Paivio, A. Changes in pupil size during an imagery task without motor response involvement. *Psychonomic Science*, 1966, 5, 405-406.
- Simpson, H.M., & Paivio, A. Effects on pupil size of manual and verbal indicators of cognitive task fulfillment. *Perception and Psychophysics*, 1968, 3, 185-190.
- Sperling, G. The information available in brief visual presentations. *Psychological Monographs*, 1960, 74 (Whole no. 11).
- Sperling, G. A model for visual memory tasks. *Human Factors*, 1963, 5, 19-31.
- Stewart, J.C. *An experimental investigation of imagery*. Unpublished doctoral thesis, University of Toronto, 1965. Cited in A. Paivio, *Imagery and verbal processes*. New York: Holt Rinehart & Winston, 1971.

- Sutherland, N.S. Outlines of a theory of visual pattern recognition in animals and man. *Proceedings of the Royal Society*, 1968, 171, 297-317.
- Werner, H., & Kaplan, B. *Symbol formation*. New York: Wiley, 1963.
- Winer, B.J. *Statistical principles in experimental design*. New York: McGraw-Hill, 1970.
- Yuille, J.C., & Paivio, A. Imagery and verbal mediation instructions in paired-associate learning. *Journal of Experimental Psychology*, 1968, 78, 436-441.