REPRESENTATIONAL MODES OF THINKING EMPLOYED BY CHILDREN AGED THIRTEEN AND FOURTEEN, AND THEIR RELATIONSHIP TO PERFORMANCE IN STANDARDISED TESTS OF ABILITY, MEASURES OF CREATIVITY AND PERSONALITY

A thesis submitted for the degree

of

Doctor of Philosophy

Francis William Potter, M.A. (Lancaster)
Diploma of Education (Advanced) (Bristol), Ed.Cert.

The University of Aston-in-Birmingham

March, 1977

ABSTRACT

This thesis proposes that despite many experimental studies of thinking, and the development of models of thinking, such as Bruner's (1966) enactive, iconic and symbolic developmental modes, the imagery and inner verbal strategies used by children need further investigation to establish a coherent, theoretical basis from which to create experimental curricula for direct improvement of those strategies.

Five hundred and twenty-three first, second and third year comprehensive school children were tested on 'recall' imagery, using a modified Betts Imagery Test; and a test of dual-coding processes (Paivio, 1971, p.179), by the P/W Visual/Verbal Questionnaire, measuring 'applied imagery' and inner verbalising. Three lines of investigation were pursued:

1. An investigation
   a. of hypothetical representational strategy differences between boys and girls; and
   b. the extent to which strategies change with increasing age.

2. The second and third year children's use of representational processes, were taken separately and compared with performance measures of perception, field independence, creativity, self-sufficiency and self-concept.

3. The second and third year children were categorised into four dual-coding strategy groups:

   a. High Visual/High Verbal   b. Low Visual/High Verbal

   c. High Visual/Low Verbal   d. Low Visual/Low Verbal

   These groups were compared on the same performance measures.

   The main result indicates that:

1. A hierarchy of dual-coding strategy use can be identified that is significantly related (.01, Binomial Test) to success or failure in the performance measures: the High Visual/High Verbal group registering the highest scores, the Low Visual/High Verbal and High Visual/Low Verbal groups registering intermediate scores, and the Low Visual/Low Verbal group registering the lowest scores on the performance measures.

Subsidiary results indicate that:

2. Boys' use of visual strategies declines, and of verbal strategies increases, with age; girls' recall imagery strategy increases with age.

Educational implications from the main result are discussed, the establishment of experimental curricula proposed, and further research suggested.

ACKNOWLEDGEMENTS

The author is deeply grateful to all those people who have so willingly helped in this research in many ways, and especially to:-

- Dr. Norman Graham, Reader in Education at the University of Aston.
- the children from Churchdown School who conscientiously formed the research population, and did so with characteristic friendliness and good-humour.
- Mr. W. E. Baker, Head of Churchdown School, Gloucestershire.
- Mr. K. Billing and Mrs. S. West for assistance with test administration.
- Mrs. Elizabeth Wells and Miss Jennifer Perraton for manifest skill and patience in typing a difficult manuscript.

and especially to

my wife and family for their unfailing support and encouragement which has sustained me over a long period of part-time study as a mature student.

CONTENTS

APPENDICES

TABLES, FIGURES AND GRAPHS

RESULTS: SECTION A1

RESULTS: SECTION A2/B2

RESULTS: SECTION A3/C2

GLOSSARY OF SPECIAL TERMS

Age and Year Groups

Year One represents age group 11-12

Year Two represents age group 12-13

Year Three represents age group 13-14

First-order strategies: primary strategies

modes of representing thought-processes; such as imagery or internal dialogue.

Second-order strategies

structural, logical, operational and planning activities

Representational Processes:

covert thinking strategies as measured by Betts and P/W Visual/Verbal Questionnaire.

'Pure Imagery' or 'Recall' Imagery

imagery of a recall type as measured by the modified Shortform of Betts Test, equivalent to Betts 'contrived' imagery.

'Applied Imagery'

representational imagery employed specifically in problem-solving, such as visual imagery used in solving visual problems, or internal dialogue: equivalent to Betts 'spontaneous' imagery.

Dual-coding Strategies: operational term derived from dual-coding hypothesis (Paivio, 1973)

'Applied' visual and verbal strategies as measured by P/W Visual/Verbal Questionnaire.

Inner Speech: internal dialogue

Inner Verbalising: internal dialogue, specific to 'talking out' the factors in a problem to be solved: covert verbalising.

CHAPTER ONE

INTRODUCTION

- an outline of the problem

A developing trend towards the individualisation of educational processes brings forward, as an urgent problem, the need for teachers to know more about how different children think, and the strategies they develop for use in their learning.

Indeed, following the philosophical and methodological advances of the curriculum development projects of the last decade, promoted by organisations such as the Nuffield Foundation and the Schools' Council, a time is approaching when the next major advance in our understanding of the educational process and how to improve it, may come from a renewed investigation into the child's primary thinking and learning processes, and how they may be improved.

This is an area which is seriously under-represented in research in this country, if one takes as a criterion the number of major projects, originated by the Schools Council, and other curriculum developers. The pragmatism, which focuses on what appears to be of immediate practical value in the curriculum, disregards more fundamental issues of thinking and learning, perhaps because they are so difficult to expose in a valid researchable way, and perhaps because the benefits of succeeding in learning more of fundamental aspects of thinking have not yet been perceived as relative to what teachers see as the educational process.

The problem needs to be tackled at this level if we are to do more than pay lip-service to the need to equip children with better, generalised problem-solving procedures which they can utilise and develop with flexibility, in order to be able to comprehend and use the changing complexes of new knowledge that constitute man's understanding of his life and place in evolution.

Some recognition of this has been evidenced by an emphasis, for example, in Schools' Council Projects on developing the processes of children's cognitive, and evaluative competence rather than the product of the performance: an emphasis on 'competence' as a deeper, more reliable factor than 'performance'.

In this the major organisations involved in curriculum development have performed an immensely important function in freeing the curriculum from the stereotypicality which tends to become a characteristic of any curriculum after a period of time, as Harold Benjamin (1939) amusingly points out in 'The Sabre Tooth Curriculum'.

Yet the underlying methodology of many of the curriculum development projects, like, for example, the Nuffield Science Projects, has been still to utilise a 'black box' approach to the child's development, which, while demanding of the child the development of problem-solving behaviours, has not inspected, or researched the fundamental nature of the problem-solving behaviours that the child is using.

Such a methodology could become a new orthodoxy, itself inhibiting further advance, and perhaps it would do so, if our attention is not directed to learning more of how the child thinks and of the representational strategies that he employs in doing so.

The argument in this research, therefore, proposes the need for more investigation of how the child develops his cognitive abilities, with a view to subsequently improving our methodologies for helping him develop.

The problem is not new. As long ago as 1916, Dewey developed a theme of argument that suggested that lack of educational advance was due, among other factors to:

a) Failure to take account of the instinctive or native powers of the young.

b) Failure to develop initiative in coping with novel situations.

c) An undue emphasis on drill and other devices which secure automatic skill at the expense of the development of personal perception.

d) Taking the adult environment as the acceptable standard for the child.

Few thinkers on education since then would disagree with these broad statements of the ways in which educators fail. Yet little research appears to have been done, especially at the secondary school level, to answer the questions that underlie the statements.

'what are the instinctive or native powers of the young?'

'what are the components of the child's 'initiative' in coping with novel situations?'

'how does personal perception develop?' Or, even more importantly from the point of view of the educator,

'what causes personal perception to fail to develop?'

The extensive debate on the place and value of discovery learning and the degree of curricular structure needed for optimum learning still begs important questions relating to the intrinsic nature of the child's thinking and learning processes.

Do natural, sequential developments of children's thinking exist? Are there identifiable patterns of thought processes, of which models can be made for the purpose of examination and comparison of different cognitive development? To what extent are such thought processes genetically determined or environmentally modifiable? And how does the child utilise and develop his own conceptual processes?

The consensus of current thinking, despite the recent furore caused by the questioning of Burt's data by Kamin (1975), can still be assumed to be that intelligence, if seen as a function of the development of the thought processes, may be genetically determined in the sense that an upper and lower limit may exist; but that it is susceptible to modification, a rich intellectual environment having the capacity to significantly adjust the extent to which an individual's potential is achieved. In Hebb's terms (1949) these are intelligence factors A and B. Vernon (1965) extended the theory by suggesting that intelligence is a compound not only of Hebb's intelligence A and B, but also of intelligence C: the result of limitations imposed upon our understanding of the interaction between intelligence A and B by the measuring instruments we use.

These simplifications, however, may obscure the possibility that another factor might be found to exist as the result of the individual's self-determined structuring of the genetic/environmental intellectual interaction: a hypothetical intelligence D, arising from developing autonomy as a result of the educational process. If a fundamental task of education is, as Boyle suggests in the Foreword of the Newsom Report of 1963, to give pupils a chance 'to acquire intelligence', we need to know more about how children receive their knowledge of the world and develop their own individual modes of representing and storing that knowledge for recall and use. Nor is this need new. There are many references in the educational and psychological literature to the theoretical existence of different representational modes of thought and the sequential patterns within which these modes develop. The field of representational thought processes is based upon theories often at odds with each other, because of the lack of evidence, especially related to the age ranges concerned within this research.

Some research specific to the thirteen and fourteen age ranges is reported in Chapter Two, the review of literature, and this includes reference to some previous work by the author, who sought to develop and test some hypotheses related to the existence of representational thinking modes used by children of fourteen to fifteen during problem-solving (Potter, F.W. and Walsh, B.M., 1969).

The research presented here is derived in part from the 1969 research project, which investigated the use of covert verbalising, and of two types of imagery 'pure' and 'applied' imagery, as defined in the glossary. The major theoretical basis for the research, however, comes from work done by other researchers under two main headings:

The role of language as representational process, and
The role of imagery as representational process.

These are the covert processes to be further investigated, in a thesis which postulates the thinking process as including composite elements of each; in Paivio's term (1971 p.179), 'the dual-coding hypothesis'.

The role of language as representational process

The theoretical background to this aspect of the research rests upon the three major sources of representational theory that have been called the Harvard School, the Genevan School and the Russian School, as typified respectively by the work of Bruner, Piaget and the Russian psychologists Vygotsky and Luria. The three schools have broadly agreed in the sequential growth of cognitive operation: Bruner's (1966) postulation of enactive, iconic and symbolic modes of representation being broadly concordant with Piaget's concrete, operational and formal stages of thought (1951). All three schools develop the concepts of mental imagery as an intermediate representational mode, significant in the development process; and of verbal behaviour, subsequently symbolising the imaginal and concrete foundations of thought.

There are sources of disagreement, however, between the three schools as to the nature of the various representational modes and their relationship and impact on each other. Consequently the three schools reflect different viewpoints concerning the nature and development of thought, especially in terms of the development from iconic to symbolic processes.

Summarised, the positions are as follows:-

a) The Genevan School regard language as a means of expressing thought. Inhelder et al (1966) in experiments relating to conservation of liquids in wide and thin beakers, and training in appropriate linguistic protocols, found that children who had shown a partial understanding of conservation on pre-tests, subsequently expressed themselves more consistently and clearly on the post-tests.

The pre-test non-conservers, however, while acquiring linguistic skills in terms of spontaneous description of what happened to the water-levels, still had not acquired an understanding of conservation, since they continued to insist that there was less to drink in the wide beaker. The Genevan workers therefore point out that while language may assist the selection, storage and retrieval of material, it cannot be responsible for its co-ordination. The Genevan argument is that co-ordination of thought takes place by assimilation and accommodation of the relevant internal intellectual structures: language is insufficient to explain the initial formation of intellectual operations.

b) The Harvard viewpoint, expressed by Bruner (1966) stresses that thought comes to conform to language, since the child inspects his language, then goes back over his experience to check for match or mis-match between what he sees with his eyes and what he has just said. It is the recognition of contradiction, at the level of language, according to Bruner, that enables the child to go back to reality and restructure the experience. Thus, for Bruner, thought makes language possible, and language in turn refines thought. Bruner's emphasis in the argument regarding intellectual development is one of the functional role of language.

c) In further contrast, the Russian School, particularly as expressed by Luria, are even more opposed to the Piagetian/Inhelder view-point since they argue that thought presupposes language.

> 'Language is not only a means of generalisation, it is at the same time the source of thought'. (Luria 1963, p.85)

Thus, the Russian view is of the role of language itself as a prime operator in intellectual development.

Other aspects of the thinking process, such as the use of imagery and visualising, appear to be disregarded by such a viewpoint, however, and these are now considered.

The Role of Imagery as representational process

As Paivio throughout his comprehensive analysis of the literature relating to imagery and verbal processes indicates, the alternative coding processes of behaviour and memory are the imaginal processes. (Paivio 1971).

He counters the behaviourist objections to mentalistic concepts, summarised by Deese (1965, p.4) that imagery by virtue of its subjective nature, is not examinable in scientific terms, by reference to numerous suggestions and evidence reported in the literature by authoritative thinkers that stimulus-response psychology cannot, of itself, provide a full account of behaviour (Paivio 1971, pp.1-8). Others supporting this viewpoint include Piaget and Inhelder (1971), Richardson(1969), Sutherland (1971), Bruner (1964) and Bruner, Olver, and Greenfield (1966), Sheehan (1967 a and b), and Neisser (1967) to name but some of the prominent researchers who have been active in this field, and whose work is reported more fully in Chapter Two.

Representational processes and the choice of the 13 and 14 year old age group

Much of the theory relating to representational processes, both verbal and imaginal, has been based upon experimental work with young children, below the age of eleven, or work with university and college students and adults.

There is comparatively little evidence from the research literature, however, of work on representational processes being undertaken with children of the secondary school age range. One important reason for this is the difficulty of gaining access for research purposes to pupils who are already beginning to be heavily committed to studying for public examinations. Furthermore, where the research is of a nature that may not produce immediate practical advantages, access to this age group is even more difficult.

Yet the secondary school age range constitutes a substantial proportion of the overall school population and it has characteristics that need investigation. By the age of fourteen, for example, substantial differences of intellectual functioning between different members of the population are being exhibited. Furthermore, if the theory of a hierarchical intellectual progress to symbolic operations holds good (Bruner 1966, Piaget 1951), then it might be useful to know more about the cognitive operations of the 13-15 age group, in terms of:

a) preferred modes of representation, either generally in terms of <u>storage</u>, or specifically, in terms of <u>utilisation</u> for different types of task.

b) the relationship of such preferred modes, if established, to <u>performance</u>, as judged by standardised tests of ability.

Such knowledge, if established, could be of advantage to teachers, who may experience difficulties with the age group arising from treating groups of children as though they are all using similar thinking and learning strategies, and can all cope with the work, irrespective of individual differences. Such an assumption may perhaps be derived from a subject-centred, as opposed to a child-centred approach. From a prima facie inspection of such an assumption, however, one can immediately argue that hypotheses could be established and should be tested, relating to whether or not children use different combinations of primary thinking strategies, and if so, what might be the concomitant results of doing so.

If the existence of differences of thinking strategies could be so established, and if means could be found to identify which of the thinking strategies or which combinations of strategies are predominant in successful performance in problem-solving, then it is not inconceivable that curriculum planning could be undertaken that would have as an objective the helping of children to inspect and modify their own thinking strategies and so secure better cognitive performance. Even a hypothetical gain of ten per cent in cognitive functioning, could constitute a very substantial advance.

However, one can only move towards establishing such a theory by asking questions, such as:

'Why are some children able to retain and use spatial features such as maps, more easily than others?', and

'<u>How do they do it</u>?', and

'Why can some children arrive at a logical response to a question when others cannot?', and again,

'<u>How do they do it</u>?'

There are even more basic questions to which we should perhaps address ourselves, relating to the existence and use of representational modes of thought. This research investigates some of these basic questions; seeking answers which might form a basis for further thought and research about the representational strategies that children use, in order to consider possible educational developments that could arise to help children inspect their own strategies and improve.

Summary

The main area that the research seeks to illuminate may be expressed by the following questions:

1. Do children in the 13 to 14 age range use primary thinking strategies, inner verbalising and visualising, in solving problems?

2. Can the strategies be identified?
   Can the strategies be quantified?

and, on the assumption, based on a small, previous research, that the answers to these questions will be affirmative (Potter and Walsh, 1969):

3. Are there discernible sex differences in the primary thinking strategies used?

4. Are the primary thinking processes modified by increasing age? If so, with what results?

and again extrapolating further,

5. Is there some identifiable hierarchy of primary thinking strategies that is linked to success in these other aspects of ability, creativity and personality?

6. Can evidence be established relating to the existence and function of primary thinking strategies which would form a justifiable basis on which to propose an experimental curriculum project aimed directly at improving those strategies?

It is the author's view that, with the notable exception of Sutherland (1971), who has sought to bring together psychological and educational theory about the imagination processes, relatively little has been attempted, at a curriculum development level, to interpret the results of the many psychological experiments related to representational aspects of thinking in terms of educational development. Indeed, at a subjective level of judgement, the gulf appears to be widening between the psychological priorities for investigation that are implicit in the work of, for example, information processing researchers such as Farnham-Diggory (1972) and Chase (1973), and those of teachers in class rooms, who face the realities of helping children investigate, think, evaluate, decide. This is not intended as a negative criticism of the work of the information-processing school; the work they do is clearly contributing to the important function of developing our understanding of thinking processes.

Rather, it should be taken as contributing to an argument that it is the professional responsibility of teachers, to consider more deeply how insights into human behaviour derived from psychological experiments might be incorporated into the curriculum, taking that word at its widest level of definition.

Furthermore, it is perhaps the responsibility of teachers if they perceive that psychologists are omitting to ask questions that may lead to psychological discoveries that can be incorporated into the curriculum, either to take investigatory action themselves, or to stimulate psychologists to do so.

This research then is in the difficult area that lies between scientific question and educational policy and practice.

It attempts to produce evidence about children's thinking that will perhaps justify and enable a new approach to the problem of children's thinking to be incorporated into an experimental curriculum.

It is clear that in an area which is as diffuse and difficult of operational definition as this, that valid evidence may be difficult to establish; but the educational consequences of succeeding, if only to a very small degree, could be of worthwhile advantage. The problems, therefore, seem worth attempting to define and investigate. The objective is to produce some empirical foundation from which a discussion of curriculum change which involves attention to primary thinking strategies, might proceed.

CHAPTER TWO

Review and analysis of Literature

The literature of representational processes is extensive and to select for inclusion and criticism in the review what is appropriate to those particular aspects which the research seeks to investigate is a severe problem.

Since 1966 a number of substantial works of review relating to the role of imagery and covert verbal processes have been published, (Bruner 1966, 1973, Neisser 1966, Sheehan 1966, 1967a and b, Sheehan and Neisser 1969, Paivio 1971, 1973, Piaget and Inhelder 1971, Radford and Burton 1974, McGuigan and Schoonover 1973, Sutherland 1971, Richardson 1969.)

Of these, Neisser and Paivio especially, have drawn together salient references to research undertaken in the field. Yet, on inspection, it is notable that comparatively little of the research undertaken has been with children of secondary school age. Exceptions to this include the work of Bruner, Hudson (1966 & 1968), Wallach and Kogan (1965), Getzels and Jackson (1962) and Piaget and Inhelder (1971), although much of the work of the latter researchers has been with younger children.

This review, therefore, attempts to set the limited research reports relevant to the thirteen to fourteen age group, against the broad backcloth of general literature of representational processes under the following headings:-

1) Representational processes in children's thinking; problems of introspection.
2) The nature of imagery and its relationship to perceptual processes.
3) Covert verbalising as a problem-solving mode.
4) Developmental factors relating to representational modes.
5) Sex differences in imagery and covert verbal processes.
6) Representational modes, creative ability and personality.
7) Problems of measurement of representational modes.

8) Environmental and cultural factors in the use of representational strategies.

9) Individual differences in the utilisation of representational strategies.

Representational processes in children's thinking: problems of introspection.

Since this research leans towards Bruner's explanations of psychological processes and supports his educational views, it is perhaps appropriate to open the review of literature with two brief statements that summarise Bruner's general view point.

Firstly he declares (1966, p.34) that four general policies should exist in Education:-

1) In relation to what is taught: that the principal emphasis should be upon the development of skills of handling, seeing and imaging and of symbolic operations.

2) That a curriculum should involve the mastery of skills that in turn lead to the mastery of more powerful skills, the establishment of self-reward sequences.
(Such a consideration can apply as well to first-order strategies as to second-order strategies; see glossary for definition of these terms).

3) The need to establish a metalanguage and 'metaskills' for dealing with continuity in change.

4) The need to bring greater resources than hitherto, to bear in designing our educational system.

Such a design for an educational system should involve careful research in high priority areas. No apology is offered for advocating that research into children's thinking should be regarded as a high priority. Consider the educational and economic advantages that might accrue if a

15% improvement could be made overall in the quality of peoples' thought-processes - if ways of raising and measuring such 'output' could be devised. Some work has been done, albeit in a small way, by Deutsch (1963) among others, who made a conscious effort to lead children to verbal skills: to a sense of paraphrase and exchange.

Secondly, Bruner's belief in the four policies is contingent with the major expression of his philosophy (1966, p.21) that the heart of the educational process consists of providing:-

> 'aids and dialogue for translating experience into more powerful systems of notation and ordering'.

These systems may arise as the result of re-structuring experience into new models by 'increasingly powerful representational systems' based upon a proposal to develop self-consciousness in intellectual development through <u>awareness</u> of notations by which re-coding takes place.

The problem, as Donaldson (1963, p.25) has emphasised, is: Can thought processes be made overt? By what means can thought be rendered available for inspection by more than one observer?

Two further questions are worth asking, in contemplating a direct study of thinking:

'Is the thinker himself aware of his thought processes?' and 'Can an observer become aware of them?'

These questions imply criticism of the introspective method of enquiry that bring difficulties to the surface if one considers at length two methods by which introspection may take place. If the subject <u>describes</u> the process of thought he has used, his description is retrospective and the thinking process may be subjected to what Binet (in Donaldson, 1963, p.27) calls 'a verbal illusion'; that is, a distortion due to verbal composition. On the other hand, if the subject is asked to 'say aloud' what he is thinking, as he thinks it, the very act of finding words to describe the thought process may distort that process.

Indeed for many years introspection has been regarded by the behaviourists led by Watson (1930), as unscientific and producing evidence that is not truly observable, testable and reproducible, and therefore inadmissable. Relatively recently (Hebb 1968) has denied that introspection is involved in reporting imagery, saying that such reports are merely verbal behaviour. For Hebb and other behaviourists only speech is objectively observable and one can only infer from it something about internal processes.

But distinction can be made between statements of introspection and introspection as a method, and Radford and Burton (1974, p.389-395) have argued, as had Burt (1962), that science has a probabalistic nature and that no scientist could insist on absolute criteria before accepting a datum. R. S. Peters (1953) has criticised the insistence on method which was characteristic of Watson, suggesting that science is not such that any one method exists that guarantees success, nor are there methods that should be proscribed. Scientific method is a broader concept than 'methods' of behavioural analysis or 'methods' of introspection. What might be of more value would be the establishment of criteria for assessing any one method as more or less useful.

Acceptance of introspection as a means of achieving data for examination has been demonstrated by numerous scientists (Neisser 1966, Paivio 1971, Holt 1964) to quote but some. Even some of the researchers who work through the medium of electrophysiological correlates of human behaviour find themselves at some point interpreting, or inferring psychological activity from their objective physiological measures (McGuigan and Schoonover 1973). Sokolov (1969) for example reported increased speech muscle activity during covert linguistic processes, including silent reading.

For in the absence of other methods of discovering how people behave covertly, introspective enquiry may be defensible, especially if the experimenter makes his assumptions clear and adheres to appropriate limitations of interpretation of data. If, as Donaldson suggests (1963, p.29) the use of introspection enables one to discover more about the processes than any study of the product will reveal of them, then the use of introspection may be further justified. It might be foolish to refuse to study what the subject can report, just because one has no grounds for believing that his report is absolutely accurate. A study of the reporting of covert processes might well be held to have validity in proportion to the number of people who report similar patterns of process, especially if these are discovered to be linked with similar patterns of performance in other cognitive tests.

The nature of imagery and its relation to perceptual processes

There may be reasons to suppose that a person's ability to perceive, and modes of thinking, as reflected in performance on spatial tests, may be connected with his whole personality organisation, as the work of Witkin et al (1954) suggests. Indeed, their researches go so far as to indicate that modes of thinking which result in a subject's high spatial test performance are linked to quality of awareness of the social world around him. Neisser (1966, p.300) is clearly thinking along lines similar to this when he says:

> 'I believe that the processes of visual cognition and perception in general may serve as useful models for memory and thought'.

This might be held to be a somewhat naive view of cognition undervaluing, as it appears to, the primacy of the role of conceptual cognitive processes as organisers of sensory experience, in order to 'know' and 'recognise' the perceptual stimuli as they are received. Brunswik (1956) is theoretically explicit about this primacy of conceptual process over perceptual process; and so is Soltis (1966, p.30) who, quoting a hypothetical example of an Amazonian Indian's instantaneous transition from a primitive culture to a modern highway, points out that although the Indian would have appropriate visual sensations on seeing an automobile, he would not recognise the automobile, since he would not be able to apply, in Ryle's term (in Soltis 1966, p.28) an automobile 'perception-recipe'.

Such a view is related to, and perhaps derived from, the early, well known work of Perky (1910) in a study of imagery that indicated that subjects striving to create an image of a banana on a screen, on being presented with a faint projected input picture of a banana, but without knowledge of this input, were unable to distinguish the percept from the image.

At this point it might be appropriate to defend the use of philosophical terms in what is essentially a psychological research; for although such terms may not lend themselves to operational definition it is difficult to see how a study of processes such as imagery and verbalising can do without epistomological support. Indeed, it might be argued, and perhaps should be recognised, that both images and covert verbal processes only exist as articles of philosophical faith. No one can really be sure that other people do, in fact, 'see' images or covertly verbalise. Philosophic support for these concepts is, therefore, particularly appropriate, especially as some evidence has been gathered that many 'objective' studies of perception, an area closely linked to imagery, for instance, have lacked careful, theoretical definition.

Richardson (1969, p.2) has attempted to produce semantic criteria for separating the concept of an image from a percept as

'Mental imagery refers to (1) all those quasi-sensory or quasi-perceptual experiences of which (2) we are self-consciously aware and which (3) exist for us in the absence of those stimulus conditions that are known to produce their genuine sensory or perceptual counterparts, and which (4) may be expected to have different consequences from their sensory or perceptual counterparts.'

Such a definition would suggest, with Zikmund (1966, in Richardson 1969, p.11), that such quasi-experiences involve the reactivation of those neuro-physiological processes of the central nervous system that were activated during the original perceptual experience, although as Richardson says, the C.N.S. activity may be at a lower level of intensity.

Paivio (1971, p.311) does not accept Richardson's criteria and argues that only the latter, having 'different consequences from their sensory and perceptual counterparts' is acceptable. In this he moves towards the adoption of a behaviourist stance since such a criterion is more likely to lead to observable experimental effects. But even in experimental work with perception there may be a need for improvement in experimental design.

Jenkin (1957) conducting an examination of the literature of perception in the ten preceding years, attempted to categorise the perceptual studies into four areas. The difficulties he found during this literature review led him to conclude that there is a need for greater concern for theoretical objectives and a corresponding need for improved methodology in the field of perceptual investigation.

That disparity of theory exists is demonstrable in the disagreement expressed between Stroud (1955) and Neisser (1966, p.33). Stroud's thesis is that the integration of successive perceptual stimuli is dependent upon their being received within what he calls the 'same, discrete psychological moment'. On the other hand, Neisser believes this to be an improbable requirement. Using, as an example, the fact that one can still understand a tape played at faster speeds, he argues that segmentation of an auditory system is not time dependent. Yet the argument may be more valid when applied to the auditory system than when applied to the integration of visual stimuli. Furthermore, Neisser's argument does not allow for the effect of extraneous intervening stimuli.

Paivio (1971) reporting a series of behavioural studies has indicated powerfully that nonverbal imagery is a major factor affecting memory, language and thought. He interprets his studies to reveal functional characteristics that distinguish imagery from symbolic verbal processes. In an argument that bears upon the Stroud, Neisser controversy, Paivio proposes that the underlying mechanisms associated with imagery and verbal processes may be viewed as independent, but connected, systems for the storage, manipulation and retrieval of stimulus information. Among the other differences between the two systems, he states that the two systems differ most clearly in their relative capacity for parallel and sequential processing. Since information contained in visual imagery is apparently spatially organised, so not only can it be processed synchronously, but sequential processing is relatively inefficient. Conversely, the verbal system is specialised for sequential organisation, presumably because of its auditory motor nature; whereas spatial organisation is more difficult in verbal terms alone (Paivio and Csapa, 1969).

The time element in verbal and imaginal information processing is therefore, clearly a factor in the processing outcome, and contributes to success or lack of success in the processing procedure.

Theoretical difficulties involving perception interact with practical difficulties and Postman (1953) points out that any perceptual study always involves the need to consider the extent to which results are influenced by the interaction of the manipulation of the stimulus on the one hand and the manipulation of the subject on the other hand.

This is, perhaps, especially important where the study is cross-sectional, when one considers the effect of age-differential on perceptual development. Wohlwill (1960), in a series of developmental studies of perception, has shown that incomplete and complex patterns are difficult for the child, as one might expect. More importantly, he has indicated that such complexities may be less daunting for the adult since perceptual assimilation effects decrease with age while contrast effects increase. Such a conclusion could explain why the young, in receipt of perceptual stimuli, concentrate on general outlines rather than internal detail; a factor which is clearly evidenced in children's drawings. Wohlwill further suggests that most unresolved questions on perception lie in this factor, of the decrease of assimilation effects with age. If such a developmental factor is a natural and inescapable one, this might be damaging for a theoretical projection from this dissertation, which is that maintained flexibility of the use of representational modes, as opposed to the possible decay of visual imagery, might be advantageous to the adult in problem-solving. Bruner (1966) suggests strongly, however, that the extent to which representational modes develop or decay is a function of the culture in which the individual resides. If one accepts this proposal, then presumably, theoretically at least, an educational system which promotes flexibility of usage of representational modes is a possibility.

Wohlwill's studies refer to the place of redundancy in perception, a concept which has been given attention by others in the field of perceptual and imagery investigation. Attneave, (1954), for instance, attempted to demonstrate the value of a concept of perceptual redundancy by applying techniques of information theory to problems of visual perception, and Grey-Walter (1968), and in personal communication, uses an extent of redundancy concept to define his 'visualists'. So does Haygood (1965) who found a significant difference between perceptual treatment groups, due to addition of redundant material.

More recently Palmer (in Norman and Rumelhart, 1975 pp. 280-307) has returned to this problem in an attempt to evolve a structural schemata model for the visual system based on the identification of 'nodes', i.e. essential features, each with a set of information specifying 'global' properties of each node: general size, location, orientation etc.

He thus suggests that interpretation of the part-whole structure is dependent on the extent to which internal part structures are differentiated. Figure I (from Norman and Rumelhart 1975, p.296) clarifies this observation.

Figure One

Aston University

Illustration removed for copyright restrictions

Aston University

Illustration removed for copyright restrictions

Aston University

Content has been removed for copyright reasons

With acknowledgments to: Norman A.D. and Rumelhart D.E. (1975)

What is far less clear is the extent to which individuals differentially select and store essential visual features (nodes) together with appropriate details needed to assist in re-interpreting perceptual imput by means of imaginal representational processes. Taking figure 2 A and B (Norman and Rumelhart 1975, p.301) for example, questions arise not only regarding a person's ability to interpret 'stick figures' and other reduced representations, but his ability to create reduced representations, and even to manipulate them for problem-solving purposes. However, the problem of manipulation of image and perception may well be a problem of competition for 'channel space' involving an interaction of environmental and internal sources of stimulation. Antrobus and Singer (1964) and Singer (1966) produced experimental evidence consistent with such a statement, yet a further experiment, Antrobus, Singer and Greenberg (1966) found that increasing the rate of signal presentation, or increasing memory load in a task, decreased the reported task-irrelevant thoughts in general, and in visual images in particular. Two further experiments treating the Perky phenomenon as a signal detection problem, Segal and Gordon (1968) and Segal and Fusella (1970) provide further confirmation that imagery and perception are continuous processes. Hochberg (1968) also includes the role of memory structures in perception in his theoretical position which proposes that successive brief glimpses of the parts of a figure will give a structured perception of the whole pattern. If such successive glances are stored as successive icons, in Bruner's term, then there is clearly a figure and ground element involving selective action with which the glimpses are joined into a single perceptual structure.

The amount of redundant material is one important characteristic of visual images. So then, is the extent to which the ability to image is under voluntary or involuntary control. McKellar and Simpson (1954) use the 'twilight' state that lies between sleep and wakefulness to investigate the vividity, autonomy and extent of change of hypnagogic imagery and suggest that retinal dust contributes to the presence of such images by acting as the 'distal' stimulus which triggers off mental activity.

McKellar's investigation is of a different type of imagery to that studied by the Habers (1964), in Neisser(1966, p.148). Using eye movements as a criterion, they discovered that some children were significantly different to others in terms of the amount of eidetic imagery possessed. There was no question about the visual character of the eidetic process.

'The most striking aspect of the eidetic child's report was the vividness and completeness of an image that was "out there" in front of him. There was no qualification in his speech, such as "I think I can see", nor did he ever use the past tense as he might have if he were combining image and memory. He was able to record very fine detail, such as the number of feathers worn by each of ten Indians in one pretest picture, the different colours in a multi-coloured Indian blanket, the expressions on the faces, and the various poses of the persons, and all from the same image'.

Neisser suggests that cultural reasons for a decline in adult capacity for eidetic imagery may exist, but he does not discount the possibility that some visual factor connected with literacy may be responsible, or even some gross age-linked physiological change. Indeed Kluver (in Neisser 1966, p.150) believes that an intimate relation may exist between eidetic imagery and the endocrine glands which are associated with age change. Sperling (1960), among others, has also investigated the after-image, discovering that some subjects could continue to 'see' and 'read' material for almost two seconds, the time by which the visual sensation may outlast the stimulus. As Neisser says (1966, p.79), it seems certain that visual input can be stored in some medium which is subject to very rapid decay.

Yet imagery of this type can by no means be similar to the types of imagery described by Gordon (1949) who used the terms 'controlled' and 'autonomous' and Betts, who as long ago as 1909, was referring to 'contrived' and 'spontaneous' imagery. Nor can the type of imagery referred to by Sperling be similar to that envisaged by El Koussy (1935) who stated that the 'K-factor depends on ability to obtain, and the facility to utilise, visual, spatial imagery'.

This opinion has been amplified by Spearman and Wyn Jones (1950) who support the proposition of a <u>specific type</u> of visual imagery that provides for effectiveness of performance in spatial tests. Such a suggestion, however, appears to overlook the fact that spatial ability may be a composite ability, Chown (1961) having claimed to find six factors of spatial ability. Nor does it accord with Slater and Bennett's (1943) finding that the spatial factor does not exist to any measureable degree at the age of 11, or Morrisby's (1967) support for Slater's position in finding that children below the age of twelve could not normally register performances on the Morrisby Shapes Test. Yet children of eleven and twelve may have clear imagery. Bruner (1967, p.65) reports on an experiment based on mathematics, in which children of primary schools age 'had a store of concrete images that served to exemplify the mathematical abstractions' in which they were engaged. 'With new problems the task was usually carried out, not simply by abstract means but also by "matching up" images: concrete props on which they leaned.' It is not surprising, therefore, that Holt (1964) was able to proclaim that the study of imagery, 'the ostracised', had returned to scientific respectability, brought back by:

> 'high prestige relatives, from "harder" disciplines like brain research'.

It is in this context that researchers like Neisser and Sheehan (1969) and Sheehan (1966, 1967) have promoted the rehabilition of imagery research.

So too have Piaget and Inhelder (1966) who, discussing static and dynamic aspects of imagery, suggest that imagery in children prior to the ages of seven and eight is characterised by a static quality, whereas later imagery is more flexible, capable of transformation and has some anticipatory quality. They suggest that early imagery is based on passive perception but that later imagery is founded on imitative acts and can be conceptualised as internalised imitation. It may be argued that such imagery is imitatively perceptual in the sense that eye movements trace the contours of a figure. Such an analysis would suggest that it is the more mature imagery that is capable of symbolising movement and transformation.

At the beginning of the twentieth century, many psychologists such as Galton (1919), Betts (1909) and Thorndike (1907), were engaged in the study of imagery as a fundamental process; but following Bartlett's study (1932) the problem remained virtually untouched until Ranken's renewed interest (1963, in Sheehan 1969) and Sheehan's development of a shortform of Betts questionnaire on mental imagery (1967).

Sheehan's (1969) study points to the effect of procedural variables on vividness of imagery, and suggests that imagery may play a special role in the recall of incidentally presented material.

On the other hand, Paivio (1971, p.347) has questioned the usefulness of vividness of imagery as a predictor of memory performance.Potter & Walsh (1969) found some discrepancy between children's performance on the Betts Shortform of Imagery Test which is based on vividness of image, and a test of use of imagery in the solving of a problem with spatial characteristics.

Some researchers have dealt with the topic of imagery as it relates to the performance of physical skills. Clarke (1960) tested one hundred and forty-four High School boys in order to discover the effect of mental practice on the development of motor skill. Using a mental practice group and a control group he concluded that 'mental practice was nearly as effective as physical practice'. Such a conclusion would, however, be very dependent on the conditions of the experiment. Nevertheless, it may well be that imagery and physical performance are related.

For example, Arnold, in 1947, suggested that a combination of kineaethetic/visual imagery could predict body sway. Start, in three papers (1964, a,b,c) found respectively, insignificant negative correlation between physical performance and intelligence; vivid autonomous imagery to be associated with low criteria scores in a physical skill performance test; and a small positive correlation between a test of kinaesthetic imagery and a physical performance which had been mentally rehearsed. The subjects in each experiment were adult males.

Covert verbalising and problem-solving

A physical effort of a different kind, small movements of the larynx, was observed to accompany thinking (Humphrey 1951, quoted in Neisser 1966, p.192). Since there appears to be no need for larynx muscles to work when thinking is taking place, then it may be argued that if the speech muscles are invoked during thinking, then covert verbalisation does take place in thinking.

Such an argument would be analogous to the use of eye movements as predictors of visual imagery (Haber, in Neisser 1969) and the correlation of blinking with mental work of a visual type (Bitterman and Soloway, 1946).

If imagery can play a special role, as Sheehan suggests, it may do so through the use of the images as 'comparative organisers' for the recall procedure. Ausubel (1963) has demonstrated a similar occurrence with regard to verbal learning, showing that learning and retention can be enhanced by the use of 'comparative language organisers'.

As with the role and use of imagery and perception, however, no general theory yet exists as to the role and use of verbalising in problem-solving. Wallace (1965, p.33) for example, quotes Woodworth (1939) who maintains that linguistic factors may be subsidiary to the main course of events in thinking, and sometimes even detrimental to effective thinking. Woodworth further asserted that thinking can sometimes be marked by introspectively observable events as non-linguistic as they are non-imaginal and non-sensory. Brown (1958) has also stressed the danger inherent in deducing the characteristics of thinking from the linguistic terms used. He refuses credence to the commonly held idea that a child moves essentially from the concrete to the abstract in his intellectual development, arguing that children use concrete terms because they are taught to do so by adults, and notnecessarily through intellectual preferences of their own. Another viewpoint has been expressed that is not coincident with this, that the child is not taught, but learns from a natural predisposition to evolve his own syntactical structures (Chomsky, 1964), although this view has also been challenged by Skinner (1957) and others. Yet against this one can set the point of view that the child is only free to operate with his 'language analysing device' within the limitations of the words he hears. The work of Lenneberg (1962) might also underline opposition to the importance of verbal behaviour to thinking, for he quotes the case study of an eight-year old boy who could understand but not speak.

Such a study may not correspond to the qualitative possibilities that are inherent in using words as stimulators of thought, and various investigators have probed this possibility. Kurtz and Hovland (1953) have found a verbalisation group superior in a test of accuracy of recognition and recall, Klein (1965) suggested that language handicaps would adversely affect reasoning ability, Deese (1962) found that both overt and covert verbalisation of associations were of use in problem-solving, Wolff (1967) produced data supporting the hypothesis that overt verbalisation facilitates concept formation, and Vernon (1964) referred to the 'necessity for verbal labelling of parts, within wholes, if inter-relations of parts are to be retained for future identification.' Two other researchers support the facilitating effects of language. Dietze (1955) working on phonetics and meanings, with pre-school children found that of groups learning different-sounding names on the one hand,

and similar-sounding names on the other, the different-sounding names group learned faster. Studying the performance of a verbalising group and a control group and using a tightly-defined manipulative problem, Gagné and Smith (1962) reported that the treatment group's verbalisation of self-discovered principles of solution took on importance as the complexity of the problem increased.

Various practical experiments have given backing to the development of a number of theories, some antithetical, regarding the importance and manner of language development in its relationship to thinking. The Whorfian hypothesis (in Carroll 1965) maintains that conceptualisation is entirely dependant on language. Brown and Lenneberg (1954) do not agree, and say that Whorf treats language as:-

'a mould into which infant minds are poured'.

Less strong than Whorf's position is that of Luria and Vinogradova (1959) who emphasise the ontogenetic aspect that links language and conceptualisation:

'As the child matures, verbal behaviour, implicit or explicit, gradually comes to mediate and regulate overt behaviour'.

Luria thus argues that when one's own speech assumes the role of reshaping one's 'significant perception' one has become, in Pavlov's term, 'the highest self-regulating system'.

This is quite a different emphasis from that of Bruner (1969, p.108) whose view of language is that it provides an internal technique for programming of person's behaviour, ability to discriminate, his forms of awareness. Support for this view at the level of covert and behaviour and its influence on thinking processes comes from McGuigan (and Schoonover, 1973). Reporting a series of studies using electromyographical measurement of the movement of speech musculature they confirm that covert oral responses occur under a variety of linguistic conditions. He further postulates that since the covert responses are part of a feed through condition, the covert response modifies the control behaviour. His results show that covert oral behaviour typically increases during silent reading and during memorisation, relative to a testing baseline, and that this phenomenon is quite general among language-proficient people.

Some interesting factors emerge. Adults selected on the basis of poor reading efficiency emit larger amplitudes of covert oral behaviour during silent reading than do adults who are proficient (Edfelt 1960). Similarly more covert oral behaviour occurs in children than in adults who were obviously more proficient readers (McGuigan et al 1964, in McGuigan and Pinkney 1971). Furthermore children selected on the basis of especially high levels of covert oral behaviour while silently reading, naturally decreased their covert oral response amplitude over the years as reading proficiency improved (McGuigan and Bailey 1969).

Data such as this indicates that amplitude of covert oral behaviour is inversely related to linguistic proficiency of selected subjects.

Channel utilisation theory touches upon this as does the proposition by Schaeffer (1973) that internalisation occurs when the overt component becomes progressively covert, as integration of skills occur in a limited capacity processing function.

As old skills become automated, processing capacity is released for the focussing of attention on new skills. That integration takes place during generalisation-directed skill use and/or problem-solving is also specifically supported by Bruner (1973). Then again, there seem to be distinct points of similarity between Luria's view of language and that of Bernstein (1967, p.232) whose notion of 'an elaborated code facilitating the verbal construction and exchange of individualised or personal symbols' emphasises rather more than does that of Luria, the importance of cultural and environmental background in the establishment of verbal symbolic modes.

Mediation and cognitive development

Two researches in particular may be seminal to the study of mediation strategies as they apply to cognitive development. Wallach and Averback (1955) demonstrated that auditory and visual memory are functionally distinct - a view supported by Paivio (1971) - and Kendler and Kendler (1962) suggested that mediators learn more rapidly than non-mediators. Assuming this to be so, it might suggest that children of different mediational propensities could use strength in one representational mode to compensate for weakness in another. At this stage, one might hypothesise that if verbal strategies are of a higher-order nature than visual strategies, then such a compensatory process might be a directional one: verbal strategies being able to compensate for weak visual strategies, but not vice versa. Providing the earlier strategic processes have been experienced, a compensating process need not operate unidirectionally, as Bruner shows in an experiment (1957, p.65) in which children are helped to develop concrete, imaginal and symbolic strategies and to use them flexibly in solving mathematical problems. Peel (1959) supports the necessity for a view of representational development as being epigenetic when he says:

> 'The geometrical abstractions implied in the straight line, in the angle and in dimensions, are not appreciated by young children until the more primitive forms, possibly connected with more undifferentiated movements and vision, have been experienced'.

Support for the notion of a hierarchical development of modalities of representation also comes from Werner and Kaplan (in Wallace 1965, p.43) who point out that gestures supply a primitive form of mediation, which precede verbal expression developmentally.

The researches reported so far focus on the complex problem of the role of maturation in learning. The difficulty of assessing the result of the ontogenetic factor has led Galperin (1966) to comment on cross-sectional studies as being inappropriate to the study of psychology. Yet the limit itations imposed by longitudinal studies mean that cross-sectional studies may often be the only source of information, and these we must interpret as best we may. This is particularly so where age and sex factors appear to influence performance differentially. It is not surprising, therefore, that opposing points of view are held. Zachariah (1958) for example, reports that in studies of accuracy of reproduction of visual image at various age levels, girls of nine years of age performed better than boys, while at age fifteen, the position was reversed. Such a linking of spatial performance and sex, is supported by Satterly (1968), and McFarlane Smith (1954) who found spatial ability to be associated with masculine attitudes and verbal ability to be associated with feminine attitudes. More recently Coltheart, Hull and Slater (1975) have indicated that phonological access to a lexicon, defined as a 'stored body of knowledge concerning the words of a language' is used more by women than men, suggesting that the sound of a word will have more effect on women than on men. On the other hand, Beard's (1965) study of perception found identical factors for both sexes. The position may also be complicated or explicated (it depends on one's point of view) by the study of representational processes used by children with a physical disability. Kates et al (1962) using otherwise matched groups of deaf and normal children, concluded that first-order representational strategies developed in basically the same way for both groups.

The key to such a parallel development seems likely to lie in the type of learning process used. A schematic type of learning, involving the meaningful linking of concept areas has been shown to be advantageous compared with rote learning (Skemp 1962, Bruner 1966) and one could argue that a schematic type learning is more likely to involve the use of representational strategies: first order thinking strategies, than is rote-learning, if rote-learning is defined as repetition.

This is not to minimise the value of second-order problem-solving strategies which involve the use of patterns of hypothesis-testing.

Stern (1965) has shown young children can be taught a hypothesis-testing strategy by demonstrating that children who have been taught to test one hypothesis at a time in a problem-solving situation, performed significantly better (.05 level) than a matched group that had no special training.

Part of the difficulty in investigating children's problem-solving performance arises from the fact that no consistent theory of the development of a problem-solving ability exists. Duncan's (1959) review of problem-solving literature from 1946-57 revealed that problem-solving appears to vary as a function of:

(a) simple sets of problems (b) complex sets of problems

(c) level of problem difficulty (d) aids to solution

(e) sex (f) age

(g) the reasoning ability of the candidate

This present research is concerned with functional representational concomitants of reasoning ability. It accepts Paivio's (1973) view that imagery variables are among the most potent mnemonic variables discovered, and that further questions should be raised relating to the fundamental characteristics of images as cognitive representations:

'What is the nature of the representational unit?'

'How are such units organised into high-order structures of an abstract nature?'

'What types of information-processing can be done by either imagery, or verbalising, or by combinations of both?'

'Do imaginal representations bear a direct isomorphic relationship to the perceptual information given by those objects and events or are they relatively abstract in the sense that perceptual information is transformed into some different format in long term memory?'

Various psychologists have implied that imaginal storage is consonant with sensory or perceptual processes (Bower 1972, Bulgelski 1970, Cooper and Shephard 1973, Hebb 1968) and this view is supported by Paivio (1973). Others prefer to conceptualise the underlying representational processes in some forms of logical propositions or abstractions. Pylyshyn (1973) has presented a strong argument for a common representational format for both linguistic and imaginal information; storage occurring in a highly abstract form of logical propositions. Rumelhart, Lindsay and Norman (1972) also present a model that involves a common propositional memory format for concepts, episodes and events, although they do not explicitly discuss the role of images. Jorgenson (in Sokolov, 1975, p.28) maintains that in all cases, thought operates with symbols, but distinguishes between non-depictive symbols (verbal), and depictive symbols which are non-verbal.

Paivio (1973) also declares the necessity to postulate separate representational systems for non-verbal and verbal information. He proposes a dual-coding theory which states that imagery is specialised for the processing of information concerning concrete objects and events, and is capable of organising imaginal units of information into higher-order structures of a synchronous character. The imagery system is dynamic, flexible and transformable.

By contrast, the verbal system is specialised for dealing with abstract information involving linguistic units, organised into higher order sequential structures. Some change of viewpoint is evident from Paivio's earlier (1971) assumptions that verbal processes might be less transformable amd more static than imagery and his view is now one of conceiving the difference between the two systems to be qualitative rather than quantitative. This seems to imply an extension of the theory of levels of meaning, (Paivio 1971, Chapter 3, Paivio and O'Neill 1970) which proposed the use of three terms, representational, referential and associative to identify different levels of cognitive coding. Briefly the levels are taken to be:-

representational level: the integration of units of information which correspond to non-linguistic and linguistic stimuli in long-term memory.

referential level: the activation of an established interconnection between imaginal and verbal representations.

associative levels which involve associations of representational units within each of the two symbolic systems.

Such a theory assumes a control process that can bias information flow within and between systems and Paivio assumes that such a control process is an intrinsic part of the representational system itself. Other theorists have made similar assumptions (Berlyne 1965, Hebb 1968, Piaget and Inhelder 1966).

While the case in general terms, for a dual-coding procedure appears to be strong, little evidence can be traced, in the literature, that illuminates the process by which it develops. This is especially so in relationship to the 11 to 14 secondary school age range. The reason for this is probably a pragmatic one. It is not easy for researchers to gain access to this age-range for research purposes that do not have some directly observable result on the educational process. Furthermore, in a research area in which data is collected by tests which may be weak in reliability, the increased sample size needed to make test results strong enough to merit some degree of interpretation, creates an additional access problem for the researcher.

These issues are especially potent in the present educational climate, in which schools are beset with problems associated with school re-organisation, curriculum development of a subject-centred type, examinations, staffing and resources, to mention but some. The value-systems of educational administrators do not always include recognition of the possibilities for development of the educational process that might arise from understanding more about the cognitive operations and development of the children.

It must be reported as a statement of fact that the author was only able to gain access to the research population referred to in Chapter Four, for the volume of testing reported, by virtue of his, then, position as Deputy Headmaster of the School.

If other researchers have had similar problems of access to a research population, this might well account for the paucity of research literature referent to representational processes, specific to the age group under investigation.

One research by Tyborowska at Piaget's instigation (in Piaget and Inhelder 1971, pp. 190-197) included samples of twenty children in each of the age groups from 5 years to 13 years, and one sample of twenty from the age group 14-16 years, in a study of reproductive images of transformations. The subjects were required to transform (a) lines of a given length into circles, and (b) circles of a given circumference into straight lines. Comparison of the incidence of percentage errors of transformation between age groups has been interpreted by Piaget to indicate that younger children utilise images in a way that is less anticipatory and more reproductive than older children.

Three factors are worthy of note here. As with earlier studies by Piaget, criticism can be made of the generalisations that are made from what are small sample sizes. No attempt is made to discriminate between the performances of boys and girls; and furthermore, the research excludes reference to the performance of the 14-16 age group sample altogether.

The author's research project (Potter and Walsh 1969) based on a population of 234 children aged 14 to 15 is not incompatable with Paivio's (1973, p.35) assertion of dual-coding cognitive operations and goes beyond it to the extent that the limited evidence from the research supports a view that children of 14 and 15 who claim high utilisation of <u>both</u> methods of coding perform better in standardised tests of ability than do children who claim low use of such representational strategies. The research (Potter and Walsh 1969) can be criticised however, in reaching this conclusion without having treated boys and girls as separate populations, and for not utilising the data in a research design with a replication.

<u>Sex differences in Imagery and Covert Verbal Processes</u>

Standard tests have frequently discussed in general terms the existence of sex differences in cognitive task performance. More specific evidence is provided, however, by Coltheart, Hull and Slater (1975) using a research population of undergraduates. They reported that phonological access to the lexicon, although used by both sexes to some extent, is used more by women than by men, and completed before visual access more often in women than in men. In suggesting that the sound of a word will have more effect in women than on men, Coltheart, Hull and Slater suggested further, that if the same pattern of sex differences appears in young children, such a finding might have educational implications. For example the use of phonic methods of teaching reading might be more appropriate for girls, and visual methods for boys.

Indeed it may be that sex differences in cognition are present early in life (Maccoby 1967, Buffery and Gray 1972). The latter two authors have argued that good evidence exists for believing that the determination of visuo-spatial skills is sex-linked to the extent that a recessive gene may be carried on the X chromosome; taking that proposition from studies which appear to indicate that in passing on visuo-spatial skills, fathers affect only their daughters and mothers principally their sons. However it must be observed that many of their conclusions with regard to the development of sexual characteristics are developed from laboratory animal experiments. The evidence relating to human beings is much more sparse. What is evident from inspection of the literature is that sex has rarely been controlled for in psychological experiments pertaining to representational processes.

Sutherland (1971 p.186) discussing sex differences in imagining says that we do not know if there is such a sex difference or not. She bases her case on the cultural and social conditioning argument. Different life-styles and expectations for boys and girls, result in a cognitive developmental pattern for each sex that is environmentally influenced, if not determined. As with the genetic/environmental argument about the nature and development of intelligence, firm evidence is difficult, perhaps even impossible to tease out. Yet R.W. Sperry (in McGuigan 1973 p.221) has noted that 'males are said to be six times more frequently afflicted than females, with congenital language disability' and that 'in a world-wide application of the Porteus (1965) maze test in many different cultures, girls scores were significantly lower than boys.' More evidence is needed if cognitive sex differences are to be identified sufficiently clearly to justify alteration of educational procedures.

Representational modes, creative ability and personality

Sutherland's view of imagining however, seems more akin to a form of general generative and creative activity than is the representational ability that this research seeks to examine. Yet it might be argued that use of representational processes has a link with creativity, if one can determine what underlies this global term.

Various attempts have been made to describe the factors relating to creative thinking. Taylor (1959) has proposed five levels of creative thinking: expressive, productive, inventive, innovative and emergentive thinking. Kettner, Guilford and Christensen (1959, in Radford 1974, p.85) described creativity as: ability to see problems, fluency of thinking, flexibility of thinking, originality, redefinition, elaboration. But these titles for factors resulting from factor analysis of subjects performance on performance tests also correspond to cells in the structure of intellect theory (Guilford 1963). There is certainly a difficulty in establishing whether these factors relate to behaviour than can be classified as creative. Guilford (1963) attempted to investigate this by asking a group of thirty-five 'recognised creative scientists' to rate twenty-eight of the factors derived from the structure of intellect model, on their importance in creative work. The four rated most highly were:-

1. Divergent production of figural transformations: that is abandoning conventional problem-solving methods for original methods.
2. Cognition of semantic transformations: seeing beyond the immediate and obvious.
3. Cognition of semantic systems: understanding the basic relationships inherent in a problem in order to solve it.

4. Convergent production of symbolic transformations: recognising that elements of a structure may be observed in such a way that they can be seen to have new functions.

This identification of characteristics, inspected from a viewpoint, that lies under the words used, includes reference to five characteristics of the thinking of this thesis: divergent thought, convergent thought, reasoning, covert use of semantic terms, and of spatial operations. Hudson (1966 and 1968) develop a theme that associates divergent thought with creativity and the arts, and convergent thought with intellect and the sciences. While he has produced some evidence that this may be so, the generalisation seems to be an oversimplification; what may be required for effective invention is not merely the ability to produce many new ideas but to be able to see the right combination for problem-solving. Nevertheless Hudson (1967, p.119) is explicit that creativity is originality; but other criteria must surely obtain, such as appropriateness to context, and other qualitative considerations such as transformation, and condensation (Jackson and Messick, 1965) or, in MacKinnon's terms, 'realisation' which includes 'a sustaining of the original insight and evaluation and elaboration of it' (1962, pp 484-95). That persistence is an ingredient of creativity is supported by Roe (1951) and Hudson (1967 p.160): but consideration of Torrance's (1967) list of creative behaviour categories:-

> curiosity, originality, independence, imaginativeness, non-conforming, sees relationships, full of ideas, experimenter, flexibility, persistence, constructive, preferring the complex, day-dreamer,

reveals the difficulty for the researcher, of decision-making concerning the categories to include and the weighting to ascribe to each category. It can further be observed that the creative characteristics listed, such as independence and curiosity can be categorised as personality traits. In this context reference must be made to Cattell's confirmation of Roe's (1951) conclusions that independence and curiosity are related traits in ... sample of scientists (in Open University Course E281 Unit 3 p.30)

Cattell suggests also that creativity is a question of personality rather than of cognitive skills. This is a view supported by MacKinnon's (1962) study of architects, an outcome of which is an observation that the importance of intelligence has been overestimated in considering creativity. However the MacKinnon study was of a special population, the results being applicable to architects with an IQ of 120+. In MacKinnon's research the creative group of subjects scored highly on a self-acceptance scale, indicating self-confidence, and also, interestingly, on the Mf femininity scale of the Minnesota Multiphasic Personality Inventory. An inference from this might be that the creative person is expressive of those aspects of the feminine side of his nature which are regarded as feminine in the American culture.

Other literature referring to creativity has also indicated a low correlation of creativity with intelligence. In Barron's words (1963, in Sutherland 1971, p.174),

> 'Where the subject matter itself requires high intelligence for the mastery of its fundamentals, as in mathematics or physics, the correlation of measured intelligence with originality in problem-solving within the discipline tends to be positive but quite low.' and
>
> 'Over the total range of intelligence and creativity a low positive correlation, probably in the neighbourhood of .40 obtains; beyond an IQ of 120 however, measured intelligence is a negligible factor in creativity.'

Getzels and Jackson (1962) have also indicated a discrepant correlation between children's performances in creativity tests and conventional intelligence tests. The average IQ of their group of twelve to seventeen year old boys and girls was over 130, and their study produced an average correlation between tests of creativity and test of intelligence of +0.26.

Hasan and Butcher (1966) partially replicated the Getzels and Jackson study with a mixed population of second year comprehensive school children in Scotland with an average IQ of 102. The children took a number of tests: a test of intelligence and ten creativity tests including four used by Getzels and Jackson. Correlations within the creativity tests averaged +0.25. The correlations between the creativity tests and the intelligence test averaged +0.46.

The Hasan and Butcher study shows clearly that in a representative population of 12 year old children there is an overlap between intelligence and creativity.

The work of Wallach and Kogan (1965) however, carried out with a sample of ten to eleven year old children of above average ability produced virtually no correlation between intelligence and creativity. Average intercorrelations in this study were: among creativity measures +0.41, among intelligence measures +0.51, yet between measures of creativity and intelligence +0.09.

This raises the question as to whether some threshold effect is operating in which the relationship between intelligence and creativity above a certain intelligence level may be different from that which operates below that intelligence level. A large number of studies are reviewed in Freeman, Butcher, and Christie's 1968 paper related to the degree of independence between intelligence and creativity. None, however, touch on the extent to which a degree of overlap might be related to the degree of use of representational thinking strategies.

Extending Potter and Walsh's (1969) conclusions that children who utilise a high incidence of representational strategies perform well in standardised tests of ability, an interesting hypothesis might be derived which would propose that an area of correlation between creativity and intelligence in children, might be where children are using a high incidence of dual-coding representational operations.

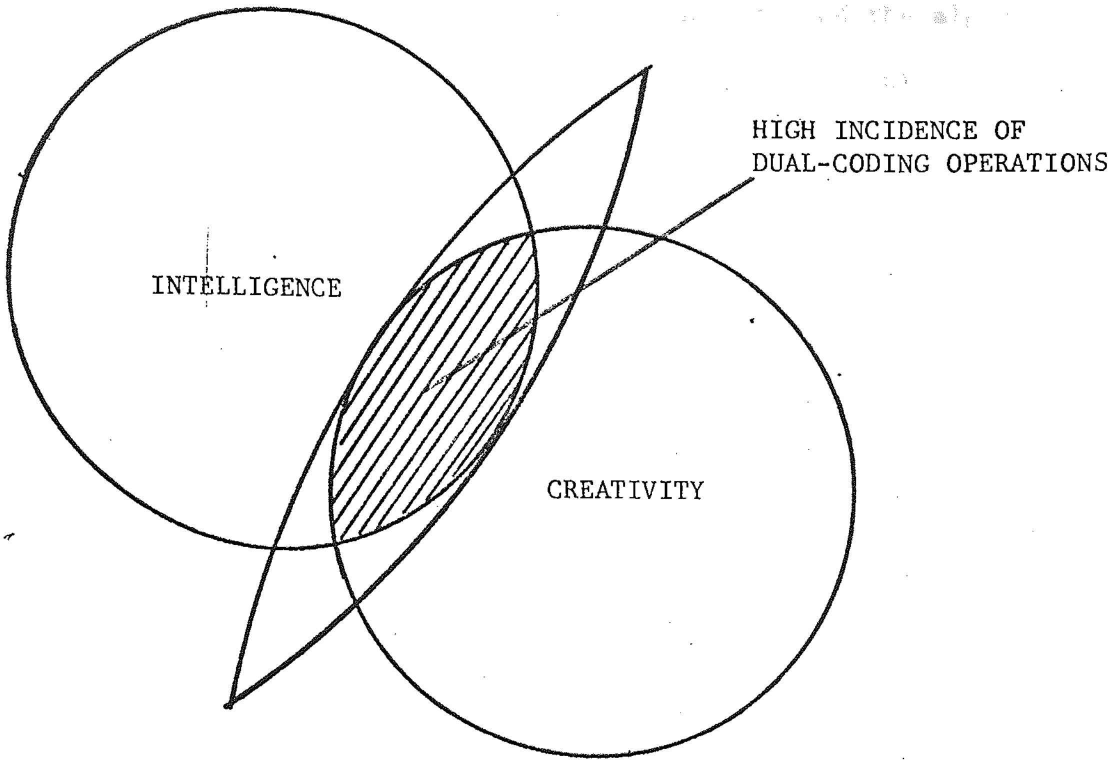


Figure Three Representation of hypothesis that high incidence of dual-coding operations correlate with intelligence and creativity.

Genetically determined or not, it does seem that spatial and representational abilities correlate with types of occupation chosen and statements of academic subjects preferred. As long ago as 1919, Galton was suggesting that choice of career as an engineer and spatial ability was correlated, Ann Roe (1963) concluded that successful physicists and mathematicians were non-visualists, but biologists had visualist capabilities. In 1965, Lewis Walkup, a major contributor to the invention of xerography, published an article pointing out that creative persons appear to have stumbled onto and then developed to a high degree of perfection, the ability to visualise - almost hallucinate - in the area in which they are creative. He advocated the development of action research directed towards education for creativity by extension of the individual's representational modes, visualising in particular.

So did Grey Walter (1968). His interest in visualising stemmed largely from his advocacy of a link between visualists and the alpha rhythm of electroencephalography. Together with Golla and Hutton (1943) he suggested that the amplitude of the alpha rhythm might serve as an objective measure of mental imagery. This thesis was supported by Short (1953) but rejected by Barratt (1956) whose research results suggest that the hypothesis of alpha rhythm suppression as an objective measure in providing an index of visual imagery, is not tenable. This is not to say that no connection exists, but that since imagery is only one of a number of factors that produce suppression effects, the alpha rhythm cannot be claimed to be an objective measure of imagery alone.

This statement points up the difficulty involved in deriving objective measures to investigate representational modes. Two ideas from Donaldson (1963, p.29) may be worthy of note in this difficult context. She suggests that modesty of claims about results of introspection may make those results acceptable to some degree, if they enable more to be discovered about the process than would be possible from the study of the product. She goes on to quote Burt's definition of an error of measurement as

> 'that part of the measurement that is attributable to factors irrelevant to the quality and quantity I want to measure'.

as justification of the use of the subject's introspective reports of mental functioning.

Environment and cultural influences upon problem-solving ability and representational processes.

One also needs to consider the effect of environmental and cultural influences upon problem-solving ability since there is a considerable volume of evidence to show that such influences bear heavily upon reasoning ability. Amster and Maraschilo (1965) noted significant difference between children of different socio-economic classes in terms of concept acquisition, and Sigel (1953), researching into developmental trends in the abstraction ability of children, concluded that social class differences influence children's ability to perform 'at representational levels'. Further backing for this viewpoint has been presented in a paper by Case, and Collinson (1962) who say that: cultural background, width of experience and verbal repertoire may play a part in determining different formal thought scores even with children of matched chronological age and mental age.

Yet cultural and environmental influences may not be regarded as the sole source of reasoning differences. Neisser (1967, p.287) suggests that it is very possible that some concept-structures, especially for space, time and language are determined genetically before any experience has accumulated. No proof can be offered that this is so. The extent to which cognitive style is determined by cultural influences such as the influence of the environment on perceptual judgements has been argued by Witkin (1967) who proposes the importance of a field-dependence-field independence factor in differentiating between cultures. Field dependent subjects are influenced in their consideration of the positional and spatial characteristics of an object which features in a background which is subject to variation. Field independent subjects can retain their own 'knowledge' of these characteristics of an object despite a variation in the background.

It has already been argued that creative people tend to be independent and autonomous in their judgements, and Spotts and Mackler (1967) have supported this with evidence that field independence correlates with divergent thinking tests. MacKinnon (1960) had previously found field independent subjects to be more original, more complex and more spontaneous. Radford (1974, p.111) quotes an assumption by Freeman, Butcher and Christie (1968) that an appropriate conceptualisation of field dependence and field independence, and their correlates, may be found in Harvey, Hunt and Schroder's (1961) conceptual systems theory.

'The theory proposes that a person's concepts are ordered according to certain patterns of organisation. It is assumed that one of the most important structural characteristics of this organisation is its degree of abstractness or conceptual level. A person at a high level is more likely to explore situations and to be creative and adaptable when faced with a changing environment. In contrast the person at a low level manifests thinking which is stereotyped, overlearned and dominated by the rules of authority. According to the theory optimal environmental conditions which allow the highest levels to be reached and characterised by maximum information feedback and allow the person to learn from that feedback.'

If figure-ground separation is of importance in this way some place must be found for considering the way in which such field independence is established. A proposition by Hochberg (in Sydney, 1971, p.47) may contribute. He uses a stimulus-response and repetition model of the perceptual process in which a perception, and hence visual, representation is built up by successive icons. In this the initial representation of the stimulus is successively supported by assimilation of the subsequent stimuli. After the original stimulus is removed the iconic representation is available for further processing. Such a theory argues for the importance of an effective representational visual process.

This review has included literature pertaining to imagery and covert verbalising, the dual-coding hypothesis; cognitive developmental factors; cognitive sex differences; and ability, creativity and personality. Where possible it has drawn upon authoritative research involving children of the age range under investigation but this aspect is sparse in literature.

Hence the author's interest in the field and the following inclusion of a short summary of the research (Potter and Walsh, 1969) which was the original entry point to it.

<u>Summary of previous research project into the use of representational modes of thinking and children's performance in tests of ability</u>
(University of Lancaster 1969)

In 1969 the author and a co-author submitted a joint dissertation on this topic as part of a taught postgraduate course at the University of Lancaster leading to the award of Master of Arts (Education).

The research, on a population of 234 fourth year children drawn from two coeducational comprehensive schools, utilised two measures of representational processes: an adaptation of the Betts Shortform of Imagery, and a devised test, the P/W Visual/Verbal Rating Questionnaire; together with three ability tests: the Morrisby Verbal Ability Test, the Morrisby Shapes Test and Raven's Matrices in order to examine hypothetical relationships between a high/low incidence of use of representational strategies and high and low performance in the standardised tests.

The results indicated that High Imagery Groups (recall imagery as measured by the Betts Test) performed significantly better than the Low Imagery Groups on the Morrisby Verbal Ability Test (P .01), the Morrisby Shapes Test (P .01) and on Raven's Matrices (P .05); and the group categorised as the High Visual/High Verbal group ('applied' imagery and covert verbalising) performed significantly better than the Low Visual/Low Verbal Group on the Morrisby Verbal Abilities Test (P .05) and the Morrisby Shapes Test (P .01). The result on Raven's Matrices was in the predicted direction but failed to reach significance (P .10).

A further section of the research identifying four groups of children who use different dual-coding strategies, and utilising an adaptation of Wood's Topological Problems presented visually and verbally, produced inconclusive results in terms of statistical significance but some interesting patterns of results (see Donaldson 1963, p.127). These results were in the direction predicted, that a hierarchy of dual-coding strategies may exist that is associated systematically with various aspects of cognitive performance.

A summary of the 1969 research, including details of the tests and procedures, has been placed in Appendix D, since the representational tests are used in this present research, and some of the results presently obtained support those obtained in 1969. The present research project arises in part from the results of the 1969 research, but mainly from the linking together of further ideas from this review of literature.

To summarise: the 1969 research indicated that for fifteen-year old children some effectiveness appears to be attached to an inter-related use of visual and verbal coding strategies relative to three standardised tests of ability. This research probes further into children's thinking by seeking to answer other questions about the possible relationship of dual-coding process to performance in tests of ability, creativity and personality at ages 13 and 14; questions about the development of coding strategies at ages 12, 13, 14, and about differential use of coding strategies by boys and girls in the same age range. What is needed is further information on children's representational processes that can be examined to see if experimental curricula to develop thinking strategies can be justified.

CHAPTER THREE

Summary of problems leading to:

Research hypotheses (Sections A1, A2/B2, A3/C2)

Null hypotheses, where it is appropriate that these are stated.

The problems to be investigated in this research derive from two sources: The suggestions for follow-up research from the Lancaster Research Project (Potter and Walsh 1969, Appendix D), and consideration of issues raised in the review of literature.

It should here be noted that arrangements to proceed with this part of the research were not made until October 1972. The period since 1969 has been rich with research interest in representational thinking processes, with numerous researches reported. A number of major textbooks including McGuigan and Schoonover (1973), Paivio (1971), Piaget and Inhelder (1971), Richardson (1969), Sutherland (1971), relating to imagery and verbal processes have also been published, further influencing the thinking behind this research project since 1969.

The 1969 research indicated three areas for follow-up research:

1. Consideration might be given to a research similar in scope to the 1969 research, but designed to test matched groups of low-ability children, or culturally disadvantaged children, on problems with specified and appropriate item difficulty. As Wallace (1965, p.44) points out,

   > 'the study of retarded children can provide insight into the conceptual process because they require it to be slowed down.'

2. Similar researches might also be made using different age groups of subjects, say age 12 and 18, to test hypotheses that different emphases are given to visual and verbal strategies at different ages.

3. Walkup's (1965) comment on the use of representational processes, especially of covert visual processes, by inventors, was noted as an assumption that needed testing.

> 'When asked if they use life-like visualizations when they are inventing, they are inclined to say, "Why, yes! Doesn't everybody".'

However, it seems that not everyone visualises to the same extent and evidence is available (Potter and Walsh,1969) that secondary school children vary considerably in the use of representational strategies.

Educational Research is needed to discover why this should be so, and to investigate the hypothesis that children vary in their appreciation of the usefulness of covert representation processes.

The extended review of literature raises more areas in which questions should be asked and theoretical hypotheses might be constructed. These include questions about the relationship of <u>differential</u> use of visual and verbal representational processes by subjects, to their perceptual ability, verbal ability, creativity, field dependence and personality.

It has been noted in the review of literature that sex has rarely been controlled for in researches into representational strategies previously undertaken; and an area of questions could also be established about the extent to which representational processes develop or degenerate in early adolescence, and the consequent effect, if any, upon the intellectual and creative life of the subject and his or her personality. A further area for consideration might include the extent to which representational processes can be modified by education.

However, these are large issues which need focussing into specific research hypotheses for investigation. The problem of refining a research area into specific questions which are of practical solution with limited resources has been discussed recently by the author, in a paper* (Kilty and Potter 1976) which contributes to a methodology by which research priorities can be established and managed, relative to resources available.

At the time that the design of this research was being established, however, the author's experience did not include this refinement of research methodology. Furthermore, decisions with regard to the type and extent of the research, the questions to ask and the means to resolve them, rested not only upon the refinement of research questions but on practical difficulties associated with the establishment and testing of a research population, and the selection of tests: issues which are discussed fully in Chapter Four.

It will be seen, therefore, that the research has a psychometric approach which has been partly determined by practical considerations. It is argued that despite misgivings by some researchers (Rex, J. in Richardson, K. and Spears, D., 1972, pp. 167-168) with regard to psychometric studies of intelligence, this approach has something to recommend it where theory is weak, in the sense that Eysenck has used the term (Eysenck, 1960) to indicate paucity of hard evidence, in contrast to strong theory that is grounded in the existence of substantial data, such as that associated with nuclear physics.

---

*Kilty, J.M. and Potter, F.W., 'Nursing Education Research Management: establishing priorities and optimising the use of resources: a methodology', Journal of Advanced Nursing, March 1976.

The question as to what should determine the specific objectives of the research was:

> Does evidence exist or can it be established relating to the existence and function of primary thinking strategies which would form a justifiable basis on which to propose an experimental curriculum project, aimed directly at improving those strategies?

It was envisaged that this research could at best only contribute towards collating or establishing such evidence. It was clear also that there would be methodological difficulties in doing so, which stem from the disparity between a psychological methodology that prefers experimental designs which focus on specific features of human behaviour and tries to control all the relevant variables and the methodology of curriculum development which is rarely in a position to do so: a methodology which more often operates by assessing the existing state of evidence for proposed change, decides on a course of action and works in an evaluative, action-modifying framework.

The problem for decision then became one of, bearing in mind the very broad objective, the problems of working in an area between psychological research and curriculum proposal, and the practical experimental constraints:

> 'How can the research be best arranged to utilise existing knowledge of representational processes, and produce integrating evidence in order to draw to the attention of teachers, aspects of children's thinking not normally taken into account in educational practice?'

This research does not set out to claim that by mounting an experimental curriculum project into representational strategies, improvements in children's thinking will be attained.

It does say, however, that despite the radical nature of the proposition, the question of doing so should be considered. Hence it was decided to follow-up the Lancaster project in a more comprehensive way, and it was hoped that in maintaining a broad experimental perspective that the research could examine several areas relating to both the incidence of use of representational strategies and the relationships of such strategies to various ability and personality factors. In this way, at least, there might be some anchoring of unfamiliar concepts of inner thinking strategies to psychological constructs which are more familiar. A broad experimental approach might also indicate which of the various areas relating to children's primary thinking strategies might take priority for subsequent investigation and curriculum experiment.

Why should a curriculum project relating to the development of primary thinking strategies need to wait on the results of a project such as this?

There are several interlocking reasons. In the first place the existing experimental evidence about the existence of covert primary thinking strategies has not been gathered into a unified theory, secondly teachers seem rarely used to discussion of aspects of how children think, although some recent work by de Bono (1976) has involved teachers in considering how the topic of thinking as a subject can be incorporated into the curriculum. However, teachers are usually more preoccupied with the overt methods used and results of thinking, expressed in subject curriculum terms.

It is likely, therefore, that there would be a credibility factor to take into account and countered in making a curriculum proposal directly relating to thinking strategies; with anticipated scepticism being best countered by propositions based on some empirical foundation, assuming that such a foundation can be established.

Against this can be set the fact that attitudes to the direct teaching of thinking are being influenced by the work of de Bono's Cognitive Research Trust (de Bono 1976): a development which has largely taken place since the commencement of this project.

Here it should be made clear, however, that de Bono's tools of thinking (pp. 116-137, 1976) are of structural types that, for the purpose of this research, are defined as second order strategies.

The argument in this research precedes the use of second-order strategies, by advocating research into first-order strategies: imagery, whether 'recall' imagery or 'applied' imagery; and a form of inner speech that operates by 'talking through' the factors in a problem; inner or covert verbalising.

Before carrying the argument further and specifying the research areas selected, it is necessary to define more closely some terms which are used to differentiate the primary thinking strategies that the project investigates.

Representational processes and dual-coding strategies

The term representational process is taken, for the purpose of this research, to include:

- recall imagery as measured by the Betts Shortform of Imagery Questionnaire: a measure of strength of recalled images. (BETTS)

  'applied' imagery, or visualising as measured in the P/W Spatial/Visual Test and the P/W Visual/Verbal Rating Scales: a measure of extent of visual manipulation of images used for problem-solving purposes. (VISQ)

  'inner' or 'covert' verbalising as measured in the P/W Spatial/Visual Test and the P/W Visual/Verbal Rating Scales: a measure of the extent to which the subject 'talks out' the issues as part of a problem-solving process. (VERBQ)

The term dual-coding strategies is taken to include only the two processes:

'applied imagery' or visualising as defined above.

and 'covert' verbalising as defined above.

since these are conceptualised as having a dynamic, manipulative function.

The problem areas for investigation were selected as follows, with the major aspects of the research falling within the propositions in Section A3/C2. The minor null hypotheses stated with each research hypothesis are derived predictions, which if rejected, may provide support for the substantive theory.

SECTION A1 (cf Diagram 1 p.78)

Here the main questions to attempt to resolve appeared to be those associated with the need to confirm that visualising and verbalising strategies are used by children of the 11 to 14 age range, and can be identified in a way that allows for some comparison with their other abilities. Other questions relating to the research population could also be investigated in this section. The 11 to 14 age range is one in which substantial differences of maturity and capability become manifest in a comprehensive school population. If Bruner's model of enactive, iconic and symbolic operations as a hierarchical development holds good and representational strategies are a measurable manifestation of this model, then visual strategies should be replaced by verbal strategies, to some extent, as children get older.

A third issue in the hypothetical pattern of development in this age range is complicated in that girls mature earlier than boys and at this age range have better language skills. Differences in preferred first-order thinking strategies might, therefore, be discovered within the age groups and, or, between the sexes.

Six main hypotheses emerge from this section:

1. That covert thinking strategies employed by 11 to 14 year old children in solving a spatial problem can be identified by the P/W Spatial Visualisation Test and P/W Visual/Verbal Rating Scales. The alternate hypothesis only is stated for this postulate.

2. That incidence of recall imagery, as measured by the Betts Shortform of Imagery Questionnaire (modified by Sheehan, 1967) declines from age 11 to 14, for boys and for girls.

3. That incidence of 'applied' imagery as measured by the P/W Spatial Visualisation Test and the P/W Verbal Rating Scale, declines from age 11 to 14, for boys and for girls.

4. That incidence of covert verbalising as measured by the P/W Spatial Visualisation Test and the P/W Verbal Rating Scale, increases from age 11 to 14, for boys and for girls.

   It is here acknowledged that a longitudinal study would have been preferred but was not feasible, practically. A set of cross-sectional comparisons between age groups was undertaken.

5. That girls use verbal strategies more than boys within each age group.

6. That boys use visual strategies more than girls within each age group.

SECTION A2/B2 (cf Diagram 1 p. 78)

Much of the research literature of imaginal and covert verbal processes relates to experimental work that has been undertaken in respect of either the imagery/verbalising mode or the other mode, covert verbalising,taken separately.

Section A3/B2 (cf Diagram 1 p. 78), which follows, develops an argument that a different approach to establishing a model of children's covert thinking processes, by observing the interaction of both processes, might be more useful.

However, in this section, Section A2/B2, it was decided to try to utilise some of the findings in previous psychological research, by observing the visual and covert verbal modes separately, in an effort to confirm and draw together some of those findings with regard to the separate thinking strategies.

To some extent, this section serves in validating the measures used in this research against results of other studies linking the single strategies such as 'recall' imagery with other abilities such as field independence.

It is noted that many of the studies reported in the literature are descriptive studies rather than explanatory ones. There are exceptions to this, however, such as Paivio's use of factor analysis (1971, p.495).

This section investigates the relationships, descriptively, by correlation and multiple regression, of the performance of children aged 12-14 in:-

1. 'recall' imagery, as measured by the test defined in A1,
2. 'applied' imagery, as measured by the test defined in A1,
3. covert verbalising, as measured by the test defined in A1,

with measures of other abilities:-

perceptual ability, field independence, reading ability, creativity, intelligence and two personality source traits, as defined in Chapter Four.

The overarching hypothesis in this section is that performance in each of the representational processes is positively related to performance in the ability measures. Specific null hypotheses in respect of each comparison are stated later in the chapter.

A subsidiary hypothesis proposes that each of 'recall' imagery, 'applied' imagery, and covert verbalising, with the other two variables being held constant, will contribute positively to the explanation of the variation in each performance ability measure.

No hypothesis can be offered for the extent of the contribution to the variance and this part of the investigation will be undertaken by a posteriori comment only, in view of the arguments advanced in Section A3/C2 which follows.

SECTION A3/C2 (cf Diagram 1 p.78)

The 1969 research had indicated from similar patterns of data from two comprehensive school populations, that children vary considerably in the extent to which they use the two dual-coding strategies: 'applied' visual strategy and covert verbal strategy. It also appeared that four main categories of strategy use could be established:-

1. Children using high visual/high verbal strategies (Hi Vis/Hi Verb).

2. Children using low visual/low verbal strategies (Low Vis/Low Verb).

3. Children using high visual/low verbal strategies (Hi Vis/Low Verb).

4. Children using low visual/high verbal strategies (Low Vis/High Verb).

Comparisons of the first two of these categories, 1 and 2, on Raven's Matrices, the Shapes Test and the Morrisby Verbal Test had indicated significant differences of performance between the high users of coding strategies and the low users.

From this data it seems arguable that a high incidence of use of both strategies contributes to successful cognitive performances, and low incidence of use of both strategies contributes to unsuccessful cognitive performances in terms of the tests defined in the preceding paragraph.

What was not clear from the data was whether or not there is difference of performance between the latter two categories, 3 and 4. If not, it is conceivable that some type of compensating mechanism may be at work between the differential use of visual and verbal strategy. If this were so, then some children may be making use of high visual strategies to compensate for low use of verbal strategies, and vice versa. This would be a very difficult hypothesis to investigate and it is not attempted in this research.

However, it is possible to postulate and test a hypothesis that groups 3 and 4, the High Visual/Low Verbal Group and the Low Visual/High Verbal Group will fall between the other two groups in the performance measures listed in Section A2/B2.

A major research hypothesis postulating the existence of a hierarchy of dual-coding strategies used, is therefore proposed:.

1. The best band of performances on measures of ability being achieved by children who make substantial use of both visual and verbal strategies in solving problems.

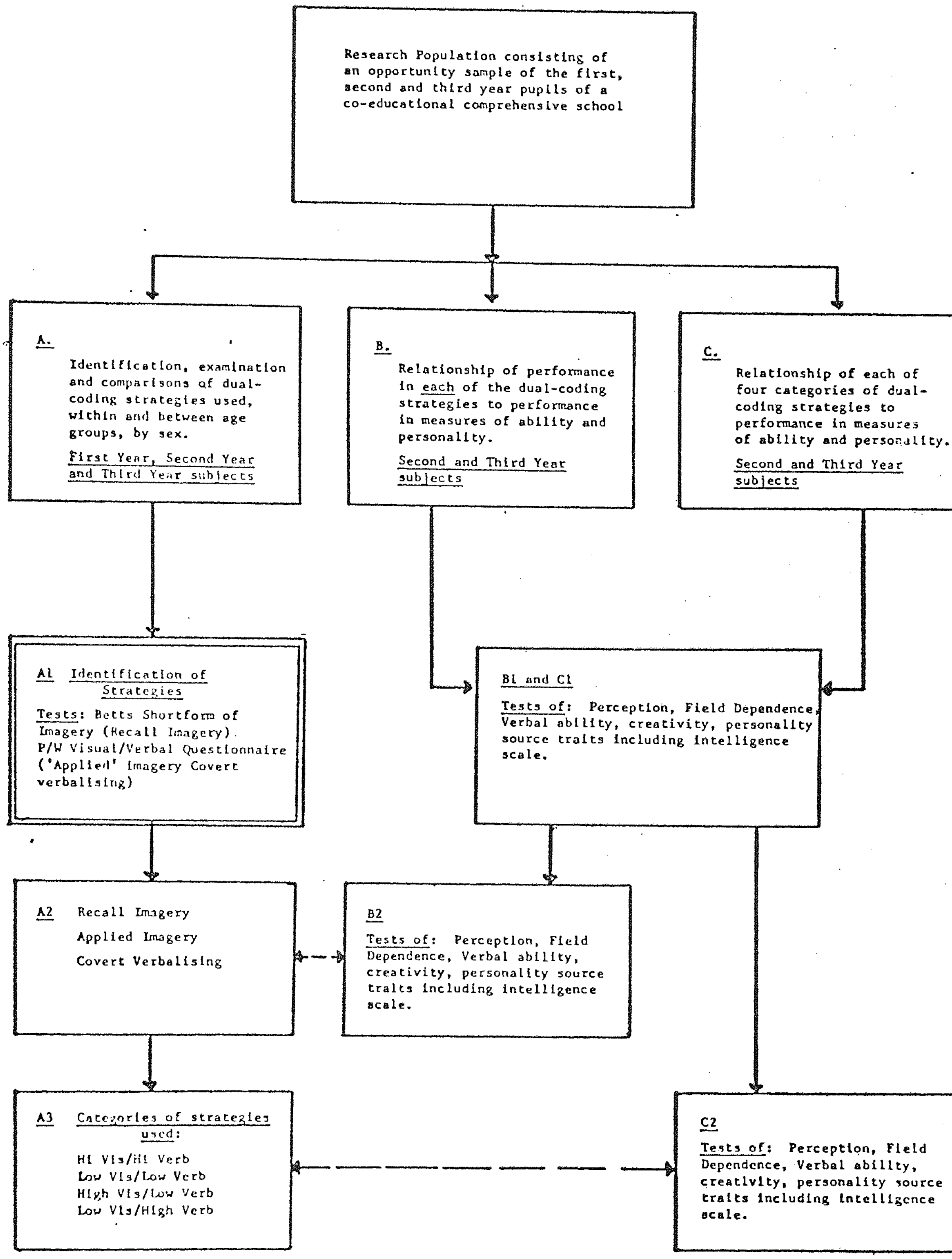
2. The middle band of performances being achieved by children who:

   either make average use of both strategies

   or use one strategy substantially to compensate for weakness in the other. (In this case some difference should be noticeable between children who are Hi Vis/Low Verb and children who are Low Vis/Hi Verb on tests which are either predominantly visual or verbal in character).

3. The lowest band of performances being registered by children who make little use of either strategy. Table 15 which follows, summarises the theory into the three main aspects of the research and indicates the inter-relationships between dual-coding strategies and measures of other abilities which were examined. Boxes A1, A2 B2, and A3 C2 indicate the three specific sections from which the research and null hypotheses were drawn.

Table I Research Design Summary One



SECTION A1 (From Table 1): HYPOTHESES ONE, TWO, THREE

Research Hypothesis One

Between age groups, within sex.

The hypothesis is that developmental factors operate in respect of visual and verbal strategies used; the incidence of visual strategies used giving way to increased use of verbal strategies with advancing age, for both boys and girls.

(The educational environment is more verbal with increasing age. The verbal mode becomes more dominant; the visual mode declines).

Null Hypotheses

'Recall' Imagery (Betts Shortform of Imagery Test)

1a First year boys do not score significantly higher than third year boys in a test of recall imagery.

1b First year girls do not score significantly higher than third year girls in a test of recall imagery.

'Applied' Imagery (P/W Tests, Appendix B)

1c First year boys do not score significantly higher than third year boys in a test of 'applied' imagery.

1d First year girls do not score significantly higher than third year girls in a test of 'applied' imagery.

Covert Verbalising (P/W Test, Appendix B)

1e Third year Boys do not score significantly higher than first year boys on a covert verbalising test.

1f Third year girls do not score significantly higher than first year girls on a covert verbalising test.

Research Hypotheses Two and Three

Within age group comparisons, between sex

Two:'Recall' Imagery

No evidence can be traced in the literature to suggest directional hypotheses for recall imagery as between boys and girls. Comparisons will be made, therefore, on a non-directional basis.

Three:'Applied' Imagery and Covert Verbalising

The hypothesis is that girls use verbal strategies more than boys at each of the age levels, and that boys use visual strategies more than girls at each age level.
(Girls are more mature than boys at ages 11-14. Girls' language facility is better than boys at this age).

Null Hypotheses

'Recall' Imagery

No significant difference of scores between boys and girls will be measured on a recall imagery test, comparisons being made within the following age levels:

2(a) first year 2(b) second year 2(c) third year

'Applied' Imagery

Boys will not score significantly higher than girls on a test of 'applied' imagery, comparisons being made within the following age levels:

3(a) first year 3(b) second year 3(c) third year

Covert Verbalising

Girls will not score significantly higher than boys on a covert verbalising test, comparisons being made within the following age levels:

3(d) first year   3(e) second year   3(f) third year

Explanatory note defining conventions in Sections A2/B2 and A3/C2, which follow.

In defining the scope of the hypotheses in Section A2/B2 and Section A3/C2, the following conventions are used:

1. The representational processes and the performance measures are as defined in Chapter Four.

2. The research population in this section consists of:
   Boys: the second and third year age groups taken together
   Girls: the second and third year age groups taken together

3. Where support for the hypothesis exists in the literature, the reference is given in parenthesis.

SECTION A2/B2 (From Table 1): HYPOTHESES FOUR, FIVE, SIX

Relationships of performance in each of the representational processes with performance in measures of ability, creativity and personality

Recall Imagery and Performance Measures

Research hypothesis Four

Recall Imagery is positively related to:

perceptual ability (Sheehan 1968; Zikmund 1966; Paivio 1971, p.111; McKellar and Simpson 1954).

field independence (Hochberg 1970, p.47; Witkin 1967; Palmer, in Norman and Rumelhart 1975, p.280).

reading ability, creativity, intelligence, self-sufficiency and self-concept.

The null hypotheses are stated as:

Recall Imagery, as defined by the modified Betts Shortform of Imagery Test is not significantly correlated with:

4(a) Perceptual ability as defined by the Morrisby Perceptual Test

4(b) Field Independence as defined by the Hidden Figures Test.

4(c) Reading ability as defined by a composite measure of reading ability.

4(d) Creativity as defined by a composite measure of creativity.

4(e) Intelligence, as defined by Cattell, factor B.

4(f) Self-sufficiency as defined by Cattell, factor Q2.

4(g) Self-concept as defined by Cattell, factor Q3.

Applied Imagery and performance measures

Research hypothesis Five

Applied Imagery is positively related to:

perceptual ability (Witkin 1954; Neisser 1966 p.300; Soltis 1966 p.30; Piaget and Inhelder 1966).

field independence (Hochberg 1970 p.47, Witkin 1967)

reading ability, creativity (Hudson, 1966, 1968), intelligence (Cattell 1969, p.28, Paivio 1971, Potter and Walsh 1969), self-sufficiency (Cattell 1969, p.33) and self-concept (Cattell 1969, p.34).

The null hypotheses are stated as:

Applied Imagery, as defined by the P/W Spatial/Visualisation Test and P/W Visual Rating Scale, is not significantly correlated with:

5(a) Perceptual ability (as previously defined)

5(b) Field Independence "

5(c) Reading ability "

5(d) Creativity "

5(e) Intelligence "

5(f) Self-sufficiency "

5(g) Self-concept "

Covert verbalising and performance measures

Research hypothesis Six

Covert verbalising is positively related to:

field independence (Witkin 1969),

reading ability (Kurtz and Hovland 1953), creativity,

intelligence (Ansubel 1963, Lenneberg 1962, Deese 1962, Klein 1965, Wolf 1967, Vernon 1964, Gagne and Smith 1962), self-sufficiency (McGuigan 1973, McGuigan 1964, McGuigan and Bailey 1969, Paivio 1973), and self-concept.

The null hypotheses are stated as:

Covert verbalising as defined by the P/W Spatial/Visualisation Test and the P/W Verbal Rating Scale is not significantly correlated with:

6(b) Field independence (as previously defined)

6(c) Reading ability "

6(d) Creativity "

6(e) Intelligence "

6(f) Self-sufficiency "

6(g) Self-concept "

SECTION A3/C2 (from Table 1): HYPOTHESIS SEVEN

Dual-Coding Strategies and Performance Measures

The 1969 project had shown that different groups of children could be established, categorised by the different dual-coding strategies that they use.

This section of the research proposes a hypothesis that states that the groups of children, categorised by the dual-coding strategies that they use, form a hierarchy which is positively related to success in the performance measures.

Schematically the hypothesis can be represented in the following way:

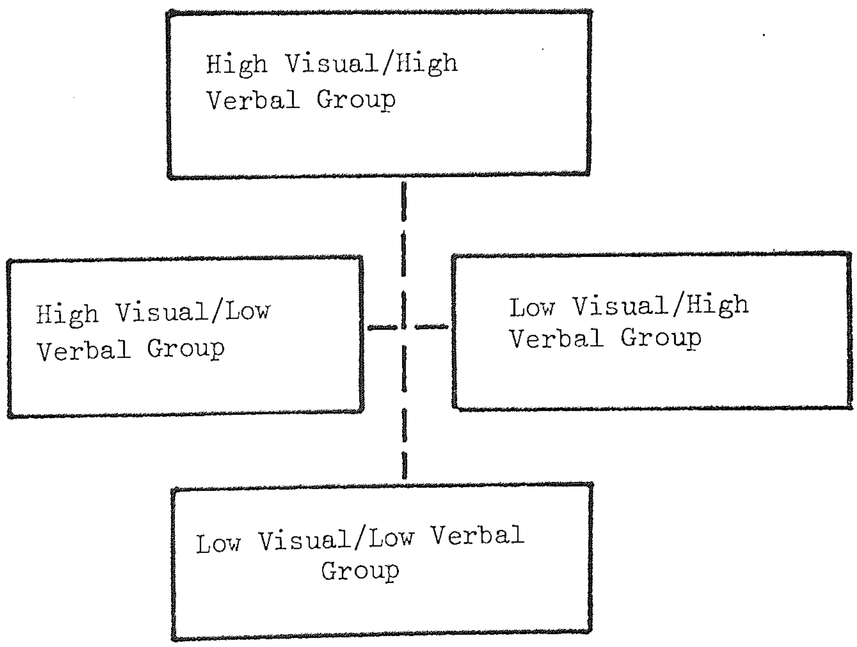
Table 2 Representation of dual-coding hypothesis

All performance tests

Hierarchical Order

1. Highest performances

2. Middle Range Performances



The hypothesis can be further extended schematically, for the High Visual/ Low Verbal group and the Low Visual/High Verbal group as follows:

Table 3 Extension of Table 2

Performance tests with high spatial component

Hierarchical Order

1. Highest Performances — High Visual/High Verbal Group
2. High Visual/Low Verbal Group
3. Low Visual/High Verbal Group
4. Lowest Performances — Low Visual/Low Verbal Group

Performance tests with a high verbal component

Hierarchical Order

1. Highest Performances — High Visual/High Verbal Group
2. Low Visual/High Verbal Group
3. High Visual/Low Verbal Group
4. Lowest Performances — Low Visual/Low Verbal Group

Research Hypothesis Seven

Stated more precisely, the research hypothesis predicts that:

7a The High Visual/High Verbal dual-coding group will score higher than all other groups on the performance measures.

7b The High Visual/Low Verbal and the Low Visual/High Verbal dual-coding groups will score lower than the High Visual/High Verbal groups, but higher than the Low Visual/Low Verbal group on the performance measures.

7c The Low Visual/Low Verbal group will therefore score lower than all the other groups on the performance measures.

7d The High Visual/Low Verbal groups will score higher than the Low Visual/High Verbal group on performance measures that have a high perceptual component.

7e The Low Visual/High Verbal group will score higher than the High Visual/Low Verbal group on performance measures that have a high verbal component.

The Summary Table which follows depicts each predicted comparison to be tested and predicts the relationship in each, (Table 4).

It should be noted that in this section of the research, the research population consists of all second and third year subjects.

SUMMARY TABLE 4

HYPOTHESES Section A3/C2 (from Table 11)

Predicted relationships between four groups of children using different combinations of dual-coding strategies, in terms of performance in thirteen measures of Perceptual Ability, Field Independence, Reading Ability, Creativity, Intelligence, Self-sufficiency and Self-concept. All subjects

N.B. 1 indicates a hypothetical better performance than 2

Line Ref.		Percep	Field Indep.	Reading		Creativity: Originality			Creativity: Fluency			Intell.	Self-Suffi.	Self-Concept
		PERCEP	HIDFIG	NATRS	READCO	SYMPRO	CONSEQ	PLOTTI	TOPICS	THEMES	THINGS	B	Q2	Q3
R	Hi Vis/Hi Verb by	1	1	1	1	1	1	1	1	1	1	1	1	1
	Low Vis/Low Verb	2	2	2	2	2	2	2	2	2	2	2	2	2
S	Hi Vis/Hi Verb by	1	1	1	1	1	1	1	1	1	1	1	1	1
	Low Vis/High Verb	2	2	2	2	2	2	2	2	2	2	2	2	2
T	Hi Vis/Hi Verb by	1	1	1	1	1	1	1	1	1	1	1	1	1
	Hi Vis/Low Verb	2	2	2	2	2	2	2	2	2	2	2	2	2
U	Hi Vis/Low Verb by	1	1	2	2	-	-	-	-	-	-	-	-	-
	Low Vis/Hi Verb	2	2	1	1	-	-	-	-	-	-	-	-	-
V	Low Vis/Hi Verb by	1	1	1	1	1	1	1	1	1	1	1	1	1
	Low Vis/Low Verb	2	2	2	2	2	2	2	2	2	2	2	2	2
W	Hi Vis/Low Verb by	1	1	1	1	1	1	1	1	1	1	1	1	1
	Low Vis/Low Verb	2	2	2	2	2	2	2	2	2	2	2	2	2

The following null hypotheses are drawn from the predictions in Table 4.

7a Subjects who are categorised as the High Visual/High Verbal dual-coding group will not score significantly higher than subjects who are categorised as High Visual/Low Verbal, Low Visual/High Verbal, Low Visual/Low Verbal dual-coding groups in the performance measures listed on page 90.

7b. Subjects who are categorised as the High Visual/Low Verbal dual-coding group and the Low Visual/High Verbal dual-coding group will not score significantly lower than the High Visual/High Verbal group, nor significantly higher than the Low Visual/High Verbal group in the performance measures listed on page 90.

7c Subjects who are categorised as the Low Visual/Low Verbal dual-coding groups will not score significantly lower than subjects who are categorised as High Visual/High Verbal, High Visual/Low Verbal, Low Visual/High Verbal dual-coding groups in the performance measures listed on page 90.

7d Subjects who are categorised as the High Visual/Low Verbal dual-coding group will not score significantly higher than subjects who are categorised as Low Visual/High Verbal dual-coding on

(a) Visual Perception (Morrisby Perceptual Abilities Test)

(b) Field Independence (Hidden Figures Test).

7e Subjects who are categorised as the Low Visual/High Verbal dual-coding group will not score significantly higher than subjects who are categorised as the High Visual/Low Verbal dual-coding group on:

(c) Reading ability (National Reading Survey)

(d) Reading ability (Reading Comprehension Test) .

Performance measures referred to in null hypotheses:

a.	Visual Perception	Morrisby Perceptual Abilities Test
b.	Field Independence	Hidden Figures Test
c.	Reading ability	National Reading Survey
d.	Reading ability	Reading Comprehension Test
e.	Creativity	O1 Plot Titles
f.	Creativity	O2 Symbol Production
g.	Creativity	O3 Consequences
h.	Creativity	FL1 Topics
i.	Creativity	FL2 Themes
j.	Creativity	FL3 Things
k.	Intelligence	Scale B. Cattell H.S.P.Q.
l.	Self-sufficiency	Scale Q2. Cattell H.S.P.Q.
m.	Self-concept	Scale Q3. Cattell H.S.P.Q.

CHAPTER FOUR

The conduct of the research : collection of data

Research Population

Tests and Materials

Administration of Tests

Computational Methods and Statistics

POPULATION

The population for this part of the research consisted of the second and third year pupils of a six/seven form entry co-educational comprehensive school in Gloucestershire. The school had been comprehensive for four years at the time of the research, having been reorganised from its previous status as a county secondary school. Organisationally the school is non-streamed and setted for English, Mathematics, Science and Languages.

The school serves a predominantly new, professional and middle class dormitory area between Gloucester and Cheltenham and the married quarters for service families; but the catchment area also contains older delapidated property, caravan sites, and blocks of flats which have been used to house families with social difficulties, collected from various parts of the rural area outside the School's catchment area.

The school, therefore, has a considerable mix of children from different social backgrounds and is a good example of a comprehensive school population.

The second and third year age groups were chosen as subjects partly on practical grounds; older age groups being well-committed to curricula leading to external examinations and therefore less available for the quite extensive testing programme that the research entailed.

At a point after negotiations had been completed for the testing with the second and third year groups, however, an opportunity was presented and utilised, to carry out a limited number of tests of dual-coding strategies on the first year population in the school. The inclusion of this age-group provided an additional opportunity to examine hypotheses relating to the development of use of dual-coding strategies.

The centering of the research around these three groups also presented opportunities for the collection of data about a research population age group that has been relatively infrequently researched in the past, with regard to their use of dual-coding strategies, and is valuable to that extent.

However, it must be observed that children in the age range eleven to fourteen differ very considerably as individuals, in their physical, emotional and mental development and these factors of difference for these age groups, coupled with differential rates of maturity between boys and girls, create serious problems in the design of experimental controls. It is largely for this reason that the tests chosen are used in a survey design using the biggest research sample obtainable within the limits of practicality. The controls for analysis of data are largely by choice of arbitrary categories, and the comparison of these categories by statistical techniques.

The numbers of children in the research population were:

Churchdown School

Table 5 Research Population

	Boys	Girls	Totals
First Year (limited test programme)	81	82	163
Second Year	92	102	194
Third Year	71	95	166
			523

Attrition of results due to some candidates missing tests is allowed for by reporting number of subjects used, in the relevant tables.

TESTS AND MATERIALS

The tests chosen are criticised in Chapter Seven and are included as appendices, the references of which are shown in parentheses:

Representational Processes:

(B) P/W Spatial Visualisation Test (group administered)

(B) P/W Visual/Verbal Rating Scale (group administered)

(B) Adaption of Betts Shortform of Imagery Questionnaire (group administered)

These three tests, together with their method of administration are described in detail and commented upon in Appendix D.

Perceptual Test

(A) The Perceptual Test from the differential battery of General Ability Tests by Morrisby J.R. (N.F.E.R. 1955). This is a test of 'good figure' ability in the gestalt sense, differentiating between testees' performance in matching perceptual forms with a given standard.

Field Dependence Test

(A) The Hidden Figures Test - cf.1 (E.T.S. 1962); a test of ability to discern which one of five simple figures can be found in a complex pattern.

Reading Tests

Ideally this section should have included the testing of oral verbal ability, since the intention in the research was to examine performance of overt verbal ability as compared with covert verbal processes used in problem-solving.

This, however, was not practicable. In the first case, oral examining procedures are often low in validity and reliability as a number of researchers have indicated (Potter F.W. 1968, Hitchman 1966). Furthermore, oral examining procedures are lengthy and it would not have been feasible to have given each of the children in the second and third year populations an adequate oral test because of the time factor.

It was therefore decided to use two measures of reading as indicators of verbal ability and call the variable Reading, rather than Verbal, which had been the original intention. This had the added advantage of avoiding confusion that might arise from the term verbal ability which has become associated with an aspect of verbal intelligence testing. The tests chosen under this heading were:

(A) Sections C and D of booklet 7, Reading Comprehension, from the battery of tests devised for the evaluation of education schievement (I.E.A. with N.F.E.R.)

(A) The National Reading Survey 1970 (distributed by the N.F.E.R.)

Creativity Tests

As discussed in the review of literature, the term creativity is a wide-ranging concept not easily reducible to levels of valid operational definition. In view of the nature and size of the research population, the measures chosen, although needing to be reasonably inclusive of major aspects of the concept, would also have to be practicable in terms of the constraints of time and research personnel.

It was therefore decided to contain, operationally, the concept of creativity within two of its constituent dimensions, originality and fluency of ideas and the tests used under this heading were:-

Originality

(B) O1 Plot Titles (2 parts) (Guildford J.P. 1962)

(B) O2 Symbol Production (2 parts) (Guildford J.P. 1962)

(B) O3 Consequences (10 parts) (Christenson P.R. Merrifield P.R. and Guilford 1958)

Ideational Fluency

(B) Fl 2 Topics (3 parts)

(B) Fl 2 Themes (2 parts)

(B) Fl 3 Things (2 parts)

Personality

Since the research is concerned with dual-coding strategies, the use of which is held to be central to cognitive functioning, and since cognitive functioning is an integral part of personality, it was decided to include a personality inventory as part of the test battery. The two major personality inventories available for use with the age groups in the research population are the Eysenck Junior Personality Inventory and the H.S.P.Q. test devised by Cattell.

No hypotheses relating to Eysenck's main dimensions had been proposed for investigation but consideration of Cattell's fourteen source traits suggested that hypotheses might be developed concerning the relationship of use of representational processes and some of these source traits. The H.S.P.Q. (CII) was therefore chosen and administered with the intention of using scales B, Q2 and Q3 in the research design.

Table 6 Research Design Summary Two

			Rep. Pr.		Perceptual			Reading		Creativity						Personality (Cattell)							
										Originality			Fluency										
			Betts	Vis/Verb	Spat/Vis	Morrisby Perceptual	Hidden figures	Nat. Reading Survey	Reading Comprehension	Symbol	Consequence	Plot Title	Topics	Themes	Things	A	B	C	H	I	Q_2	Q_3	Age
File	Subfile	Sample size																					
3rd Ch	Boys	71	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Girls	95	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Total	166	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓								
2nd Ch	Boys	92	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Girls	102	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Total	194	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓								
1st Ch	Boys	81	✓	✓	✓																		✓
	Girls	82	✓	✓	✓																		✓
	Total	163	✓	✓	✓																		

Research Population, sample sizes and tests completed, within sub-files

ADMINISTRATION OF TESTS

All tests were group administered in strict accordance with the instruction pertaining to each test.

Motivation of the Subjects

As with the research summarised in part one, subjects were told that the tests were being conducted in order to investigate students' thinking processes in order to find ways of improving educational methods.

From careful observation of the subjects during the tests, it was clear that they maintained a high degree of interest and endeavour throughout. The results of the tests can therefore be assumed to be valid in terms of student effort to complete them appropriately.

Total Testing Time

For each first year subject: 45 mins.

For each second and third year subject: 6hrs 50 mins.
(includes administration time)

Difficulty in Testing

The tests were conducted at the end of the Spring Term 1973 and various members of the School Staff were recruited as test administrators in view of the large number of tests being taken. Each member of staff who assisted was carefully briefed both about the nature of the research and the administration of each test.

Some overcrowding occurred during some of the tests but careful invigilation ensured that the test conduct was in accordance with high standards of testing procedure.

Marking of Tests

The tests other than the creativity tests present no problems in marking since they are marked according to a specifically objective marking scheme.

The creativity tests, however, include a measure of subjective judgement, especially in respect of the marking of Symbol Production and Themes. The marking of these tests, therefore, was not undertaken by the author but by another qualified teacher whose brief in marking the tests was:

1. To use strictly numerical criteria in the tests in which it was appropriate to do so. (for example 'Plot Titles').

2. To endeavour to maintain standard criteria of judgement in the tests in which marker judgement is a factor in the test result (for example 'Symbol Production').

COMPUTATIONAL METHODS AND STATISTICS

Procedure A1 (from Table 1 , Research Design Summary)

Comparisons of representational strategies used, within and between age-groups by sex

Hypotheses relating to recall imagery (1a, 1b, 2a, 2b, 2c) were tested by comparison of mean scores by t-tests.

Hypotheses relating to the dual-coding strategies (1c, 1d, 1e, 1f, 3a to 3f) were submitted to non-parametric analysis in the following way:

Subjects using dual-coding strategies (cf Tables 7, 8, 9) were categorised and counted under the following headings:

High Visual/High Verbal 1/1, 1/2,* 2/1, 2/2

Low Visual/Low Verbal 3/3, 3/4, 3/5, 4/3, 4/4, 4/5, 5/3, 5/4, 5/5

This division of categories was arrived at in order to achieve as near to parity of numbers as possible, between the two groups. Chi-square analyses were computed using a Hewlett Packard computer, and utilising chi-square formula 6.4, corrected for continuity, (Siegel 1956, p.109).

Although some disparity of distribution was found, with the results of the visual and verbal questionnaire producing skewed characteristics, (histograms 1,2,3 p.109), mean scores were also compared by T-tests.

<u>Procedure A2/B2 (from Table 1 , Research Design Summary)</u>

<u>Relationship of performance in each of the representational strategies to performance in measures of ability and personality (Tables 19 - 21)</u>

The data was entered on punch cards and processed on to magnetic tape through the University of Surrey link with the University of London CDC 7600 computer. Under S.P.S.S. procedures (Nie et al, 1975), processing and computation commenced on 1st October, 1975. Due to a severely protracted series of problems, including card slippage and faulty magnetic tape, computing was not completed until October 1976.

Statistical analyses used in this section were Pearson Product Moment Correlations (Hypotheses 4,5,6) and Multiple Regression (SPSS, 1975, p.354).

* 1/2 indicates a rating of 1 on the Visual Scale and 2 on the Verbal Scale.

Procedure A3/C2 (from Table 1.)

Relationships of each of four categories of dual-coding strategies to performance in measures of ability and personality (Tables 38 - 51)

In this section, the dual-coding strategies were categorised under a different formula from that used in procedure A1, in order to utilise the largest number of subjects possible within each category. The categories established were:-

1.	High Visual/High Verbal	1/1, 1/2, 2/1, 2/2
2.	High Visual/Low Verbal	1/3, 1/4, 1/5, 2/3, 2/4, 2/5
3.	Low Visual/High Verbal	5/1, 5/2, 4/1, 4/2, 3/1, 3/2
4.	Low Visual/Low Verbal	3/3, 3/4, 3/5, 4/3, 4/4, 4/5, 5/5, 5/3, 5/4

The data cards were re-sorted into the four categories so established, by age group and by sex, including only those subjects who had registered both a visual and a verbal rating.

Taking second and third year subjects all together, the four categories were each compared with each other on performance in the following variables:
MORPER, HIDFIG, NATRS, READCO, SYMPRO, CONSEQ, PLOTTI, TOPICS, THEMES, THINGS, B, Q2, Q3.

Missing values for each variable were re-coded as the mean score for that variable, in order to maximise the number of cases available for inclusion. T-tests were then performed for each of the comparisons made (hypotheses 7A to 7E) (SPSS t-test procedure, 1975 p.267-274).

Between-groups analysis of variance

An analysis of variance was also undertaken of the four dual-coding groups relative to each of the above-mentioned variables. In doing this a problem was encountered in that this analysis could not be performed with S.P.S.S. procedures since the dependent variable, VISVERB, is a composite of the variables,visualising (VISQ) and verbalising (VERBQ).

The reason, further explicated, is as follows:

1. VISQ and VERBQ are summed in different visual/verbal combinations to produce the dual-coding strategy groups:

   A. High Visual/High Verbal (range 2-4)

   B. High Visual/Low Verbal (range 4-7)

   C. Low Visual/High Verbal (range 4-7)

   D. Low Visual/Low Verbal (range 6-10)

2. The visual/verbal combinations so formed would normally form the independent variables but because the composite scores overlap in the ranges, cannot be used in this way.

3. The problem, therefore, becomes one of utilising the four (overlapping score) groups A, B, C, D as the groups defining performance in the other variables. The visual/verbal variable (VISVERB) cannot, therefore, be used as independent variable in a ONEWAY (S.P.S.S.) analysis.

4. Consideration was given to other possibilities of a re-definition of the S.P.S.S. subfile structure on the basis of the groups as in para. 1 A, B, C, D above. However, the S.P.S.S. procedures allow for combinations of subfiles to be entered in calculations but not to be used in direct comparison as separate group entities.

A different computer package to produce between group analysis of variance was therefore used. BMD1V (Bio-medical Data Programmes) and in order to achieve the necessary coding of missing values to the mean of each variable, a new set of data cards was prepared.

Report and discussion of error of statistical analysis

It must be reported that these analyses of variance were intended to be carried out as a precursor to the selection of an a posteriori test to check the validity of the significant differences between the dual-coding groups that had been shown by the t-test procedures. The S.P.S.S. 'Oneway' programme contains a selection of a posteriori tests which can be so utilised; selection of the test being dependent on the nature of the data and the power of the a posteriori test required.

Since the between-group analyses of variance had been computed by the BMD1V programme which does not contain facility for a posteriori tests, it was decided to calculate a Duncan's (1951) Multiple Range and Multiple F Test for each of the thirteen variables by hand calculation. This was done.

The results appeared to indicate that none of the comparisons between the dual-coding groups on any of the thirteen variables was significant. This was a matter for concern since the Duncan multiple range test results were not only contradictory to the t-test results, but contradictory to the overall F test results derived from the between-groups' analysis of variance.

A search of the literature relating to statistics pertaining to comparisons of means revealed authority (Winer, 1971 p.196) that states:

> 'If the meaningful comparisons are relatively few in number and are planned before the data are obtained, the F test associated with individual components of variation should be used.'

The text further states that a priori comparisons are justified whether or not the overall F test is significant.

The hypotheses in section A3/C2 were pre-planned, and do fit into a previously defined experimental framework. It is considered that since they are directional, requiring one-tailed tests of significance, the t-tests are valid, and the Duncan multiple range tests should not have been used. Nor, according to Winer are the overall F tests absolutely needed. Nevertheless, they have been included in the research as appendix C .

Further analyses in section A3/C2

Following the construction of Table 58, which did not reveal a clear pattern of results capable of interpretation in terms of the null hypotheses for this section, two other methods of analysis of data were undertaken:-

1. The computation of predictions concerning performance of the dual-

coding groups on thirteen variables in Table 51, supported by arithmetical comparisons, relative to predictions not supported; and the subsequent testing of these by the Binomial Test (Siegel 1956, p.41), in respect of

a) The overall pattern of predictions (from Table 51)

b) Null hypotheses 7A, 7B, 7C. (Tables 52,53,54,55).

2. Further analysis of the rank orders in seven variables derived from mean scores of the four dual-coding groups. In these analyses the actual rank orders obtained were tested against the predicted rank orders and a Kendall Coefficient of Concordance (Siegel, 1956 pp. 229-238) calculated to provide a test of significance (Tables 56 and 57).

CHAPTER FIVE

Tables of Results

Section A1

Identification, examination and comparisons of recall imagery and dual-coding strategies used, between age groups, and within age groups by sex.

First year, second year and third year boys and girls.

Tables 7 to 18d.

Section A2/B2

Recall imagery, and dual-coding strategies taken separately, compared with performance in measures of ability, creativity and personality.

Second and third year boys. Second and third year girls.

All second and third year subjects combined.

Tables 19 to 21. (N.B. Tables 22-23 have been placed in Appendix C).

Section A3/C2

Comparisons between four groups, categorised by use of dual-coding strategies, on performance in measures of ability, creativity and personality.

All second and third year subjects.

Tables 25 to 57. (N.B. Table 58 has been placed in Appendix C).

Section A1

Table 7 Incidence of visual/verbal strategies used: first year

BOYS (79)

Verbal Strategy	Visual Strategy (High Use) 1	2	3	(Low Use) 4	5	
High Use 1	7	0	6	0	0	13
2	1	2	2	1	0	6
3	8	9	9	3	2	31
Low Use 4	3	2	6	1	1	13
5	3	8	4	1	0	16
	22	21	27	6	3	

GIRLS (82)

Verbal	Visual Strategy (High Use) 1	2	3	(Low Use) 4	5		Verbal Totals
High Use 1	4	2	5	0	0	11	24
2	7	3	6	0	2	18	24
3	9	9	9	2	1	30	61
Low Use 4	1	2	1	0	1	5	18
5	2	4	6	1	5	18	34
	33	20	27	3	9		
Visual Totals:	55	41	52	9	9		

Table 8 Incidence of visual/verbal strategies used: second year

BOYS(85)

Verbal Strategy	Visual (High Use) 1	2	3	(Low Use) 4	5	
High Use 1	6	10	7	0	1	24
2	1	11	4	2	0	18
3	8	8	11	0	0	27
Low Use 4	2	1	5	1	0	9
5	5	2	0	0	0	7
	22	32	27	3	1	

GIRLS (86)

Verbal	Visual (High Use) 1	2	3	(Low Use) 4	5		Verbal Totals
High Use 1	1	5	6	0	0	12	36
2	1	4	10	4	0	19	37
3	11	6	12	3	1	33	60
Low Use 4	0	6	2	0	2	10	19
5	3	1	5	0	1	10	17
	16	22	35	7	4		
Visual Totals:	38	54	62	10	5		

Table 9 Incidence of visual/verbal strategies used: third year

BOYS (65)

Verbal Strategy	Visual (High Use) 1	2	3	(Low Use) 4	5	
High Use 1	8	12	4	1	0	25
2	1	7	2	1	0	11
3	6	5	5	2	2	20
Low Use 4	1	2	2	0	0	5
5	0	2	0	1	1	4
	16	28	13	5	3	

GIRLS (87)

Verbal	Visual (High Use) 1	2	3	(Low Use) 4	5		Verbal Totals
High Use 1	7	9	8	2	0	26	51
2	2	13	4	2	1	22	33
3	3	7	17	0	0	27	47
Low Use 4	1	3	0	0	0	4	9
5	3	1	4	0	0	8	12
	16	33	33	4	1		
Visual Totals:	32	61	46	9	4		

Histograms 1, 2, 3. Incidence of Visual and Verbal Strategies used; by age group and sex.

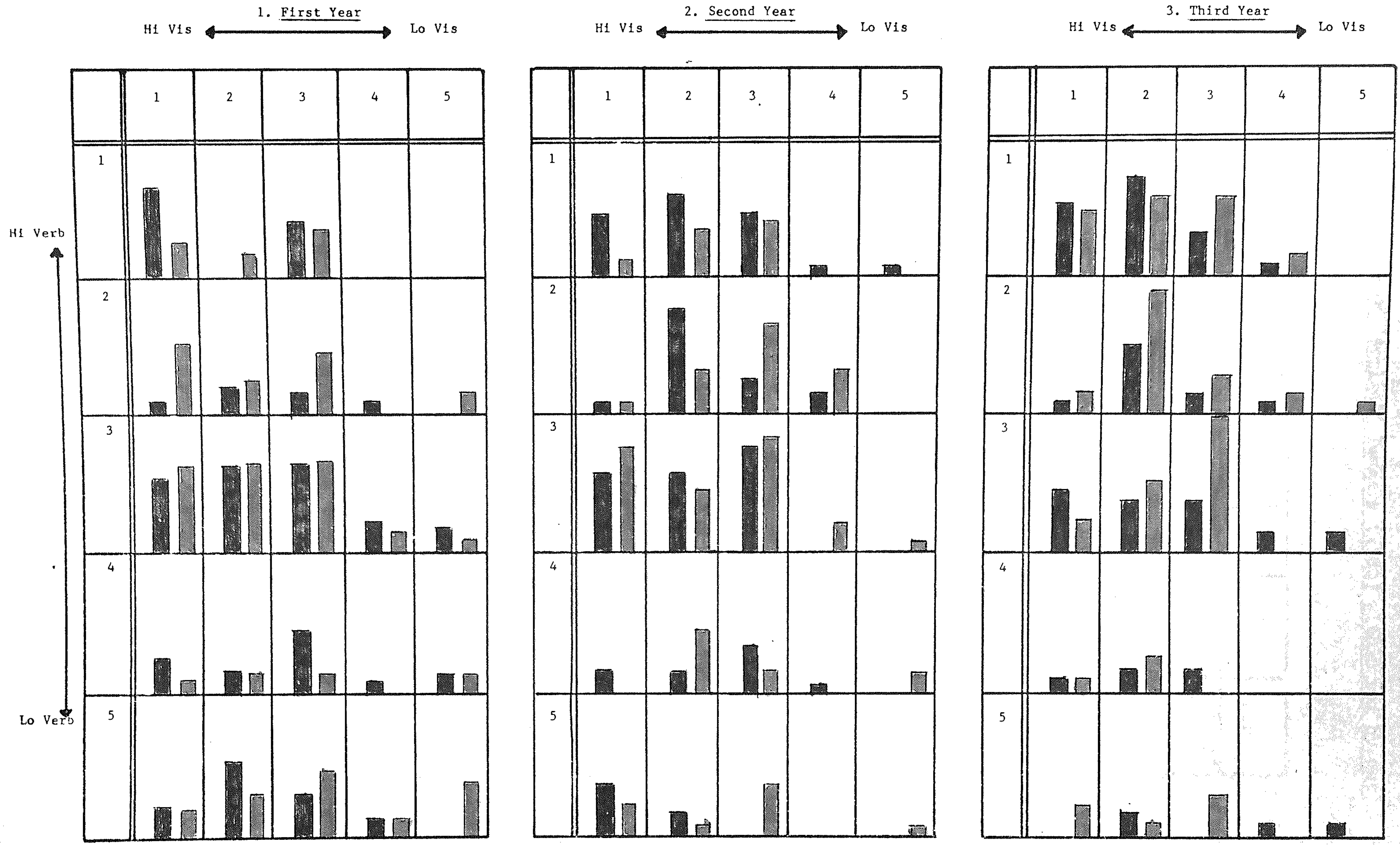


Table 10 Performance on 'Applied' Imagery (VISQ) within sex by age

BOYS

	High Visual	Low Visual	d_f	X^2	Sig
First Year Boys	43	36	1	1.51	.15 N.S.
Second Year Boys	54	31			
Second Year Boys	54	31	1	3.175	.05
Third Year Boys	44	21			
First Year Boys	43	36	1	2.88	.05
Third Year Boys	44	21			

Table 11

GIRLS

	High Visual	Low Visual	d_f	X^2	Sig.
First Year Girls	43	39	1	2.059	.10 N.S.
Second Year Girls	38	46			
Second Year Girls	38	46	1	1.728	.10 N.S
Third Year Girls	49	38			
First Year Girls	43	39	1	1.453	.15 N.S
Third Year Girls	49	38			

Table 12 Performance on Covert Verbalising (VERBQ) within sex by age

BOYS

	High Verbal	Low Verbal	d_f	X^2	Sig
First Year Boys	19	60	1	3.242	.05
Second Year Boys	42	43			
Second Year Boys	42	43	1	2.899	.05
Third Year Boys	36	29			
First Year Boys	19	60	1	3.932	.025
Third Year Boys	36	29			

Table 13

GIRLS

	High Verbal	Low Verbal	d_f	X^2	Sig
First Year Girls	29	53	1	3.68	.05
Second Year Girls	31	53			
Second Year Girls	31	53	1	2.093	.10 N.S
Third Year Girls	48	39			
First Year Girls	29	53	1	2.102	.10 N.S
Third Year Girls	48	39			

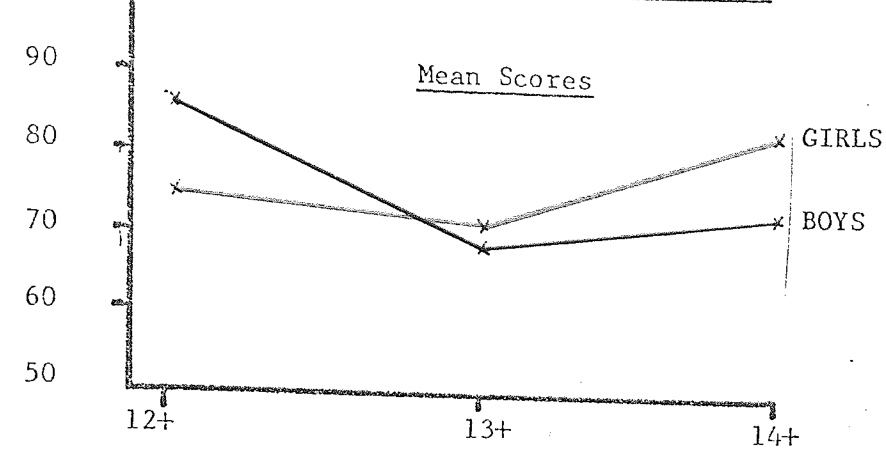
Table 14 Performance on 'Applied' Imagery (VISQ) within age, by sex

	High Visual	Low Visual	df	Chi Square	Sig
First Year Boys	43	36	1	1.559	.15 N.S
First Year Girls	43	39			
Second Year Boys	54	31	1	2.06	.10 N.S
Second Year Girls	38	46			
Third Year Boys	44	21	1	.631	N.S
Third Year Girls	49	38			

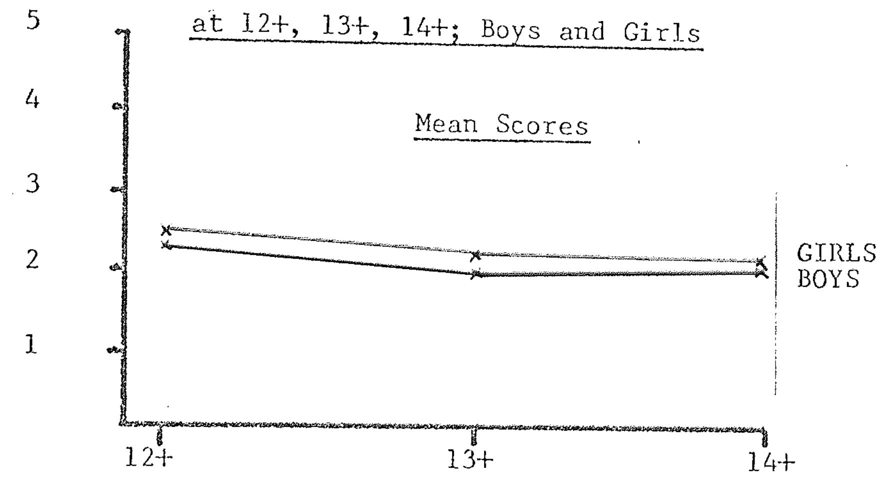
Table 15 Performance on Covert Verbalising (VERBQ) within age, by sex

	High Verbal	Low Verbal	df	Chi Square	Sig
First Year Boys	19	60	1	4.861	.025
First Year Girls	29	53			
Second Year Boys	42	43	1	3.277	.05
Second Year Girls	31	51			
Third Year Boys	36	29	1	.747	N.S
Third Year Girls	48	39			

GRAPH 4 Betts Imagery Questionnaire. Recall Imagery at 12+, 13+, 14+; Boys and Girls



GRAPH 5 VISQ. 'Applied' Imagery at 12+, 13+, 14+; Boys and Girls



GRAPH 6 VERBQ. Covert Verbalising at 12+, 13+, 14+; Boys and Girls

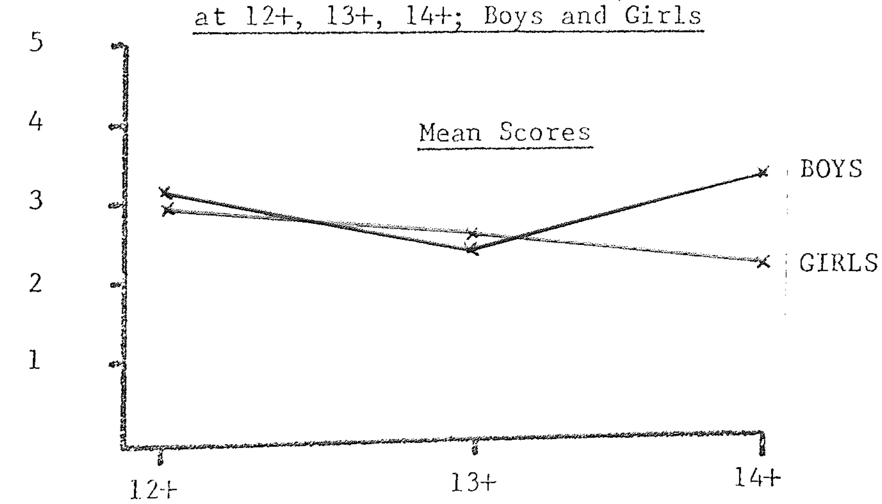


Table 16a <u>Comparison of Mean Scores on Recall Imagery (BETTS) within sex, by age</u>

BOYS

	Pop		BETTS		BETTS		BETTS	
First Year Boys	81	Mn	86.25	d_f171			86.25	d_f150
		SE	3.70	t= 3.39			3.70	t = 2.33
Second Year Boys	92	Mn	68.51		68.51	d_f161		
		SE	3.7	.001	3.7	t = .873		.05
Third Year Boys	71	Mn			73.34	N.S	73.34	
		SE			4.12		4.12	

Table 16b

GIRLS

First Year Girls	82	Mn	77.10	d_f182			77.10	d_f164
		SE	3.25	t = 1.14			3.25	t = 1.376
Second Year Girls	102	Mn	71.29	N.S	71.29	d_f184		N.S
		SE	3.92		3.92	t = 2.34		
Third Year Girls	84	Mn			83.76	.05	83.76	
		SE			3.6		3.6	

Table 16c Comparison of Mean Scores on Recall Imagery (BETTS) within age, by sex

	Pop		BETTS	
				Sig
First Year Boys	81	Mn	86.25	d_f161
		SE	3.70	t = 1.90
First Year Girls	82	Mn	76.88	
		SE	3.25	N.S
Second Year Boys	92	Mn	68.51	d_f192
		SE	3.70	t = .515
Second Year Girls	102	Mn	71.29	
		SE	3.92	N.S
Third Year Boys	71	Mn	73.34	d_f153
		SE	4.12	t = 1.90
Third Year Girls	84	Mn	83.76	
		SE	3.6	N.S

Table 17a Comparison of Mean Scores on 'Applied' Imagery (VISQ) within sex, by age

BOYS

	Pop		VISQ		VISQ		VISQ	
First Year Boys	81	Mn	2.35	d_f171 t = 2.71 .01			2.35	d_f150 t = 1.56 N.S
		SE	.12				.12	
Second Year Boys	92	Mn	1.90		1.90	d_f161 t = .879 N.S		
		SE	.115		.115			
Third Year Boys	71	Mn			2.06		2.06	
		SE			.142		.142	

Table 17b

GIRLS

	Pop		VISQ		VISQ		VISQ	
First Year Girls	82	Mn	2.45	d_f182 t = 1.390 N.S			2.45	d_f164 t = 2.045 .05
		SE	.138				.138	
Second Year Girls	102	Mn	2.19		2.19	d_f184 t = .476 N.S		
		SE	.127		.127			
Third Year Girls	84	Mn			2.11		2.11	
		SE			.11		.11	

Table 17c Comparison of Mean Scores on Covert Verbalising (VERBQ) within sex, by age

BOYS

	Pop		VERBQ		VERBQ		VERBQ	
First Year Boys	81	Mn	3.12	$d_f 171$			3.12	$d_f 150$
		SE	.145	t = 4.20			.145	t = .841
Second Year Boys	92	Mn	2.25		2.25	$d_f 161$		
		SE	.149	.01	.149			N.S
Third Year Boys	71	Mn			3.30	t = 4.83	3.30	
		SE			.158	.01	.158	

Table 17d

GIRLS

First Year Girls	82	Mn	3.01	$d_f 182$			3.01	$d_f 164$
		SE	.145	t = 2.99			.145	
Second Year Girls	102	Mn	2.40	.01	2.40	$d_f 184$		t = 4.2
		SE	.144		.144	t = 1.15		.01
Third Year Girls	84	Mn			2.17	N.S	2.17	
		SE			.139		.139	

Table 17e Comparison of Mean Scores on 'Applied' Imagery (VISQ) within age, by sex

	Pop.			t	Sig
First Year Boys	81	Mn	2.35	df 161	N.S.
		SE	.12		
First Year Girls	82	Mn	2.45	.555	
		SE	.138		
Second Year Boys	92	Mn	1.90	df 192	.10
		SE	.115		
Second Year Girls	102	Mn	2.19	1.695	N.S.
		SE	.127		
Third Year Boys	71	Mn	2.06	df 153	N.S.
		SE	.142		
Third Year Girls	84	Mn	2.11	.279	
		SE	.11		

Table 17f Comparison of Mean Scores on Covert Verbalising (VERBQ) within age, by sex

	Pop.				
First Year Boys	81	Mn	3.12	df 161	N.S.
		SE	.145		
First Year Girls	82	Mn	3.01	.536	
		SE	.145		
Second Year Boys	92	Mn	2.25	df 192	
		SE	.149		
Second Year Girls	102	Mn	2.40	.724	N.S.
		SE	.144		
Third Year Boys	71	Mn	3.30	df 153	.001
		SE	.158		
Third Year Girls	84	Mn	2.17	5.38	
		SE	.139		

Summary Table 18a (from Tables 10, 11,17, 18) Dual-coding Strategies

Direction of results, significance from t-tests, significance from chi-squares, within sex, by age

Visual Strategies	Means		Chi-square Sig.
	Dir	Sig	
First Year Boys Second Year Boys	✓	.01	.15
Second Year Boys Third Year Boys	✗	N.S.	.05
First Year Boys Third Year Boys	✓	N.S.	.05
First Year Girls Second Year Girls	✓	N.S.	.10 N.S.
Second Year Girls Third Year Girls	✓	N.S.	.10 N.S.
First Year Girls Third Year Girls	✓	.05	.15 N.S.
Direction predicted Direction opposite prediction	✓ ✗		

Summary Table 18b

Verbal Strategies	Means		Chi-square Sig.
	Dir	Sig	
First Year Boys Second Year Boys	✗	.01	.05
Second Year Boys Third Year Boys	✓	.01	.05
First Year Boys Third Year Boys	✓	N.S.	.025
First Year Girls Second Year Girls	✗	.01	.05
Second Year Girls Third Year Girls	✗	N.S.	.10 N.S.
First Year Girls Third Year Girls	✗	.01	.10 N.S.
Direction Predicted Direction opposite to prediction	✓ ✗		

Summary Table 18c (from Tables 14, 15, 17c, 17d)

Direction of results, significance from t-tests, significance from chi-square, within age, by sex.

Dual-coding strategies

Visual Strategies	Means		Chi-square Sig
	Dir	Sig	
First Year Boys First Year Girls	✗	N.S.	N.S.
Second Year Boys Second Year Girls	✗	N.S.	N.S.
Third Year Boys Third Year Girls	✗	N.S.	N.S.
Direction predicted Direction opp. predict.	✓ ✗		

Summary Table 18d (from Tables 14,15, 17c, 17d)

Verbal Strategies	Means		Chi-square Sig
	Dir	Sig	
First Year Boys First Year Girls	✗	N.S.	.025
Second Year Boys Second Year Girls	✓	N.S.	.05
Third Year Boys Third Year Girls	✗	.001	N.S.
Direction predicted Direction opp. predict.	✓ ✗		

Section A2/B2

Summary tables 19-21 from computer results in Appendix C

Table 19 Simple and multiple correlations of recall imagery (BETTS), and separate dual-coding strategies (VISQ, VERBQ) with measures of ability, creativity and personality. 163 second and third year boys

	BETTS	VISQ	VERBQ	MORPER	HIDFIG	READIN	CREATI	B	Q2	Q3
VISQ	.571**									
VERBQ	.446**	.359**								
MORPER	.197**	.009	.032							
HIDFIG	.315**	.336**	.172*	.203**						
READIN	.165*	.186*	-.019	.422**	.178*					
CREATI	.072	.059	.065	.507**	.184*	.589**				
B	.227**	.192*	.098	.455**	.225**	.643**	.403**			
Q2	.211**	.180*	.200*	.246**	.062	.480**	.251**	.547**		
Q3	.144*	.104	.262	.297**	.155**	.459**	.241**	.571**	.650*	
				.597**	.439**	.772**	.680**	.749**	.709**	.733**

Significance levels * = .05 ** = .01

Table 20 Simple and multiple correlations of recall imagery (BETTS) and separate dual-coding strategies (VISQ, VERBQ) with measures of ability, creativity and personality. 197 second and third year girls.

	BETTS	VISQ	VERBQ	MORPER	HIDFIG	READIN	CREATI	B	Q2	Q3
VISQ	.561**									
VERBQ	.418**	.382**								
MORPER	.015	.100	.036							
HIDFIG	.327**	.166*	.207**	.297**						
READIN	.154*	.144*	.146*	.479**	.272**					
CREATI	.058	.148*	.034	.463**	.100	.444**				
B	.154*	.136	.106	.577**	.284**	.792**	.339**			
Q2	.210**	.202**	.165*	.406**	.226**	.526**	.220**	.593**		
Q3	.240**	.173*	.188*	.386**	.253**	.569**	.234**	.624**	.693**	
				.674**	.464**	.823**	.565**	.850**	.731**	.752**

Significance levels * = .05 ** = .01

Table 21 Simple and multiple correlations of recall imagery (BETTS) and separate dual-coding strategies (VISQ, VERBQ) with measures of ability, creativity and personality. 360 second and third year subjects

	BETTS	VISQ	VERBQ	MORPER	HIDFIG	READIN	CREATI	B	Q2	Q3
VISQ	.564**									
VERBQ	.430**	.374**								
MORPER	.096	.068	.036							
HIDFIG	.326**	.237**	.190**	.253**						
READIN	.160*	.162*	.073	.453**	.229**					
CREATI	.064	.106	.048	.483**	.140*	.512**				
B	.184**	.162*	.104	.524**	.257**	.728**	.366**			
Q2	.207**	.178*	.173*	.320**	.151*	.498**	.233**	.556**		
Q3	.196**	.144*	.222**	.346**	.208**	.519**	.237**	.600**	.659**	
				.623**	.416**	.784**	.598**	.803**	.699**	.730**

Significance levels * = .05 ** = .01

Note. Departure from research intention

Multiple regression analyses were undertaken for boys and girls in respect of the relationships between the representational strategies and the seven composite variables; creativity, field independence, perceptual ability, intelligence, reading ability, self-sufficiency, self-concept. The results are given in Tables 22, 23, 24, which have been placed in Appendix C. However, this line of research was discontinued in view of the results of Section A3/C2 which appear to indicate that a compensatory use of the dual-coding strategies may be operating where children use one strategy in preference to the other.

Section A3/C2

Summary tables 25-50 from computer results in Appendix C.

Cross - Comparisons of performance in thirteen variables by four categories of dual-coding groups.

Second and Third Year subjects taken together.

The dual-coding groups are colour coded as follows:-

High Visual/High Verbal Group	(Hi Vi/Hi Ve)
Low Visual/Low Verbal Group	(Lo Vi/Lo Ve)
High Visual/Low Verbal Group	(Hi Vi/Lo Ve)
Low Visual/High Verbal Group	(Lo Vi/Hi Ve)

t-tests are computed by S.P.S.S. procedure (1975, p.269 para 17.2.7.3.)

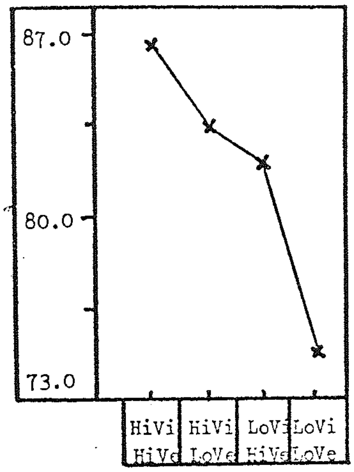
Figures shown in the tables are corrected to the nearest decimal place.

One-tailed tests of significance are used throughout, the significance level being set at .05

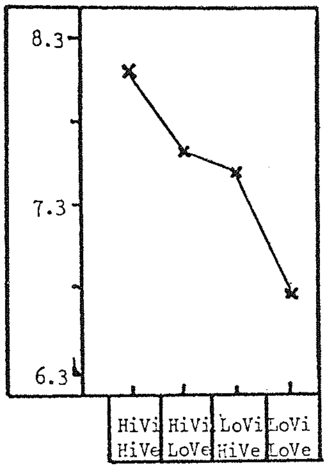
N.B. The graphs in each table are presented in order to demonstrate the overall patterns of results. The truncated form is used in order to save space.

Tables 25-37. Graphical representation of performance in thirteen variables by four categories of dual-coding groups. (From Tables 38 - 50)

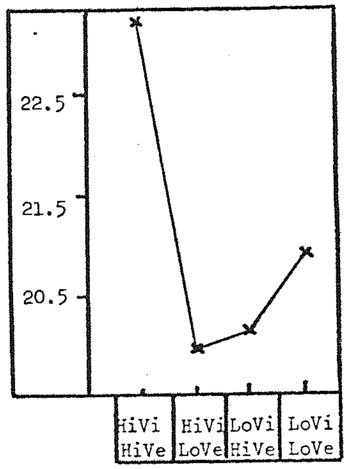
Table 25. MORPFR



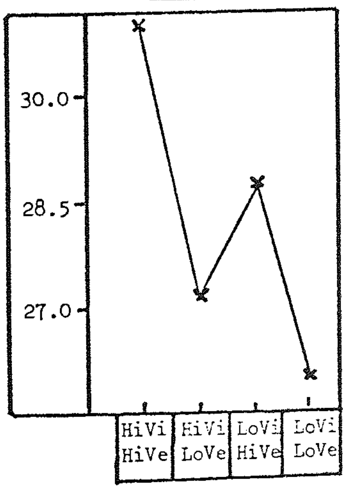
26. HIDFIG



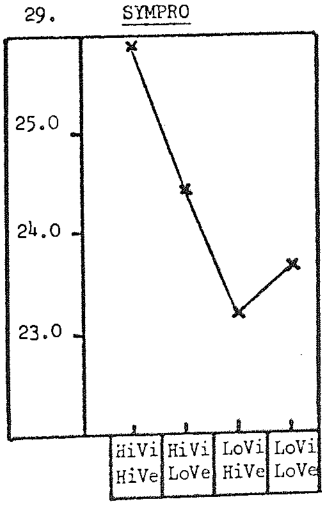
27. NATRS



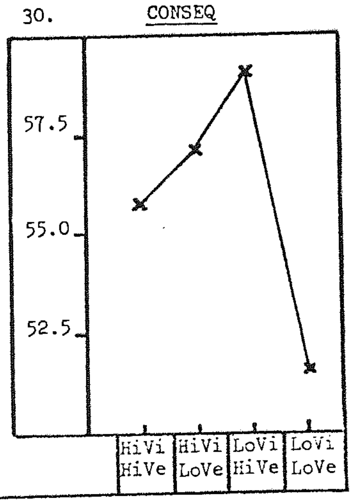
26. READCO



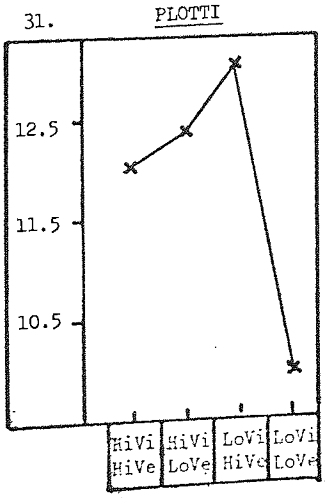
29. SYMPRO



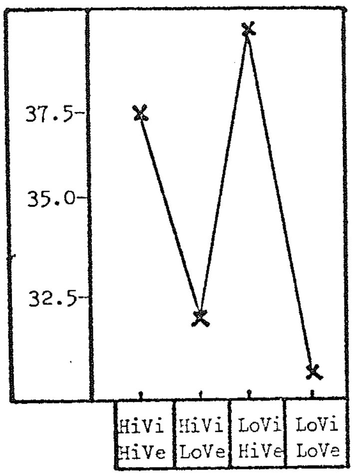
30. CONSEQ



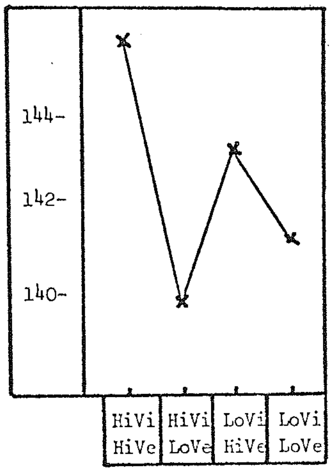
31. PLOTTI



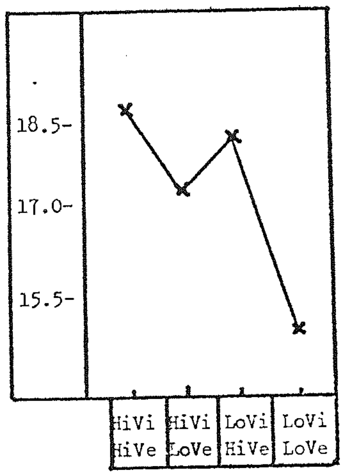
32. TOPICS



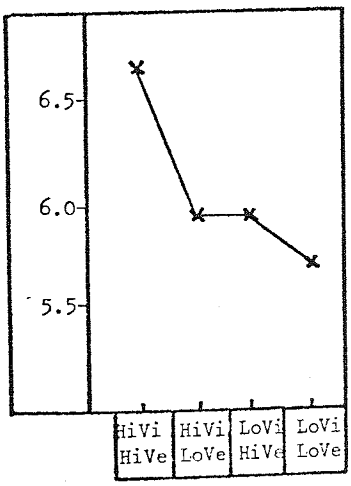
33. THEMES



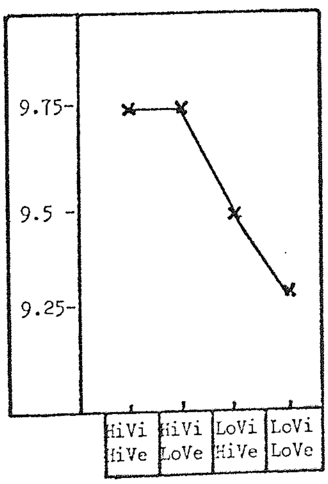
34. THINGS



35. B



36. Q2



37. Q3

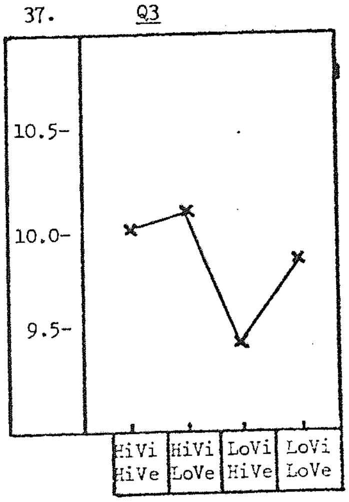
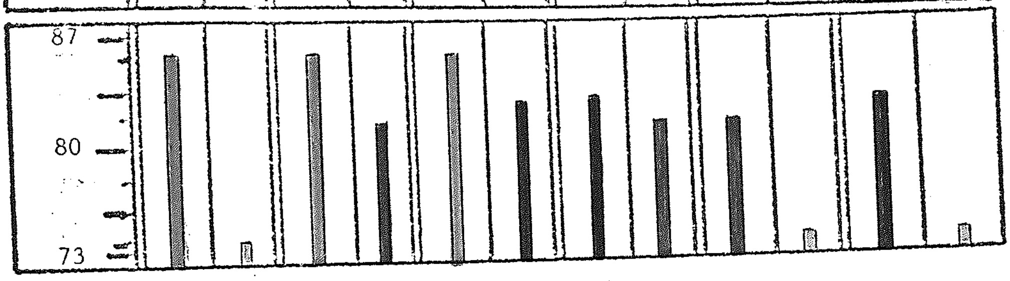
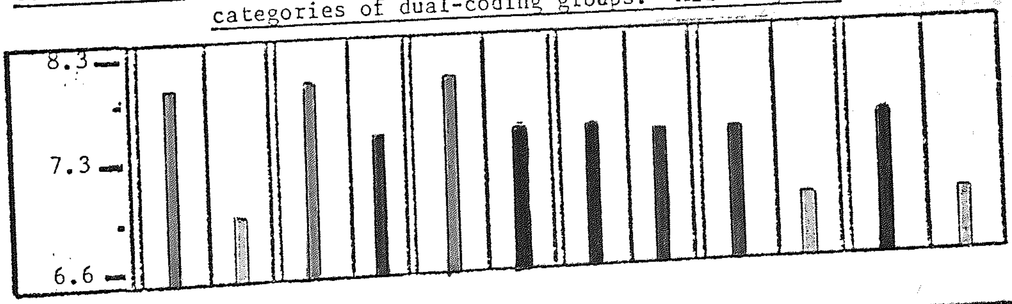


Table 38 Performance in perceptual ability (MORPER) by four categories of dual-coding groups. All subjects



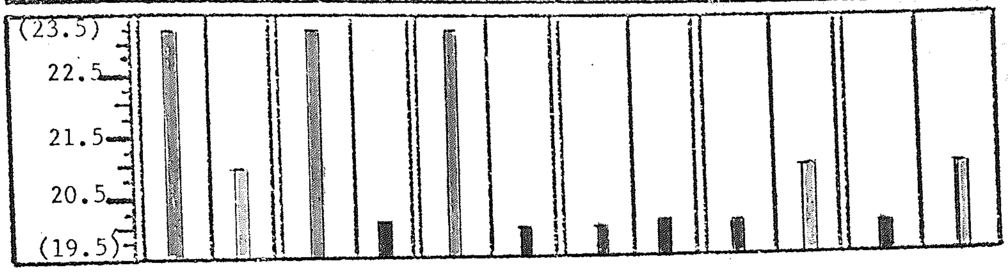
Mn Score	Hi Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Hi Ve	Lo Vi Hi Ve	Hi Vi Hi Ve	Hi Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Hi Ve	Lo Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Lo Ve
Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	86.8	73.2	86.8	81.8	86.8	83.7	83.7	81.8	81.8	73.2	83.7	73.2
S.D.	21.8	18.4	21.8	23.4	21.8	18.3	18.3	23.4	23.4	18.4	18.4	18.4
F	1.40		1.15		1.41		1.62		1.61		1.01	
t	3.15		1.36		1.03		.55		1.79		2.74	
Signif	.001		.09		.15		.29		.03		.004	
d.f.	127		156		181		145		91		116	

Table 39 Performance in field independence (HIDFIG) by four categories of dual-coding groups. All subjects



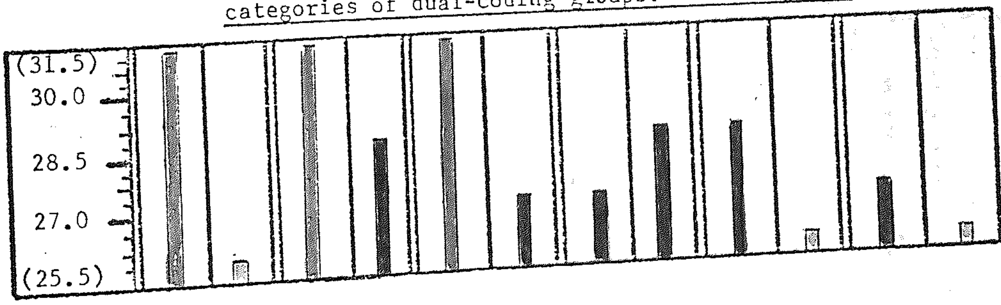
Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn	7.8	6.9	7.8	7.4	7.8	7.5	7.5	7.4	7.4	6.9	7.5	6.9
S.D.	4.1	3.6	4.0	4.2	4.1	3.9	3.9	4.1	4.2	3.6	3.9	3.6
F	1.27		1.04		1.08		1.12		1.32		1.17	
t	1.16		.55		.49		.12		.65		.81	
Signif	.125		.29		.31		.45		.26		.29	
d.f.	127		156		181		145		91		116	

Table 40 Performance in reading ability (NATRS) by four categories of dual-coding groups. All subjects



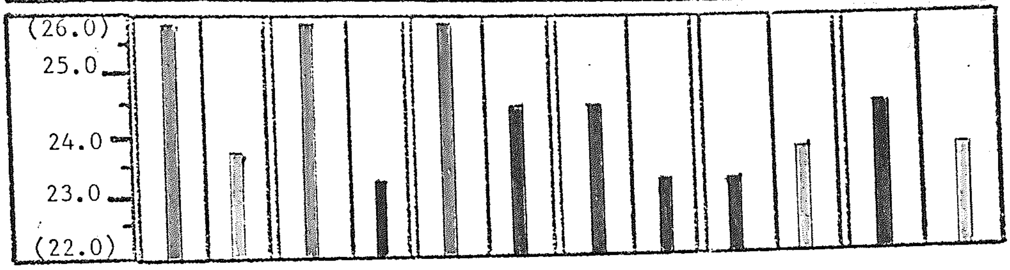
Mn Score	Hi Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Hi Ve	Lo Vi Hi Ve	Hi Vi Hi Ve	Hi Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Hi Ve	Lo Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Lo Ve
Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	23.3	20.9	23.3	20.2	23.3	19.8	19.8	20.2	20.2	20.9	19.8	20.9
S.D.	9.3	5.2	9.3	6.3	9.3	5.8	5.7	6.3	6.3	5.2	5.7	5.2
F.	3.18		2.15		2.60		1.21		1.48		1.22	
t.	1.38		2.26		2.98		-.40		-.52		-.93	
Signif	.08		.01		.002		.34		.30		.18	
d.f.	127		156		181		145		91		116	

Table 41 Performance in reading comprehension (READCO) by four categories of dual-coding groups. All subjects



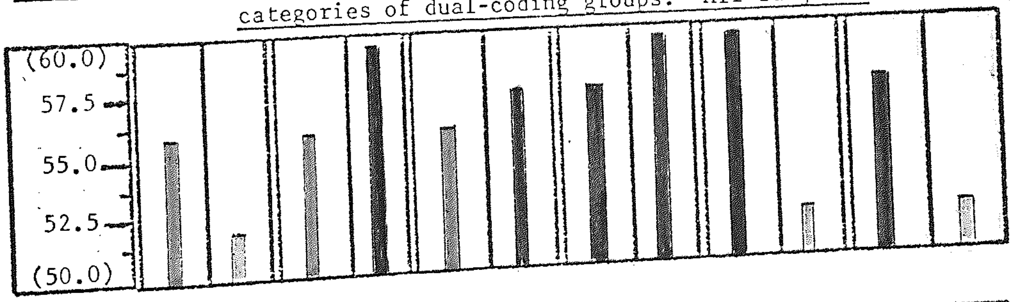
Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	31.3	25.9	31.3	28.7	31.3	27.1	27.1	28.7	28.7	25.9	27.1	25.9
S.D.	9.2	9.6	9.2	8.8	9.2	8.1	8.1	8.7	8.8	9.6	8.1	9.6
F.	1.11		1.08		1.27		1.17		1.20		1.41	
t.	2.85		1.79		3.30		-1.14		1.39		.65	
Signif	.002		.03		.001		.13		.08		.26	
d.f.	127		156		181		145		91		116	

Table 42 Performance in originality (SYMPRO) by four categories of dual-coding groups. All subjects



Mn Score	Hi Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Hi Ve	Lo Vi Hi Ve	Hi Vi Hi Ve	Hi Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Hi Ve	Lo Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Lo Ve
Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	25.9	23.7	25.9	23.3	25.9	24.8	24.8	23.3	23.3	23.7	24.8	23.7
S.D.	10.8	10.8	10.8	9.3	10.8	10.8	10.7	9.2	9.2	10.9	10.7	10.8
F.	1.01		1.37		1.01		1.36		1.38		1.02	
t.	1.04		1.59		.71		.89		-.17		.52	
Signif	.15		.06		.24		.18		.43		.30	
d.f.	127		156		181		145		91		116	

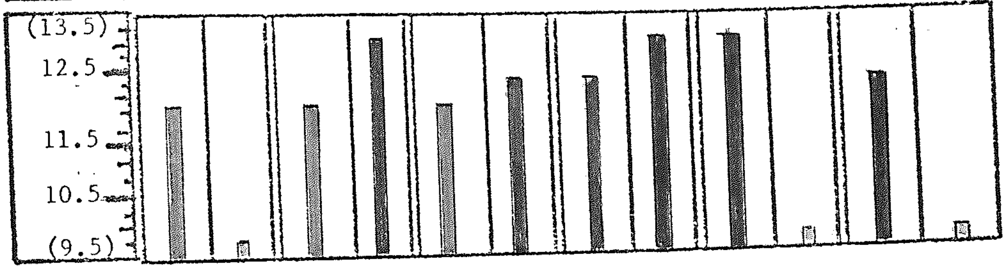
Table 43 Performance in originality (CONSEQ) by four categories of dual-coding groups. All subjects



Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	55.5	51.6	55.5	58.8	55.5	57.2	57.2	58.8	58.8	51.6	57.2	51.6
S.D.	17.3	24.8	17.2	16.7	17.3	17.5	17.5	16.7	16.7	24.8	17.5	24.8
F.	2.07		1.06		1.03		1.09		2.20		2.01	
t.	.97		-1.18		-.67		-.54		1.64		1.36	
Signif	.16		.12		.25		.29		.05		.09	
d.f.	127		156		181		145		91		116	

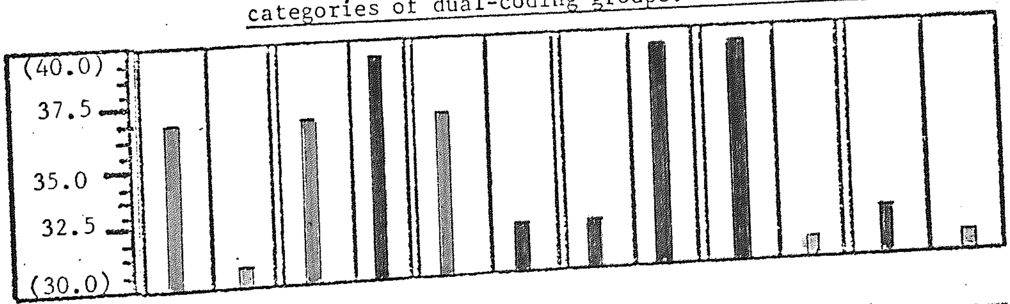
Table 44 — Performance in originality (PLOTTI) by four categories of dual-coding groups. All subjects

Mn Score	Hi Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Hi Ve	Lo Vi Hi Ve	Hi Vi Hi Ve	Hi Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Hi Ve	Lo Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Lo Ve



Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	12.0	9.7	12.0	13.1	12.0	12.2	12.2	13.1	13.1	9.7	12.2	9.7
S.D.	4.7	4.7	4.7	9.8	4.6	5.1	5.1	9.7	9.8	4.7	5.1	4.7
F.	1.01		4.40		1.20		3.66		4.34		1.19	
t.	2.37		-.92		-.29		-.69		1.81		2.38	
Signif	.009		.15		.39		.25		.03		.01	
d.f.	127		156		181		145		91		116	

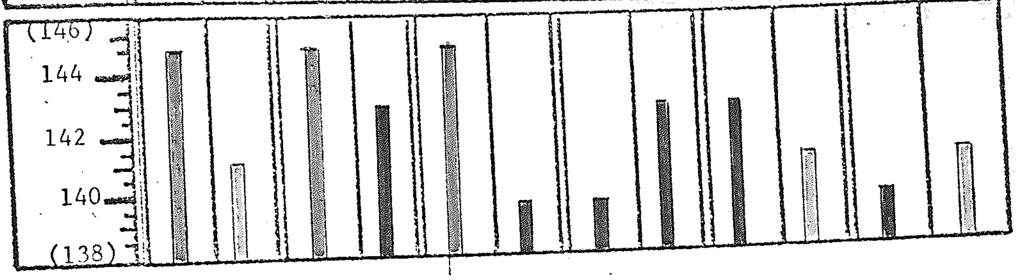
Table 45 — Performance in ideational fluency (TOPICS) by four categories of dual-coding groups. All subjects



Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	36.5	30.3	36.5	38.5	36.5	31.2	31.2	38.5	38.5	30.3	31.2	30.3
S.D.	15.3	15.3	15.3	19.5	15.3	11.5	11.5	19.5	19.5	15.4	11.4	15.4
F.	1.01		1.62		1.79		2.90		1.61		1.80	
t.	1.98		-.71		2.62		-2.84		2.05		.34	
Signif	.02		.24		.005		.002		.02		.36	
d.f.	127		156		181		145		91		116	

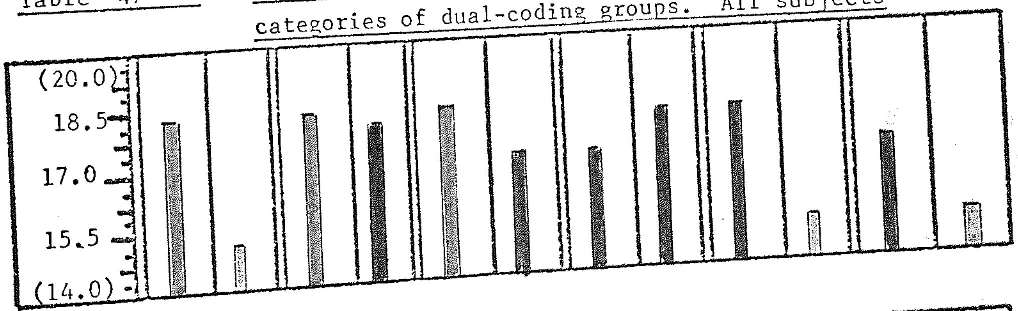
Table 46 Performance in ideational fluency (THEMES) by four categories of dual-coding groups. All subjects

Mn Score	Hi Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Hi Ve	Lo Vi Hi Ve	Hi Vi Hi Ve	Hi Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Hi Ve	Lo Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Lo Ve



Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	144.9	141.3	144.9	143.3	144.9	139.7	139.7	143.3	143.5	141.3	139.7	141.3
S.D.	41.7	50.3	41.7	37.1	41.7	40.2	40.2	37.0	37.1	50.3	40.2	50.3
F.	1.45		1.27		1.08		1.18		1.84		1.56	
t.	.39		.22		.85		-.57		.22		-.19	
Signif	.35		.41		.19		.29		.21		.43	
d.f.	127		156		181		145		91		116	

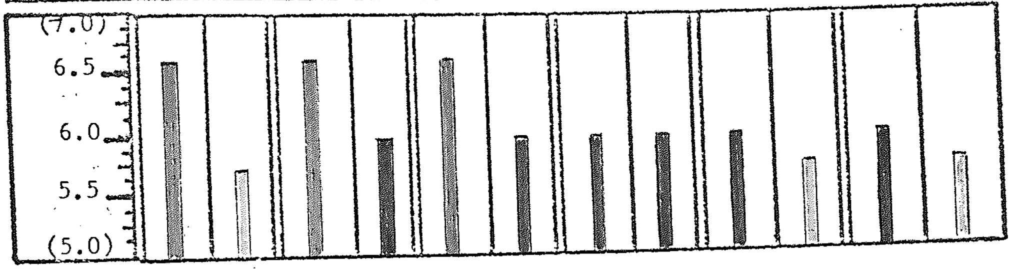
Table 47 Performance in ideational fluency (THINGS) by four categories of dual-coding groups. All subjects



Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	18.4	15.0	18.4	18.1	18.4	17.3	17.3	18.1	18.1	15.0	17.3	15.0
S.D.	6.2	5.6	6.3	5.6	6.3	5.2	5.2	5.6	5.6	5.6	5.2	5.6
F.	1.26		1.23		1.44		1.17		1.02		1.14	
t.	2.71		.31		1.23		-.83		2.50		2.10	
Signif	.004		.38		.11		.20		.007		.02	
d.f.	127		156		181		145		91		116	

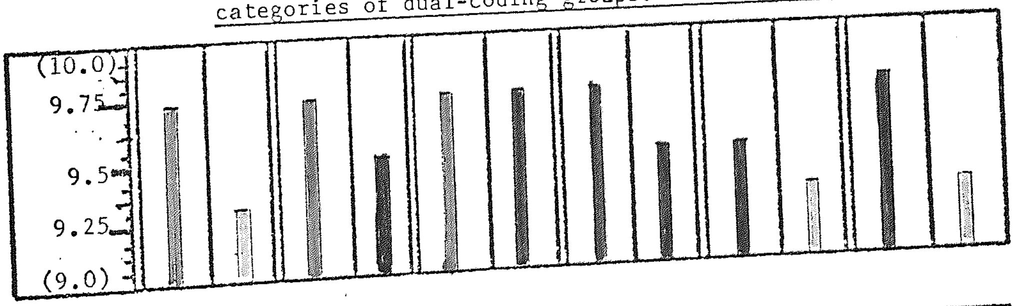
Table 48 Performance in an intelligence scale (B) by four categories of dual-coding groups. All subjects.

Mn Score	Hi Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Hi Ve	Lo Vi Hi Ve	Hi Vi Hi Ve	Hi Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Hi Ve	Lo Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Lo Ve



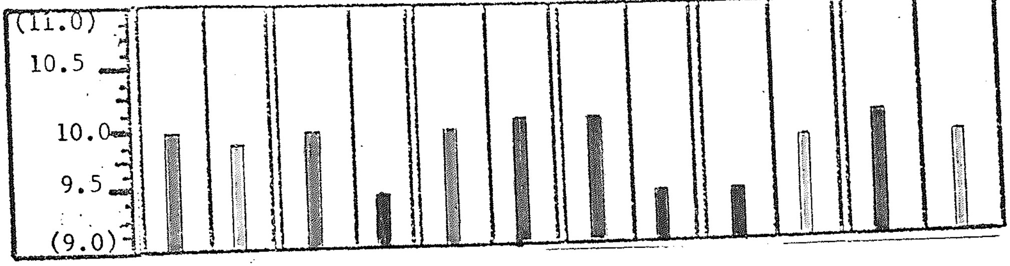
Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	6.6	5.7	6.6	6.0	6.6	6.0	6.0	6.0	6.0	5.7	6.0	5.7
S.D.	1.53	1.96	1.5	1.6	1.5	1.6	1.6	1.6	1.6	2.0	1.6	2.0
F.	1.63		1.13		1.12		1.01		1.45		1.46	
t.	2.71		2.15		2.43		-.06		.94		.97	
Signif	.004		.02		.008		.48		.17		.17	
d.f.	127		156		181		145		91		116	

Table 49 Performance in a self-sufficiency scale (Q2) by four categories of dual-coding groups. All subjects



Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	9.7	9.3	9.7	9.5	9.7	9.7	9.7	9.5	9.5	9.3	9.7	9.3
S.D.	2.8	2.3	2.8	3.0	2.8	2.8	2.8	3.0	3.0	2.3	2.8	2.3
F.	1.47		1.16		1.01		1.17		1.71		1.46	
t.	.87		.51		.14		.38		.39		.76	
Signif	.19		.30		.45		.35		.35		.22	
d.f.	127		156		181		145		91		116	

Table 50 Performance in a self-concept scale (Q3) by four categories of dual-coding groups. All subjects.



	Hi Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Hi Ve	Lo Vi Hi Ve	Hi Vi Hi Ve	Hi Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Hi Ve	Lo Vi Hi Ve	Lo Vi Lo Ve	Hi Vi Lo Ve	Lo Vi Lo Ve
Cases	97	32	97	61	97	86	86	61	61	32	86	32
Mn.	10.0	9.9	10.0	9.4	10.0	10.2	10.2	9.4	9.4	9.9	10.2	9.9
S.D.	3.3	2.9	3.3	2.8	3.3	2.8	2.7	2.8	2.8	2.9	2.8	2.8
F.	1.28		1.32		1.39		1.05		1.03		1.09	
t.	.18		1.21		-.49		1.78		-.80		.58	
Signif	.43		.11		.31		.03		.21		.28	
d.f.	127		156		181		145		91		116	

SUMMARY TABLE 51

Results from Tables 38-50

Predicted relationships between four groups of children using different combinations of dual-coding strategies, in terms of performance in thirteen variables

✓ indicates direction as predicted

Line Ref.	Cases		Percep.	Field Indep.	Reading		Creativity: Originality		Creativity: Fluency				Intell.	Self-Suffi.	Self-Concept
			PERCEP	HIDFIG	NATRS	READCO	SYMPRO	CONSEQ	PLOTTI	TOPICS	THEMES	THINGS	B	Q2	Q3
R	97	Hi Vis/Hi Verb by	1	1	1	1	1	1	1	1	1	1	1	1	1
	32	Low Vis/Low Verb	2	2	2	2	2	2	2	2	2	2	2	2	2
		Direction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Significance	.001	N.S.	.08	.002	N.S.	N.S.	.009	.02	N.S.	.004	.004	N.S.	N.S.
S	97	Hi Vis/Hi Verb by	1	1	1	1	1	1	1	1	1	1	1	1	1
	61	Low Vis/High Verb	2	2	2	2	2	2	2	2	2	2	2	2	2
		Direction	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓
		Significance	NS(.09)	N.S.	.01	.03	NS (.06)	N.S.	N.S.	N.S.	N.S.	N.S.	.02	N.S.	N.S.
T	97	Hi Vis/Hi Verb by	1	1	1	1	1	1	1	1	1	1	1	1	1
	56	Hi Vis/Low Verb	2	2	2	2	2	2	2	2	2	2	2	2	2
		Direction	✓	✓	✓	✓	✓			✓	✓	✓	✓	same	
		Significance	NS (.15)	N.S.	.002	.001	N.S.	N.S.	N.S.	.005	N.S.	N.S.	.005	N.S.	N.S.
U	56	Hi Vis/Low Verb by	1	1	2	2	-	-	-	-	-	-	-	-	-
	61	Low Vis/Hi Verb	2	2	1	1	-	-	-	-	-	-	-	-	-
		Direction	✓	✓	✓										
		Significance	N.S.	N.S.	N.S.	N.S.									
V	61	Low Vis/Hi Verb by	1	1	1	1	1	1	1	1	1	1	1	1	1
	32	Low Vis/Low Verb	2	2	2	2	2	2	2	2	2	2	2	2	2
		Direction	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓
		Significance	.03	N.S.	N.S.	NS (.08)	N.S.	.05	.03	.02	N.S.	.007	N.S.	N.S.	N.S.
W	56	Hi Vis/Low Verb by	1	1	1	1	1	1	1	1	1	1	1	1	1
	32	Low Vis/Low Verb	2	2	2	2	2	2	2	2	2	2	2	2	2
		Direction	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓

Table 52 (from Summary Table 51). Predicted relationships between four groups of children using different combinations of dual-coding strategies, in terms of performance on thirteen variables. Predictions supported or not supported.

No. of Predictions	Predictions supported	Predictions not supported	Signif.
69	57	12	.01

(Siegal 1956, p.41)

Table 53 (from Summary Table 51, lines R, S, T)
Alternative hypothesis 7A. High Visual/High Verbal groups will score higher than all other groups.

No. of Predictions	Predictions supported	Predictions not supported	Signif.
39	32	7	.001

Table 54 (from Summary Table 51, lines S, T, U, V, W)
Alternative hypothesis 7B. The High Visual/Low Verbal and Low Visual/High Verbal groups will score less than the High Visual/High Verbal and more than the Low Visual/Low Verbal groups

No. of Predictions	Predictions supported	Predictions not supported	Signif.
52	41	11	.001

Table 55 (from Summary Table 51, lines R, V, W)
The Low Visual/Low Verbal group will score lower than all other groups.

No. of Predictions	Predictions supported	Predictions not supported	Signif.
39	35	4	.001

Results in tables 52-55 submitted to the Binomial Test (Siegel p.41); one-tailed tests of significance

In Tables 56 and 57 which follow, the separate reading variables (NATRS and READCO) are combined to form a composite variable, Reading.

Similarly the variables associated with originality and ideational fluency (SYMPRO, CONSEQ, PLOTTI, THEMES, TOPICS, THINGS) are combined to form a composite variable, Creativity.

Tables 56 and 57 present the actual rank orders derived from mean scores in the seven variables, in order to test actual rank orders against predicted rank orders.

Table 56. Mean Scores and ranks of four categories of dual-coding groups by seven variables, including composite variables for Reading and Creativity. 360 Second and Third Year subjects.

	Hi Vis Hi Verb	Lo Vis Hi Verb	Hi Vis Low Verb	Low Vis Low Verb
Perceptual Ability	86.8 (1)	81.8 (3)	83.7 (2)	73.2 (4)
Field Independence	7.8 (1)	7.4 (3)	7.5 (2)	6.9 (4)
Reading	27.3 (1)	24.5 (2)	23.5 (3)	23.4 (4)
Creativity	48.9 (2)	49.2 (1)	47.1 (3)	45.3 (4)
Intelligence	6.6 (1)	6.0 (2)	6.0 (2)	5.7 (4)
Self-sufficiency	9.7 (1)	9.5 (3)	9.7 (1)	9.3 (4)
Self-concept	10.0 (2)	9.4 (4)	10.2 (1)	9.9 (3)
Ranks in Brackets				

Table 57. Predicted and actual rank orders of four categories of dual-coding groups by seven variables (from Tables 53). 360 Second and Third Year subjects.

	Predicted Ranks			
	1	2	3	4
Perceptual Ability	1	3	2	4
Field Independence	1	2	3	4
Reading	1	2	3	4
Creativity	2	1	3	4
Intelligence	1	2	3	4
Self-sufficiency	1	3	1	4
Self-concept	2	4	1	3

Actual Ranks

Kendall Coefficient of Concordance (Predicted and actual rank orders)

s = 164.75 W = .51 Significance .01

CHAPTER SIX

Statement of Results

STATEMENT OF RESULTS

SECTION A1

The research and null hypotheses relate to comparisons to be made within sex, and between age, of first and third year level children. However, comparisons have also been undertaken and reported in the tables of results in respect of the second year age level. These additional comparisons will be included in the statement of results where appropriate.

As indicated in Chapter Four, parametric analyses have been made of recall imagery data with significance set at the .05 level. The dual-coding strategies, however, have been subject to both parametric and non-parametric analyses in this section. The non-parametric results, with significance set at the .05 level, form the basis of the statements of results because of the skewed distribution patterns revealed in histograms 1, 2 and 3. The parametric analyses are included in support of the non-parametric analyses since the research population groups entered into the computations range from 163 to 194 and are considerably larger than the minimum of 30 subjects advocated by Guilford (1965 p.181). Where parametric analysis is used in this way, significance is set at the .01 level.

The reason for doing this is that a decision as to whether to use _either_ parametric _or_ non-parametric analyses with data derived from weak measurement could result too easily in either a Type I error in the case of the parametric analyses or a Type II error in the case of the non-parametric analyses. It is considered that by using both techniques, and by setting the more powerful parametric test significance level at .01, the possibility of making a mistaken experimental conclusion is minimised.

Simple Inspection of Data: Tables 7, 8, 9 and Histograms 1, 2, 3.

The tables and histograms reveal the following patterns of results:

1. A strong clustering of results for both boys and girls at all three age levels in the Higher Visual categories 1, 2, 3 and in the Higher Verbal categories 1, 2, 3.

2. Under-representation of boys and girls at all three age levels in Low Visual categories 4 and 5.

3. Under-representation of boys and girls at all three age levels in Low Verbal categories 4 and 5.

4. Stronger representation for boys and for girls in the Low Verbal categories 4 and 5 at First Year level than at Third Year level.

Research Hypothesis One

Restatement of Between age groups, within sex hypothesis

The hypothesis is that developmental factors operate in respect of visual and verbal strategies used; the incidence of visual strategies used giving way to increased use of verbal strategies with advancing age, for both boys and girls.

Research Hypothesis One Result

from inspection of Graph 4 and Table 16a

Recall Imagery

1a Boys at first year level score significantly higher on a test of recall imagery than boys at third year level (.05, Table 16a) and boys at first year level score significantly higher on a test of recall imagery than boys at second year level (.001, Table 16a).

The Null hypothesis 1a is therefore rejected.

1b Girls at third year level score higher than girls at first year level, the result not reaching significance, and girls at third year level score higher than girls at second year level (.05, Table 16b).

Null hypothesis 1b is not rejected.

Applied Imagery

1c Boys at first year level score significantly higher on a test of 'applied' imagery than boys of third year level (.05, Chi square, Table 10).

Boys at second year level do not score higher than boys at third year level.

Boys at first year level score higher than boys at second year level.

Null hypothesis 1c is rejected.

1d Girls at first year level score higher on a test of applied imagery than girls at third year level, the results not reaching significance (Table 11) (.05, t-test, Table 17b).

All between age comparisons of applied imagery reveal results in the direction of the prediction that visualising declines from first to third year, but the significance levels set are not sustained. The Null hypothesis 1d is not rejected.

Covert Verbalising

1e Boys at third year level score significantly higher on a test of covert verbalising than boys at first year level (.025, Table 12). Boys at third year level score significantly higher than boys at second year level (.05, Table 12) although boys at second year level do not score higher than boys at first year level.

Null hypothesis 1e is rejected

1f Girls at third year level do not score higher on a test of covert verbalising than girls at first year level. In all between age-level comparisons on tests of covert verbalising, older girls score lower than younger girls.

Null hypothesis 1f is not rejected.

Restatement of Research Hypothesis Two

In comparisons between sex, and within age-groups, boys and girls will score differently on a test of recall imagery: ages 12-14 (two-tailed test).

Research Hypothesis Two Result

From inspection of Table 16c and Graph 4, it is observed that, on a test of recall imagery:

a. First year boys score higher than first year girls

b. Second year boys score lower than second year girls

c. Third year boys score lower than third year girls

none of the results reaching significance.

Null hypotheses 2a, 2b, 2c are not rejected

Re-statement of Research Hypothesis Three

Girls use verbal strategies more than boys at each age level, and boys use visual strategies more than girls at each age level: ages 12-14.

Research Hypothesis Three Result

Applied Imagery

3 From inspection of tables 14, 17e and Graph 5, it is observed that on a test of 'applied' imagery:

a. First year boys score lower than first year girls

b. Second year boys score lower than first year girls

c. Third year boys score lower than first year girls

none of the results reaching significance

Null hypotheses 3a, b, c are not rejected

Covert Verbalising

3 From inspection of tables 15, 17f, Graph 5, 18c and d, it is observed that on a test of covert verbalising:

d. First year girls score lower than first year boys

e. Second year girls score higher than second year boys (.05)

f. Third year girls score lower than third year boys

Null hypotheses 3d, f are not rejected

Null hypothesis 3e is rejected

SUMMARY, SECTION A1

The hypotheses in this section are based on two sets of assumptions:

a. That girls within the age range 11-14 have better language facility than boys, covert verbalising being associated with that facility.

b. That boys in the age range 11-14 have better spatial ability than girls, applied imagery being associated with that facility, recall imagery being used as a 'base-line' measure.

The results do not illuminate these assumptions and appear to indicate that for boys; recall and 'applied' imagery declines, and covert verbalising increases; while for girls, recall imagery increases, 'applied' imagery declines and covert verbalising declines. These results are not easy to interpret in the light of a theoretical position that associates use of dual-coding processes with success in other measures (Section A3/C2). Maturational factors may be operating, with boys developing faster in some unexpected respects than girls, from age 11-14. The growth of girls' recall imagery in this age-range is interesting.

STATEMENT OF RESULTS

SECTION A2/B2

Correlation of performance in each of the representational processes taken separately with performance in measures of ability, creativity and personality.

Research Hypothesis Four (from Tables 19, 20, 21)

Recall imagery, Boys

Recall imagery correlates with perception (.01), field independence (.01), reading ability (.05), intelligence (.01), self-sufficiency (.01), self-concept (.05), applied imagery (.01) and covert verbalising (.01) - No significant correlation was observed between recall imagery and creativity.

Recall imagery, Girls

Recall imagery correlates with field independence (.01), reading ability (.05), intelligence (.05), self-sufficiency (.01), self-concept (.01), applied imagery (.01) and covert verbalising (.01) - No significant correlation was observed between recall imagery and perception, or recall imagery and creativity.

Research Hypothesis Five (from Tables 19, 20, 21)

Applied imagery, Boys

Applied imagery correlates with covert verbalising (.01), field independence (.01), reading ability (.05), intelligence (.01), self-sufficiency (.05) - No significant correlation was observed between applied imagery and perception, applied imagery and creativity, or applied imagery and self-concept.

Applied imagery, Girls

Applied imagery correlates with covert verbalising (.01), field independence (.05), reading ability (.05), creativity (.05), self-sufficiency (.01), and self-concept (.05).

- No significant correlation was observed between applied imagery and perception, or applied imagery and intelligence.

Research Hypothesis Six (from tables 19, 20, 21.)

Covert verbalising, Boys

Covert verbalising correlates with field independence (.05), self-sufficiency (.05).

- No significant correlation was observed between covert verbalising and perception, reading ability, creativity, intelligence or self-concept.

Covert verbalising, Girls

Covert verbalising correlates with field independence (.01), reading (.05), self-sufficiency (.05), self-concept (.05).

- No significant correlation was observed between covert verbalising and perception, creativity and intelligence.

Taking the variables listed in tables 19, 20, 21., it is note-worthy that of 135 correlations predicted in this section, 109 were sustained significantly, giving support to other research findings, listed on pp. 83-85.

STATEMENT OF RESULTS

SECTION A3/C2

Re-statement of Research Hypothesis Seven

The research hypothesis predicts that:

7a The High Visual/High Verbal dual-coding group will score higher than all other groups on the performance measures.

7b The High Visual/Low Verbal and the Low Visual/High Verbal dual-coding groups will score lower than the High Visual/High Verbal groups, but higher than the Low Visual/Low Verbal group on the performance measures.

7c The Low Visual/Low Verbal group will therefore score lower than all the other groups on the performance measures.

7d The High Visual/Low Verbal groups will score higher than the Low Visual/High Verbal group on performance measures that have a high perceptual component.

7e The Low Visual/High Verbal group will score higher than the High Visual/Low Verbal group on performance measures that have a high verbal component.

Research Hypothesis Seven

Perceptual Ability (MORPER) (Table 38)

SECTION A2/C3

The High visual/High verbal group scored

significantly better than the Low visual/Low verbal group (.001), and although failing to reach significance scored better than the Low visual/High verbal group (.09) and the High visual/Low verbal group (.15).

The Low visual/Low verbal group scored

significantly less than all other groups:

- the High visual/High verbal groups (.001)
- The Low visual/High verbal groups (.03)
- The High visual/Low verbal groups (.004)

The Low visual/High verbal group scored

marginally less than the High visual/Low verbal group, the results not reaching significance.

Field Independence (HIDFIG) (Table 39)

The High visual/High verbal groups scored

better than all three other groups, none of the results reaching significance.

The Low visual/Low verbal group scored

less than all three other groups, none of the results reaching significance.

The High visual/Low verbal group scored

marginally better than the Low visual/High verbal group, the results not reaching significance.

Reading Ability (NATRS) (Table 40)

The High visual/High verbal group scored

significantly better than all three other groups in two comparisons:

- the Low visual/Low verbal group (.08) *(Marginally lower)
- the Low visual/High verbal group (.01)
- the High visual/Low verbal group (.002)

The Low visual/Low verbal group scored

significantly less than the High visual/High verbal group but marginally better than the other two groups, the results not reaching significance.

The Low visual/High verbal group scored

marginally better than the High visual/Low verbal group, the result not reaching significance.

Reading Comprehension (READCO)(Table 41)

The High visual/High verbal group scored

significantly better than all three other groups:

- the Low visual/Low verbal group (.002)
- the Low visual/High verbal group (.03)
- the High visual/Low verbal group (.001)

The Low visual Low verbal group scored

significantly less than the High visual/High verbal group (.002), less than the Low visual/High verbal group, the result just failing to reach significance (.08), and non-significantly less than the High visual/Low verbal group.

The High verbal/Low visual group scored

marginally better than the Low verbal/High visual group, the result not reaching significance.

Originality (SYMPRO) (Table 42)

The High visual/High verbal group scored

better than all other three groups :

the result with the Low Visual/High verbal group just failing to reach significance (.06) and the other results also not reaching significance.

The Low visual/Low verbal group scored

marginally better than the Low visual/High verbal group and marginally less than the other two groups, all results failing to reach significance.

The High visual/Low verbal group scored

marginally better than the Low visual/High verbal group, the result not reaching significance.

(No prediction made for this comparison).

Originality (CONSEQ)(Table 43)

The High visual/High verbal group scored

better than the Low visual/Low verbal group, the result not reaching significance; and less than the other two groups, the results not reaching significance.

The Low visual/Low verbal group scored

less than all other three groups, the result with the Low visual/High verbal group being significant (.05) and the result with the High visual/Low verbal group failing to reach significance (.09) by a small margin.

The Low visual/High verbal group scored

marginally better than the High visual/Low verbal group, the result not reaching significance.

(No prediction made for this comparison).

Originalty (PLOTTI) (Table 44)

The High visual/High verbal group scored

significantly better than the Low visual/Low verbal groups (.009) but marginally less than the other two groups, the results not reaching significance.

The Low visual/Low verbal group scored

significantly less than all three other groups:

- the High visual/High verbal group (.009)
- the Low visual/High verbal group (.03)
- the High visual/Low verbal group (.01)

The Low visual/High verbal group scored

marginally better than the High visual/Low verbal group, the result not reaching significance.

(No prediction made for this comparison).

Ideational Fluency (TOPICS) (Table 45)

The High visual/High verbal group scored

significantly better than :

- the Low visual/Low verbal group (.02)
- the High visual/Low verbal group (.005)

and less than the Low visual/High verbal group, the result not reaching significance.

The Low visual/Low verbal group scored

significantly less than :

- the High visual/High verbal group (.02)
- the Low visual/High verbal group (.02)

and less than the High visual/Low verbal group, the result not reaching significance.

The Low visual/High verbal group scored

significantly better than the High visual/Low verbal group (.002).

(No prediction made for this comparison)

Ideational Fluency (THEMES)(Table 46)

The High visual/High verbal group scored

better than all three other groups, the results not reaching significance.

The Low visual/Low verbal group scored

less than the High visual/High verbal group, and the Low visual/High verbal group and better than the High visual/Low verbal group, none of the results reaching significance.

The Low visual/High verbal group scored

better than the High visual/Low verbal group, the result not reaching significance.

(No prediction made for this comparison)

Ideational Fluency (THINGS)(Table 47)

The High visual/High verbal group scored

significantly better than the Low visual/Low verbal group (.004) and marginally better than the other two groups, the results not reaching significance.

The Low visual/Low verbal group scored

significantly less than all three other groups :

- the High visual/High verbal group (.004)
- the Low visual/High verbal group (.007)
- the High visual/Low verbal group (.02)

The Low visual/High verbal group scored

marginally better than the High visual/Low verbal group, the result not reaching significance.

(No prediction made for this comparison).

Intelligence (B) (Table 48)

The High visual/High verbal group scored

significantly better than all other three groups:

- the Low visual/Low verbal group (.004)
- the Low visual/High verbal group (.02)
- the High visual/Low verbal group (.008)

The Low visual/Low verbal group scored

significantly less than the High visual/High verbal group (.004) and less than the other two groups, the results failing to reach significance.

The Low visual/High verbal group scored

the same mean score as the High visual/Low verbal group. (No prediction made for this comparison).

Self-sufficiency scale (Q2)(Table 49)

The High visual/High verbal group scored

better than the Low visual/Low verbal group and the Low visual/High verbal group and had the same mean score as the High visual/Low verbal group, the results not reaching significance.

The Low visual/Low verbal group scored

less than all other groups, the results not reaching significance.

The Low visual/High verbal group scored

less than the High visual/Low verbal group, the result not reaching significance.

(No prediction made for this comparison).

Self-concept scale (Q3) (Table 50)

The High visual/High verbal group scored

better than the Low visual/Low verbal group and the Low visual/High verbal group and less than the High visual/Low verbal group, the result not reaching significance.

The Low visual/Low verbal group scored

less than all other three groups, the results not reaching significance.

The High visual/Low verbal group scored

significantly better than the Low visual/High verbal group (.03)

(No prediction made for this comparison)

Summary Table 51

The table summarises results of predictions of comparative performance in measures of ability, creativity and personality between four groups of children who use different combinations of dual-coding strategy.

Of sixty-nine cells containing predictions of direction of performance between the four groups, fifty seven results were in the direction predicted, twenty three of these results reaching significance, and five other results just failing to reach significance.

The predictions for the High Visual/High Verbal dual-coding group were that they would perform better than all other dual-coding groups in all measures.

For children in the High Visual/High Verbal dual-coding group, their results were better than other groups in thirty two out of thirty nine cases; fifteen of these results reaching significance. A further analysis of the results indicates that in comparing the High Visual/High Verbal group with the other dual-coding groups in:-

Perceptual ability

results were in the direction predicted in three cases out of three, with one result reaching significance and one result just failing to reach significance.

Field Independence

results were in the direction predicted in three cases out of three, none reaching significance.

Reading ability

results were in the direction predicted in six cases out of six, all results reaching significance.

Creativity

results were in the direction predicted in thirteen cases out of eighteen, four results reaching significance and one other result just failing to reach significance. Of the results reaching

/ contd ...

significance, three occurred when the High visual/High verbal group was compared with the Low visual/Low verbal group.

Intelligence

results were in the direction indicated in three cases out of three, with all results reaching significance.

Self-sufficiency

results were in the direction predicted in two cases out of three, neither result reaching significance.

Self-concept

results were in the direction predicted in two cases out of three, neither result reaching significance.

The predictions for the Low visual/Low verbal dual-coding group were that they would perform less well than all other dual-coding groups.

For children in the Low visual/Low verbal dual-coding groups, their results were poorer than all other groups in thirty five out of thirty nine cases; fifteen of these results reaching significance and two others just failing to reach significance. A further analysis of results indicates that in comparing the Low Visual/Low Verbal group with the other dual-coding groups in:-

Perceptual ability

results were in the direction predicted in three cases out of three, with all results reaching significance.

Field Independence

results were in the direction predicted in three cases out of three, none reaching significance.

Reading ability

results were in the direction predicted in four cases out of six, with two results reaching significance and two other results just failing to reach significance.

Creativity

results were in the direction predicted in sixteen cases out of eighteen, with nine results reaching significance and one other result just failing to reach significance.

Intelligence

results were in the direction predicted in three cases out of three, with one result reaching significance.

Self-sufficiency

results were in the direction predicted in three cases out of three, none reaching significance.

Self-concept

results were inthe direction predicted in three cases out of three, none reaching significance.

The predictions for the comparisons of performance between the High Visual/Low Verbal dual-coding group and the Low Visual/High Verbal group were that the High Visual/Low Verbal group would perform better than the Low Visual/High Verbal group on the measures of perception and field independence, whereas the Low Visual/High Verbal group would perform better in the measures of reading.

Perceptual ability

The High visual/Low verbal group performed better than the Low visual/High verbal group as predicted, the result not reaching significance.

Field Independence

The High visual/Low verbal group performed better than the Low visual/High verbal group as predicted, the result not reaching significance.

Reading ability

The Low visual/High verbal group performed better than the High visual/Low verbal group on a test of Reading Comprehension, the result just failing to reach significance, but worse on a test of Reading Vocabulary, the result not reaching significance.

Table 58 which follows summarises results from tests relating to Null hypotheses 7A to 7E, in terms which indicate whether the null hypothesis can be rejected or not for each of the thirteen variables.

In each case the null hypothesis is only rejected from evidence supported by one-tailed tests of significance at the .05 level.

At this level of analysis of results, no clear pattern emerges that will allow for an overall rejection of null hypotheses 7A to 7E, in respect of all variables. In the following cases, however, the null hypothesis can clearly be rejected for the variables listed taking a rigorous standard of decision in respect of all comparisons.

<u>7A</u>

d. Reading (READCO) Three out of three comparisons

j. Intelligence (B) Three out of three comparisons

<u>7C</u>

a. Visual perception (MORPER) Three out of three comparisons

g. Creativity (O3) Three out of three comparisons

j. Creativity (FL3) Three out of three comparisons

The null hypotheses stated in section A3/C2 can be rejected or not rejected as shown in the following table.

Table 58 Rejection or Acceptance of Null Hypotheses 7A, 7B, 7C, 7D, 7E

Null hypothesis	7A The High Visual/High Verbal group will not score higher than:			7B The Hi Vis/Lo Verb and Lo Vis/Hi Verb groups will not score higher than the Hi Vis/Hi Verb group or lower than the Lo Vis/Lo Verb group				7C The Low Visual/Low Verbal Group will not score lower than		
				Hi Vis/Lo Verb		Lo Vis/Hi Verb				
	Lo Vis/ Lo Verb	Hi Vis/ Lo Verb	Lo Vis/ Hi Verb	Hi Vis/ Hi Verb	Lo Vis/ Lo Verb	Hi Vis/ Hi Verb	Lo Vis/ Lo Verb	Hi Vis/ Hi Verb	Hi Vis/ Lo Verb	Lo Vis/ Hi Verb
a Visual perception (MORPER)	R	NR	NR	NR	R	NR	R		R	R
b Field independence (HIDFIG)	NR	NR	NR	NR	NR	NR	NR		NR	NR
c Reading (NATRS)	NR	R	R	R	NR	R	NR		NR	NR
d Reading (READCO)	R	R	R	R	NR	R	NR		NR	NR
e Creativity (O1)	NR	NR	NR	NR	NR	NR	NR		NR	NR
f Creativity (O2)	NR	NR	NR	NR	NR	NR	R		NR	R
g Creativity (O3)	R	NR	NR	NR	R	NR	R		R	R
h Creativity (FL1)	R	R	NR	R	NR	NR	R		NR	R
i Creativity (FL2)	NR	NR	NR	NR	NR	NR	NR		NR	NR
j Creativity (FL3)	R	NR	NR	NR	R	NR	R		R	R
k Intelligence (B)	R	R	R	R	NR	R	NR		NR	NR
l Self-sufficiency (Q2)	NR	NR	NR	NR	NR	NR	NR		NR	NR
m Self-concept (Q3)	NR	NR	NR	NR	NR	NR	NR		NR	NR

Null Hypothesis	7D The High Visual/Low Verbal group will not score higher than the Low Visual/High Verbal group	7E The Low Visual/High Verbal group will not score higher than the High Visual/Low Verbal Group
a Visual perception (MPAT)	NR	-
b Field independence (HFT)	NR	-
c Reading (NATRS)	-	NR
d Reading (READCO)	-	NR

R = Null Hypothesis rejected

NR = Null Hypothesis not rejected

Statement of results from additional analyses of the data in section A3/C2; Tables 52-57

Although no clear overall pattern of results emerges from Table 58, it was noted that from the sub-sections of null hypotheses 7A to 7E formed by each of the thirteen variables, 38 sub-sections of the null hypotheses can be rejected out of a possible total of 121. It was further noted that 5 other sub-sections of the null hypotheses failed to reach rejection levels only marginally.

As discussed in the conclusions, it is acknowledged that the measures are not strong and may not be revealing the underlying abilities to an extent to which differences between groups can be clearly supported by statistical significance levels.

However, Donaldson (1963, p.127) has referred to the advice of Lawley in pointing out that an overall pattern of arithmetical results in the predicted direction, despite lack of support in terms of statistical significance, may still be acceptable towards the establishment of hypotheses for verification by further experiment.

Accordingly an extension of the original design was undertaken by a further investigation of the results in section A3/C2, by determining the predictions supported by arithmetical results, and testing the number of predictions supported against the number of predictions not supported, by Binomial Test, using a one-tailed test of significance.

The results of these further analyses can be stated as follows:

From Table 52

In the overall pattern of predicted relationships between the four groups of children using different combinations of dual-coding strategies, tested over thirteen variables, 57 directional predictions out of 69 are supported. (.01 level, Binomial Test).

The research hypothesis stating that a hierarchy of dual-coding strategies is associated with performance in the measures used is, therefore supported.

From Table 53

Null hypothesis 7A, that the High Visual/High Verbal group will not score higher than all other groups, is rejected if patterns of predictions based on arithmetical comparisons are used, 32 out of 39 directional predictions being supported. (.001 level, Binomial Test).

From Table 54

Null hypothesis 7B, that the High Visual/Low Verbal and the Low Visual/High Verbal groups will not score lower than the High Visual/ High Verbal group nor higher than the Low Visual/Low Verbal group, is rejected if patterns of predictions based on arithmetical comparisons are used, 41 out of 52 directional predictions being supported. (.001 level, Binomial Test).

From Table 55

Null hypothesis 7C, that the Low Visual/Low Verbal group will not score lower than all the other groups is rejected if patterns of predictions based on arithmetical comparisons are used, 35 out of 39 directional predictions being supported. (.001 level, Binomial Test).

Hypotheses 7D and 7E were not subjected to this procedure because the number of predictions made, two predictions in respect of each hypothesis, is small.

Further analyses of the rank orders on seven variables derived from mean scores of the four categories of dual-coding groups were also made. The results from Tables 56 and 57 show that:

a. <u>The predicted rank orders of the four dual-coding groups are confirmed for</u>:

<u>Perceptual ability</u> (Predicted and actual ranks)

1. High Visual/High Verbal Group 2. High Visual/Low Verbal Group
3. Low Visual/High Verbal Group. 4. Low Visual/Low Verbal Group

<u>Reading</u> (Predicted and actual ranks)

1. High Visual/High Verbal group. 2. Low Visual/High Verbal group
3. High Visual/Low Verbal group 4. Low Visual/Low Verbal group

<u>Intelligence</u> (Predicted and actual ranks)

1. High Visual/High Verbal group 2. Low Visual/High Verbal group
3. High Visual/Low Verbal group 4. Low Visual/Low Verbal group

b. <u>The predicted rank orders of the four dual-coding groups are partly supported for</u>:

<u>Creativity</u> (Actual ranks)

1. Low Visual/High Verbal group 2. High Visual/High Verbal group
3. High Visual/Low Verbal group 4. Low Visual/Low Verbal group

(Predicted ranks 1 and 2 are reversed)

<u>Self-sufficiency</u> (Actual ranks)

1= High Visual/High Verbal group 1= Low Visual/High Verbal Group

3. High Visual/Low Verbal group 4. Low Visual/Low Verbal group

(Low Visual/High Verbal and High Visual/Low Verbal groups are not as predicted, i.e. 2 and 3 respectively)

<u>Self-concept</u>

c. <u>The predicted rank orders of the four dual-coding groups receive little support from the actual rank orders</u>.

1. High Visual/Low Verbal group 2. High Visual/High Verbal group

3. Low Visual/Low Verbal group 4. Low Visual/High Verbal group

Testing the overall pattern of predicted and actual rank orders by the Kendall Coefficient of Concordance (Siegel 1956, p.229-238) yields a significance level of .01.

<u>SUMMARY: SECTION A3/C2</u>

The prediction that dual-coding strategy availability is associated positively with results in the performance measures is supported from the evidence of Tables 52-55.

CHAPTER SEVEN

A note of criticism of the research

The conclusions in the following chapter are presented in the context of this criticism of the research and are subject to limitations now discussed under the following headings: theory and statement of the problems, research design procedures, measurement and analyses.

Theory and statement of the problems

The fundamental difficulty of the research is that it seeks to bring together into an experimental survey, some of the results from a highly complex pattern of previous psychological researches, with the objective of forming a basis for a functional development of curriculum. In undertaking what is a molar rather than a molecular approach, and in making that approach from a standpoint that is between that of psychologist and educationist, the research begins from a position that is conceptually and experimentally elusive.

Yet the need to attempt to create such a cumulative approach is supported by an argument by Baddeley (1976, pp.371-377) who refers to a disquiet with cognitive psychology that may be based on a phenomenon - driven psychology that is:

> 'currently concerned with generating and exploring relatively isolated phenomena'.

Baddeley offers a view that by undertaking such research, substantial progress has been made, but that in order to ensure that the progress is in the right direction, concepts and results must be subject to a form of checking that establishes their ecological validity (Brunswik, 1956, in Baddeley 1976, p.374). Thus to decide which of a wealth of newly-discovered phenomena is worth pursuing is

'to ask oneself whether it is likely to survive outside the sheltered world of the psychological laboratory' (1976, p.375).

It can be argued that this research can be justified if it leads to some more parsimonious educational development that improves the thinking of children. In acting as a form of checking of ecological validity, however, a price must be paid in terms of a reversion to a weak theoretical position.

The theory is weak in two respects.

In the first place there is little guidance from the research literature about likely links, or disparities between recall imagery as measured by a strength of imagery recall test, and dynamic imagery as measured by a form of mental manipulation test, although Richardson (1969) has argued that recall imagery ability forms a 'base line' for those of imagery that is more functional.

In the second place there is little integrating guidance from the research literature than can justify the hypotheses of Section A1, about the differential usage of representational processes in respect of sex, or developmental differences in terms of the age limits under investigation. But the theoretical weaknesses here, caused by inadequate prior evidence, as opposed to methodological weaknesses which will be referred to later, may themselves be the justification for inspecting and examining the incidences of representational processes used by boys and girls, especially at the age groups investigated, where changes and differences may be manifest. Weak theory in this sense is a non-pejorative term.

Rather more support has been demonstrated in the review of literature for the theoretical basis of Section A2/B2 in which the representational strategies are compared separately with the abilities which form the ability measures. Yet in terms of one of the major objectives of the research; to establish a basis from which curriculum experiments might proceed, the theory of Section A2/B2 simply proposes a framework supportive of previous research, and adds only a little to knowledge of relationships between representational strategies and the ability criteria: perceptual ability, reading ability, etc. Nevertheless, the results appear to give effective support to previous work.

However, it is in the third Section A3/C2 that the research endeavours to explicate the dual-coding hypothesis in a new experimental form. At the time of considering the theoretical basis for this section, in 1971, the experimenter did not have knowledge of Paivio's work which was about to be published but which was subsequently accepted as corroborative of the Section A3/C2 dual-coding theory.

Research Design

Some criticism can also be made of the complexity of the research design as illustrated in Table 1 , p. 78 By attempting to inspect three different areas of research proposition within the compass of this level of research, the whole is made weaker than if a more rigorous attempt had been made to inspect one of the areas.

On the other hand, the starting point of the research design comes from the a priori hypotheses proposed in respect of Section A3/C2 which necessitated the gathering of evidence of a type, and from an age group, that is rarely accessible. Accordingly, the information likely to be so gathered was considered carefully, together with available research literature in order to propose the further hypotheses of Section A1 and A2/B2. By this means some rarely available information was more extensively examined, and it is suggested, justifies the complexity of the research design.

The first reported sections, A1 and A2/B2 should therefore be seen as subsidiary to, and additional to, Section A3/C2, the main area of the research.

The research design has certain other limitations which need to be made specific.

Firstly, an assumption of the study is that previous research into visual and verbal processes can, in fact, be integrated into a form that will enable evidence to be established that will justify further predictions in respect of educational programmes to be established using as a background, the dual-coding hypothesis.

Secondly, the evidence obtained, in view of the weakness of theoretical argument and methodological approach, means that conclusions are only presented in a guarded and tentative form.

Thirdly, some difficulty has been experienced in adequately defining the special terms employed in the study; the glossary is an attempt to meet this difficulty; but where special terms are used it is always a matter of question as to whether the semantics involved are descriptive enough to sensitise the reader to the experimenter's intention.

Fourthly, the sampling method used, opportunity samples from one school, despite the fact that the comprehensive school year group populations are each composed of a wide spread of ability, means that in the strictest sense, the results are only to be seen as applicable to those samples in that one school. Further generalisation to the whole population can only be made in a tenuous way. On the other hand, the results obtained with the sample might be used with some justification to generate proposals for further research with a better sampling frame. In this sense, the opportunity sample used, especially in view of its size and ability spread relative to the whole population, may reasonably be considered to be a substantial study in its own right.

Fifthly, no replication could be attempted. However, it is observed that some of the results, particularly those in respect of performances compared between the High Visual/High Verbal Group and the Low Visual/Low Verbal group in the performance measures, are highly supportive of results obtained in the Lancaster Research Project, 1969 (Appendix D).

A sixth area of weakness is in respect of comparisons made in Section A3/C2 between the four dual-coding groups and the performance measures. The research design at this point establishes the dual-coding groups on the basis of the visual/verbal questionnaire applied to a spatial visual test and then compares the groups derived from results on this test on the performance measures. The assumption is made that strategies used in the solving of the spatial/visual problem are carried over and used in a similar way in the ability tests of ability, creativity and personality.

Such an assumption may not be tenable. On the other hand, it can be argued that by the time the subjects reach the operational problem, problem five in the test (P/W Spatial Visualisation Test, Appendix A), they will have thought through enough problems to have arrived at some position of mental set which utilises the thinking strategies with which they are most comfortable.

An alternative approach which would relate the visual/verbal questionnaire to an item or items from one of the tests in each of the main areas of the ability measures, was considered. This approach, although having the advantage of relating each representational strategy measurement, directly to the content of the test used, was rejected.

This decision was based on two arguments:

1. Repeated exposure to the test questionnaire would itself influence the style of response. This problem has been commented on by Sutherland (p.150, 1971), who raises fundamental issues of re-test variation that may not be attributable to underlying differences in thinking ability but to interpretation differences connected with test semantics.

2. The same test techniques to measure the representational strategies had been used in the Lancaster research (1969). By using them with a different research problem, basis for comparing results between this project and the Lancaster project would exist.

Procedures

Notwithstanding these arguments, the measures of representational processes are themselves weak. So also are the creativity test measures which lack evidence of validity and reliability, are difficult to score objectively, depend on the motivation and mental set of the subjects, and are subject to time constraints that may not be conducive to creative behaviour.

Criticism may also be made of the use of short-scale tests from the H.S.P.Q. as measures of intelligence, self-sufficiency and self-concept. However, the tests do give some reasonable indication of the constructs that they represent. In the practical circumstances of the project, which has been entirely self-financed, and is limited to that extent, a decision to use the tests was made in the understanding that research conclusions would be interpreted bearing in mind the test weaknesses.

Measurement and analyses

Both non-parametric and parametric analyses are made in Section A1; but parametric analyses only, in sections A2/B2 and A3/C2. The tests used are all assumed to be of interval scale except the P/W Visual/Verbal Questionnaire which is ordinal. This scale is the subject of both parametric and non-parametric analyses. Authority for this practice of using ordinal measurement in parametric analysis is taken from Abelson and Tukey* (1959), who argue that:

> 'the proper assignment of numeric values to the categories of an ordered metric scale will allow it to be treated as though it measured at the interval level'.

and from Laboritz* (1970), who says:

> 'Although some small error may accompany the treatment of ordinal variables as interval, this is offset by the use of more powerful, more sensitive, better developed and more clearly interpretable statistics with known sampling error'. (*in Nie et al, S.P.S.S., 1975, p.6).

In view of the criticisms made, therefore, the research conclusions which follow are presented, and to be interpreted, with caution.

CHAPTER EIGHT

Conclusions, discussion, and implications for education

Although the research has been subjected to severe criticisms in the preceding chapter, conclusions may be usefully drawn from it, and these are made under the following headings, taking the main research area first:-

1. Conclusions from Section A3/C2.
2. Conclusions from Section A2/B2.
3. Conclusions from Section A1.
4. Discussion of conclusions in the context of other literature.
5. Educational implications.

CONCLUSIONS : SECTION A3/C2

Dual-coding processes and performance measures

Results from this section indicate that in respect of this research population, support can be demonstrated for the major research hypothesis of the existence of a hierarchy of dual-coding strategies:

> the best performances on the ability measures, being registered by those children who use both visual and verbal strategies in problem-solving; the poorest performances being registered by children who appear not to use visual or verbal strategies; and intermediate performances being registered by children who appear to use a predominance of one of the strategies only; either verbal or visual.

This support is derived from three sources:-

1. Evidence from the individual comparisons of performances made by the four dual-coding groups and reported in Tables 38-50, and in the statements of results.

2. Summary evidence from Tables 52-55, and in the statements of results on pages 164/5 , which compare the number of directional predictions supported with the number of directional predictions made. It should be noted that this evidence is not based on an overall pattern of rejections of null hypotheses by statistically significant results, which would have been preferred, but on overall patterns of arithmetical results in a predicted direction tested by single statistical tests.

Nevertheless, the results of these analyses are interesting in terms of their support for the major research hypotheses, numbered 7A, 7B, 7C, and can be summarised as follows:

The major research hypothesis, investigated by comparing four dual-coding groups on performance on thirteen variables, yielded 69 directional predictions, of which 57 were supported (.01).

In more detail the results demonstrate that:-

a. The High Visual/High Verbal Strategy group performed better than all other groups on all variables to the extent that 32 out of 39 directional predictions were supported (.001).

b. The High Visual/Low Verbal Strategy group and the Low Visual/High Verbal Strategy group performed less well than the High Visual/High Verbal Strategy group but better than the Low Visual/Low Verbal Strategy group on all variables to the extent that 41 out of 52 directional predictions were supported (.001).

3. Some confirmatory evidence is drawn from Tables 56 and 57 and from the statements of results on pages 165/6 . In these analyses, rank orders achieved by the four dual-coding groups on seven variables; perceptual ability, field independence, reading*, creativity*, intelligence, self-sufficiency and self-concept, were compared with rank orders predicted in terms of the research theory.

In four of the variables, perceptual ability, field independence,

*Composite variables

reading* and intelligence, the rank orders were completely as predicted. In creativity, the ranks predicted for the High Visual/High Verbal group and the Low Visual/High Verbal group, were reversed, other ranks being as predicted. Rank orders for self-sufficiency and self-concept were not as predicted, and the research hypotheses are, therefore, not supported. Nevertheless a statistical test of all ranks predicted, by actual rank achieved, indicates support for the major research hypothesis (.01), as defined by 7A, 7B, 7C p 164 with the exception of results relating to the personality measures: self-sufficiency and self-concept.

Support is not evident for research hypotheses 7D and 7E, which sought to establish relative positions between the two intermediate strategy groups, by predicting that:

7D The High Visual/Low Verbal group would perform better than the Low Visual/High Verbal group on tests with a high perceptual content, and:

7E The Low Visual/High Verbal group would perform better than the High Visual/Low Verbal group on tests with a high verbal content.

Table 58 reveals that these predictions are not supported statistically, although Table 51 (lines U and V) indicates that of eight directional predictions associated with hypotheses 7D and 7E, six are in the direction predicted arithmetically. Research hypotheses 7D and 7E are not, therefore, supported.

*Composite variables

The results of section A3/C2, although not directly comparable with those of the Lancaster Project (1969) since the performance variables are different, are supportive of it. From that project, the results indicated that a High Visual/High Verbal Strategy group performed significantly better than a Low Visual/ Low Verbal Strategy group on a verbal test (.05, Morrisby Verbal Ability Test), and on a perceptual test (.01, Morrisby Shapes Test). In the test of spatial intelligence the result was in the direction predicted but failed to reach significance (.01 Raven's Matrices Test).

Results from the Lancaster Project had also indicated that the Low Visual/Low Verbal group were over-represented in the Low ability groups and under-represented in the High ability groups derived from the three standardised tests. Results in the current project (Tables 38-50), extend that conclusion to suggest that inadequate use of either of the dual-coding strategies is an indicator of a potentially weaker thinking ability than use of both.

Omission of use of either of the dual-coding strategies, therefore, seems to be an indicator of a functional weakness in terms of the performance measures used. This should have educational implications which will be discussed.

The empirical data, however, does not allow for comparative differential conclusions to be drawn in respect of the two intermediate strategy groups, High Visual/Low Verbal and Low Visual/High Verbal. Extrapolating, since it appears that little difference exists between them in terms of performance on the ability measures, it may be that some form of compensatory functioning is occurring which enables the -

subject to manage with a low incidence of use of one strategy, by depending on the other, although by doing so the subject is unlikely to do as well as the subject who has both strategies at his disposal. This might be the subject of further conjecture that children who score low on ability tests, do so because of lack of dual-coding strategies. Causality cannot firmly be claimed, however, and it may be that interventionist educational activity in a controlled experiment is the only way of demonstrating that a causal pattern may exist, and that benefit could, indeed, accrue from an educational programme designed to stimulate children's awareness and use of the dual-coding strategies. However, this supposition can only be tested by establishing an experimental programme.

Conclusions: Section A2/B2

Representational strategies taken separately with performance measures; ability, creativity, personality.

Recall Imagery

The results of section A2/B2 indicated that performance in the test of recall imagery correlates positively and significantly with the following measures:

Boys: perceptual ability, field independence, reading ability, intelligence, self-sufficiency, self-concept, applied imagery and covert verbalising.

Girls: field independence, reading ability, intelligence, self-sufficiency, self-concept, applied imagery and covert verbalising.

Significant correlations were not observed with measures of the following:

Boys and Girls: creativity

Girls only: perception

Conclusions to be drawn from these observations are that those second and third year children in the research population who possess a well-developed ability to recall images, as assessed by a vividness of imagery questionnaire, also tend to perform well in the ability measures, with the exception of the creativity tests, for both boys and girls, and of the perceptual ability test for girls. This does not indicate that causal factors are involved, or even that ability in recall imagery is a necessary basis for ability in the other measures, but the results are interesting in several ways.

In the first case, the research literature of recall imagery is ambivalent with regard to imagery's relationships with abilities such as those tested by the ability measures. For example, Sutherland (1971, p.150) has raised questions about creativity tests, qualifying her doubts about the relationship of these tests to levels of imaginative thought by questioning the semantic context of words used in the instructions of the test, the emotional context of the testing, and also by arguing that an element of selectivity, referent to responses worth communicating, might even be operating to influence the numbers of responses made in creativity tests. Encapsulated in these questions is the problem:

'What do we mean by imagination?'

and here it seems that Sutherland is referring to a wider connotation of imagination than the term 'recall imagery' which is used as the basis of this section. Yet to some extent it seems surprising that with the positive correlations established for recall imagery with the other performance measures, the recall imagery/creativity correlation is not supported statistically, and it may be that the lack of such a correlation is in itself some indication of support for Sutherland's view of the importance of semantic interpretation; bearing in mind the strongly verbal characteristics of the creativity tests used in this research, as against the strongly visual characteristic of the Betts Shortform of Imagery Test used to measure recall imagery.

As to the relationship of performance in recall imagery with performance in the other measures of ability, an experiment by Sheehan and Neisser, 1969 (in Sheehan, 1972, pp.153/4) has already produced some evidence that imagery functions adaptively in unexpected recall, with the vivid imagers producing significantly better performances in the unexpected recall of task material. However, this evidence is probably more relevant to a simple function of memory than to the manipulation and controlability of images function that seems to be available for use by high performers in tests such as the Field Independence Test. The problem now raised seems to be one of needing to discover more about the facilitating effect of imagery in the performance of such tests, by different individuals, and to investigate further suggestions that interference effects involving imagery do occur from some items (Bulgelski, 1968, in Paivio, 1971, p.336). A paper by Paivio (in Sheehan, 1972, pp.260-262) has also drawn attention to the difficulties of establishing operational definitions of vividness of recall, independently of memory performance. As Paivio says:

> 'It is difficult to see how different memory modalities could be scaled on vividness in such a way that cross-modal comparisons of relative effectiveness would be possible'.

Such a problem may be a real one for the psychologist, but in our present understanding of cognitive functioning it may not yet be a necessary one for the educator.

Baddeley's viewpoint (1976, p.372) is that in research in cognitive psychology, 'current levels of aspiration are unrealistically high'. The educationist's corollorary ot this may be that teachers are not yet, to any substantial degree, attempting to incorporate such advances in cognitive psychology, that have been made, as a basis for curricular advance. The development of experimental intervention strategies based on cognitive advances should perhaps have more priority.

The intention of this part of this research was to attempt to discover if vividness of recall imagery correlated with high performance on a series of standard measures. That such correlations were found for the research population used, although not indicating causality, does provide an argument for endeavouring to discover if causality does exist, perhaps by mounting a controlled research programme of recall imagery training and measuring effects over time on results in tests of ability.

Applied Imagery

The topic of controllability of images itself raises fundamental questions, and Richardson (in Sheehan, 1972, pp. 126/7) has suggested that measurement of imagery control cannot be made without reference to imagery vividness. Richardson suggests that:

> 'for any measure of imagery control, baseline studies are required to examine test-retest reliabilities for controllability at each of, for example, the quantities of imagery vividness'.

His prediction is that 'reliability co-efficients for control should increase in magnitude for each increase in the level of imagery vividness'.

This may be so. On the other hand an argument that awareness of the possibility of controlling imagery, deriving from the first test measurement, may alter the measures in a re-test of that control strategy, thus affecting the possibility of establishing Richardson's hypothesis. Indeed, if control of imagery could be used as the stimulus to educational improvement, this might negate Richardson's hypothesis which tends to suggest that control of imagery is a fixed characteristic.

The results of section A2/B2 in this research indicate that results in the test of applied imagery correlated positively and significantly with the following measures:

Boys: covert verbalising, field independence, reading ability, intelligence, self-sufficiency.

Girls: covert verbalising, field independence, reading ability, creativity, self-sufficiency, self-concept.

The results are interpreted tentatively and attention is drawn cautiously to three issues:

1. For boys and for girls, performance in applied imagery correlates with covert verbalising. This could be taken as further support for the suggestions in section A3/C2 which indicated the existence of a hierarchy of dual-coding strategies, associated with performance in the ability measures.

2. The correlation of applied imagery:
   a) for boys, with intelligence (problem-solving?)
   b) for girls, with creativity but not intelligence.

It is not easy to see how one might interpret this. A surface interpretation might suggest that boys may indeed be using an applied imagery strategy in problem-solving, whereas girls use an applied imagery strategy in creativity tests. Such an interpretation, however, might conceal a range of possibilities that underlie the result. For example, the extent to which creativity and intelligence lack correlation at these age groups may be a factor. Or as Barron (in Sutherland, 1974, p.174) has suggested (previously quoted, p. 56), motivational and stylistic variables are major determinances of creativity.

It seems reasonable to categorise an applied imagery strategy as a stylistic cognitive variable, but in view of the apparent difference between boys and girls, registered in terms of correlation of applied imagery strategy and intelligence on the one hand, and applied imagery and creativity on the other hand, motivational factors may be playing a larger part, boys and girls preferring different test types.

However, this is speculative, since no evidence of motivational factors associated with the taking of the tests was gathered. With hindsight, this is regretted, since an opportunity to investigate motivational factors relating to the use of representational strategies has been missed.

3. Applied imagery correlates significantly with self-concept for girls, but not for boys.

A similar pattern of correlation was established in respect of the covert verbalising strategy, which correlated significantly with self-concept for girls but not for boys.

Conceivably these correlations may simply be reflecting the difference in maturity for girls and boys, aged thirteen and fourteen.

Covert Verbalising

The results of section A2/B2 also indicated that performance in a test of covert verbalising correlates positively and significantly with:

Boys: field independence, self-sufficiency

Girls: field independence, reading ability, self-sufficiency, and self-concept.

The correlations with field independence for both boys and girls are interesting, and taken together with similar correlations for recall imagery and applied imagery, might be interpreted as indicating that cognitive independence is related to effective use of representational strategies. However, in a non-supportive result in section A3/C2, self-sufficiency and self-concept were not shown to be related to dual-coding group performance. Yet, taking the positive evidence of correlation for both boys and girls, of self-sufficiency with recall imagery, applied imagery, and covert verbalising, a pattern begins to emerge of field independence and self-sufficiency, linked to the possession of a facility to use representational strategies.

Moreover, in view of the absence of correlations between covert verbalising and the other abilities tested, an assumption might be made that at these age levels, the visual thinking strategies are still being used substantially. It may follow that an inner speech facility is not as well developed at these age levels as subsequently.

The Lancaster Project, undertaken with children of fourteen years of age did indicate that at that age verbal strategies were beginning to predominate. This speculation, however, needs to be the subject of further investigation with wider age ranges and bigger samples.

Conclusions: Section A1

Within-sex by age, and between sex comparisons of representational strategies used

The results from this section were less firm than those from the other sections, but the following tentative conclusions can be made in respect of the research population and the research hypotheses stated.

Research hypothesis One proposed that the use of visual strategies declines, and the use of verbal strategies increases with increase of age from eleven to thirteen years. For boys, the results support this hypothesis for all three strategies: recall imagery, applied imagery and covert verbalising.

The hypothesis, however, is not supported for girls in any of the three strategies examined. In fact a reverse hypothesis might be more justified in respect of recall imagery, in which older girls scored higher than younger girls, although it should be noted that a (.05) significance level was only achieved for the comparison in which third year girls scored more than second year girls in vividness of imagery. Similarly, in each comparison made, comparing older girls with younger girls, the older girls registered less in covert verbalising.

Yet for applied imagery, between age comparisons are in the direction predicted, but at non-significant levels.

The result is interesting but it points up the difficulty, previously expressed, of drawing inferences from cross-modal comparisons. Several explanations of this pattern of strategy change with age are possible. One explanation might be that the hypothetical position of visual strategies giving way to verbal strategies is, in fact, correct only for boys of this age, and not for girls of this age. More evidence than is provided here would be needed to substantiate such a statement, however. An alternative explanation might be that girls of 11 to 13 years, having already moved ahead of boys verbally, are using this period of time to extend visual strategies (while boys are extending their verbal strategies): a balancing up of strategies for boys and for girls. More evidence of strategies used is needed, however, before any but the most speculative conclusions can be drawn.

Research Hypothesis Two suggested that representational strategy differences between boys and girls might exist within age groups on recall imagery; but except for the previous paragraph which involves within-sex developmental differences, and not direct between sex comparisons, the research hypothesis is not substantiated.

Research Hypothesis Three predicted that girls would use verbal strategies more than boys at each age level, and that boys would use visual strategies more than girls at each age level. This hypothesis is not substantiated, either.

At first sight these results appear to contradict those of Research Hypothesis One. However, this need not be the case, since it must be accepted that the tests are weak, and may be discriminating inadequately. In consequence it could be argued that any between-sex differences which might exist in respect of representational strategies, within age groups, would be likely to be of a smaller order of magnitude than, for example, the differential expressed for boys between the ages of 11 and 13. If this is so, then the maturing factor, and its effect on use of strategies may be greater than any conceivable between-sex differences in the use of representational strategies. If such an assumption is well founded then it would be reasonable to conclude that further investigation of between-sex differences in the use of representational strategies may not be worthwhile.

Developmental factors in respect of representational strategies, operating within each sex might well be worth further investigation, however, especially if one extrapolates to suggesting that educational and, or, environmental influences may be operating to influence children in the extent to which they choose to make use of the strategies available to them.

Discussion of conclusions in the context of other literature

The conclusions from the tests used with this research population can be summarised briefly as:

1. For boys, the use of visual strategies declines, and of verbal strategies increases, from age eleven to thirteen.

2. These changes of strategy are not demonstrated for girls and arithmetical trends appear to show the reverse. A possible cause for the differences may be a 'balancing up' of visual and verbal strategies used by boys and girls due to factors of difference in maturity.

3. The use of 'recall imagery' correlates positively and significantly with abilities as follows:

   <u>Boys</u>: perception, field independence, reading ability, intelligence, self-sufficiency, self-concept, applied imagery, covert verbalising.

   <u>Girls</u>: field independence, reading ability, intelligence, self-sufficiency, self-concept, applied imagery, covert verbalising.

4. The use of 'applied' imagery correlates positively and significantly with abilities as follows:

   <u>Boys</u>: covert verbalising, field independence, reading ability, intelligence, self-sufficiency.

   <u>Girls</u>: covert verbalising, field independence, reading ability, creativity, self-sufficiency, self-concept.

5. The use of covert verbalising correlates positively and significantly with abilities as follows:

   <u>Boys</u>: field independence, self-sufficiency

   <u>Girls</u>: field independence, reading ability, self-sufficiency, self-concept.

6. A hierarchy of use of dual-coding strategies exists in which

   a. the best performances in ability, creativity, and personality tests are registered by children who claim high use of both visual and covert verbal strategies.

   b. intermediate performances in ability, creativity and personality tests are registered by children who claim high use of one of the strategies, visual or covert verbal.

   c. the lowest performances in ability, creativity and personality tests are registered by children who claim low use of both visual and covert verbal strategies.

This research was not designed as a replication of the 1969 Lancaster Project, but the results complement those of that project in several important respects, especially with regard to conclusion six.

The 1969 project had concluded that in respect of the different strategies used for:

Recall imagery The High Imagery Group (Betts) was under-represented in the Low Ability group, rather than over-represented in the High Ability Group, whereas the Low Imagery group was under-represented in the High Ability group rather than over-represented in the Low Ability group,

and that for:

Dual-coding strategies The High Visual/Verbal Group was under-represented in the Low Ability group and over-represented in the High Ability group, whereas the Low Visual/Verbal group was over-represented in the Low Ability group and under-represented in the High Ability group.

Although these patterns of representation have not been investigated in the same way in the current research, it seems possible now that considering conclusion six, and at least in respect of the research population used:

1. The use of multiple representational strategies appears to be significantly associated with performance as defined in the tests, and it may be important to ensure that children have a range of strategy-combinations at their disposal.

   Recent researches in the field of information-processing are strongly supportive of this conclusion. Posner (in Chase, 1973, p.35) indicates that the efficiency of solving a problem may be critically dependent upon the form of representation used. He quotes Brooks (1968) and Snyder (1972), who have suggested that the manipulation of spatial representational strategies for spatial tasks, and verbal strategies for verbal tasks, are advantageous in problem-solving. This might seem self-evident, but the question that is not answered by such a statement is that although the use of such strategies independently of each other may appear to be demonstrable, experimentally, and appear to be associated with successful performance, is multiple code use more effective? Posner's paper (in Chase 1973, p.66) evades the point and his conclusion simply appears to 'support the reality of multiple codes'.

The evidence from this research points towards an answer to the question by indicating that availability of differential of combinations of multiple code strategies appears to be associated with success. If this is so, there seems to be a case for establishing educational programmes which would lead children to inspect and develop their primary thinking strategies, and to encourage children to more flexibility between the strategies, in problem solving.

2. Competence in Recall Imagery is associated with success in the performance measures; perhaps as a 'base-line' strategy (in Richardson's sense of the term).

Such a viewpoint can only be held with reservation, for it may be that inappropriate use of recall imagery can inhibit problem-solving by creating interference and redundancy effects. Furthermore, Sheehan (1972, p.319) has referred to

> 'the partial or almost complete disappearance of imagery as individuals mature in our society'

and suggests, as does Richardson (1969, p.40 and p.134) that the reason for imagery having less and less survival value is that

> 'language is usually more important than imagery'.

It may be that in a highly verbal environment, imagery ability atrophies through lack of use, but if this is so, for maturer members of society, it may be that the loss of this facility is to some extent, an unrecognized impediment, if one accepts with Paivio (1971, p.34), the efficiency of imagery's parallel-processing capability, or that imagery is a major psychological correlate of deep structure of relatively concrete sentences (1971, p.439).

Here again one must ask what Paivio is meaning by the word 'imagery' in that context. It can be assumed that he is referring to imagery-concreteness as defining intensity of denotative meaning (as in 1971, p.84), leaving 'the major portion of connotative meaning' to semantic factors.

Piaget (1971, pp. 382/3) also refers to the function of the image as being 'to designate, not to interpret'. However Piaget modifies this position to some extent by indicating that images may have an <u>interpretative</u> role in those cases where they <u>schematize rather than copy directly</u> (author's underlines). In this instance the image may be 'incorporating its own stylization, as words do'.

3. <u>If this is the case, then 'applied' imagery in the sense in which it is used in this thesis is probably a more important cognitive style variable than recall imagery, and is a development from it.</u>

Certainly there is strong supportive evidence from Cooper and Shepherd, of the existence of a capability, for example, for mentally rotating spatial objects (in Chase, 1973, p.170). As Cooper and Shepherd suggest, such an ability may be significantly important in various activities: at an elementary level, in rearranging furniture or fitting together variously shaped pieces of a machine; and at a more complex level, working out more creative solutions to problems with a spatial component in geometry, or electrical engineering.

Transformation strategies other than the rotation of mental images are also available; reflection, dilation, reduction, and plastic transformations such as stretching, bending and folding. There may also be other examples of applied imagery process and use, for which words are inadequate substitutes, but which have application in topology or modelling. An example of the power of insightful integrating imagery with a significant result in molecular biology is Watson's 'seeing' the spiral constitution of D.N.A. (1968). At a different level, Cooper and Shepherd also draw attention to evidence of marked improvement in motor skills as a result of purely mental practice, citing Rawlings, Rawlings, Chen and Yilk (1972), Richardson (1969) (in Chase 1972, p.76).

To what extent Watson's insight can be explained by the application of imagery is, of course, arguable since that particular imaginal event was obviously built on a sub-structure of long-term memory. Information-processing psychology would argue, however, that we need to know more of the way in which 'knowing how' develops, and can be used. In Simon's terms (in Farnham-Diggory, 1972, p.11) this means discovering more about 'programmes', 'strategies', 'rules, rituals and tricks of the trade'. Similarly, educators need to know more about the possibilities, problems and results of developing such 'programmes' and 'strategies', or whether educational intervention programmes can in fact be evolved which will influence directly, the primary cognitive strategies that children use. Indeed an undercurrent which often seems present in the literature of imaginal and verbal processes is some suggestion of permanence or near-permanence of thinking styles. Hence the frequency of categorization of people into visualisers and non-visualisers (Richardson, 1969 p.132), or 'literal' and 'schematic' perceivers (Sutcliffe, in Richardson, 1969, p.134).

That this research has also categorised the subjects into dual-coding groups is not, however, to defend a position of permanence of cognitive thinking style, but to establish some base lines from which educational development might proceed; an expectation of the possibility, change and development of primary cognitive styles.

4. <u>The relationship of imagery, covert verbalising, and reading</u>

The results of this research support the existence of relationships between imagery and covert verbalising on the one hand, and verbal ability, as defined by the reading tests on the other hand. This may not be new in general terms; Paivio (1971, p.434), for example, has referred to the strength of the dual-coding approach in that it specifies a distinct functional role for non-verbal imagery in the understanding and production of language. He has also commented, not only on the relative distinctions between the transformational characteristics of imaginal thought, a parallel process; but the capacity for verbal systems to deal with abstract problems, sequentially: the two systems functioning interactively. However, the evidence of this research with children of thirteen and fourteen is supportive of that theoretical position and is new in respect of the age-groups concerned. Moreover, Paivio's theoretical assumption (1971, pp. 434/5) that verbal behaviour, mediated by imagery, is likely to be more flexible and creative than that mediated by the verbal symbolic system, may find support from the model of interdependence between structures and processes argued by Inhelder (in Farnham-Diggory, 1972, p.114) under the heading of 'compensation'. If such a concept is applicable to the dual-coding hypothesis then this would go some way to explaining why the High Visual/Low Verbal groups and the Low Visual/High Verbal group jointly occupy the middle ground in the ability measures.

In arguing the interactive nature of the dual-coding process, Paivio (1971, p.437) states that 'linguistic competence and performance are dependent upon a substrate of imagery'. The relative performances of the dual-coding groups defined in this research, on measures of reading, while not explanatory of Paivio's theoretical position, may be, to some extent, confirmatory of it.

5. High level combinations of the dual-coding strategies are associated with success in the performance measures and low-level combinations of the dual-coding strategies are associated with lack of success in the performance measures.

What then are the educational implications of this statement?

If omission of use of representational strategies is a significant occurrence in the low-scoring ability groups, a strong case can be made for the development of an experimental curriculum in which direct attempts are made to sensitise children, especially low-ability children, to primary strategies that are available, to help them develop such strategies further, and to encourage them to use the strategies in a flexible way, moving between strategies as the circumstance demands.

The dual-coding hypothesis states that high imagery conditions are effective in learning and memory because they increase the probability that both visual and verbal processes will play a part in item retrieval. The suggestion is parsimonious in explaining the superiority of, for example, pictures over concrete words, and of concrete words over abstract words in memory tasks (Sheehan, 1972, p.263).

The support that the dual-coding hypothesis has received from numerous researchers, including the work of Bahrick and Boucher (1968), Kurtz and Hoveland (1953), Wilgosh (1970), and Paivio and Csapo (1969) is supplemented by the results of this research.

The possible usefulness of the dual-coding hypothesis as a basis for experimental curriculum development may therefore be proposed. Attempts should be made to devise more direct intervention strategies for the development of primary thinking strategies.

A major aim in this research was stated in Chapter One, to begin to produce evidence about children's thinking in a way that will lead to functional applications of psychological research results by teachers. An argument for a new approach to children's thinking, to be incorporated into an experimental curriculum can therefore be presented. A difficulty foreseen here is the need to overcome possible scepticism about the experimental use and development of dual-coding strategies in an educational context.

It is hoped that this research will have moved towards overcoming that scepticism to the extent that educational experiment concerning primary thinking strategies is seen to be worth attempting. The judgement to be made now, however, is one of educational policy rather than of investigating a scientific question.

In the first instance, this could take the form of instituting small-scale experimental programmes in which teachers could be involved, through in-service courses and workshops, in developing educational activities based on devising applications of the dual-coding hypothesis, to stimulate children's imaginal and covert verbal processes. Such workshops might need to start from an objective examination of the research literature; to provide a theoretical background to the development of practical activities which should follow.

Hagan (in Farnham-Diggory 1972, p.76) has already called for care in devising such programmes, pointing out, for example, that merely associating verbal labels with visual processes, or creating strings of imaginal labels should only be the precursor to a mnemonic mediation which, in Flavell's terms (1970, p.208, in Farnham-Diggory 1972, p.77) operates as 'a planful, instrumental, cognitive act'. Implicit in this is the need to act further for the identification of attention strategies, verbalising and imagery strategies, mnemonic strategies and plans.

De Bono (1976) working from a different set of hypotheses directed at establishing the improvement of children's thinking as a skill, has already demonstrated that teachers can be interested in an unusual, and possibly for some, an esoteric approach to children's thinking development:

> '.... always surprised how easy it is to convince teachers that there is value to be gained in doing this work' (de Bono, 1976, p.141).

Some of de Bono's precepts could be utilised in work aimed at developing the primary thinking strategies of 'recall' and 'applied' imagery and covert verbalising. For example, the importance of letting children know the possible benefits of a different style of approach, 'Destinations direct attention' (1976, p.124). The importance of an appropriate attitude to a development run as 'Let's see how we can <u>make</u> this work' (1976, p.152) as opposed to a trial run in which the issue is doubted. And yet again, 'The objective is to develop transferable skill by <u>conscious</u> practice of the process'.

Richardson (1969, p.181) has pointed out that individuals differ in their conscious control of imagining, so some form of individual monitoring would be necessary.

Lastly, a strong need is to focus on ways of ensuring that children feel that they are doing well, even in situations where there are no right or wrong answers; using achievement as a motivating force. In this way, the emotional aspects of imagery and verbalising which constitute major attributes of imagination, but which are so frequently left out of test activity (Sutherland 1971, p.153) should be included in an educational programme by more specifically involving the children in understanding and developing their own primary thinking strategies.

This thesis concludes that attempts should be made to attain such an objective. Project Three in the next chapter suggests a possible way of proceeding towards this objective.

CHAPTER NINE

Suggestions for Further Research

SUGGESTIONS FOR FURTHER RESEARCH

From consideration of the conclusions of this research and from other researches, three main options appear to exist as a follow-up to this project.

1. No further action.
2. Further psychological research which is experimentally more precise, using the hierarchy of strategies conclusion as a basis for further questions and hypotheses.
3. Experimental Curriculum Development in the use of primary coding processes.

No evidence can be discerned from this research project, or from the research literature that the first alternative, to abandon this line of research, should be preferred. Indeed, if a function of the educationalist is to investigate how children might improve their cognitive functioning then this alternative is a non sequitur and is rejected.

A more difficult problem is to decide whether priority should be given to the second alternative, further and experimentally more precise psychological research; or to the third alternative, experimental curriculum development, in order to attempt to improve children's acquisition and use of primary coding processes.

To arrive at a resolution of the problem, criteria for judging the alternative must be stated. On the one hand, further more precise psychological experiments may be of considerable value in adding to the weight of psychological literature so supporting our understanding of cognitive processes. Such experiments must, however, of their nature, if they are to be more precise, tend to focus on small facets of human behaviour, with a resulting problem in integrating the knowledge so derived into a coherent theoretical and practical framework that will actually be to the benefit of children. This is not to argue that no benefit will accrue. To improve our insights into human functioning is clearly of importance.

The second course of action is valid and two specific outline proposals for further investigation are included in this chapter:

Project 1 Sex Differences in Visual or Verbal analysis over different age groups

Project 2 Categorising from words and pictures

On the other hand, the development of an experimental curriculum which aims directly to improve children's use of coding strategies may also be of importance.

A balance of judgement which leads to the advocacy of the third course of action as a priority must also include, albeit at a subjective level, some judgement of its likelihood of success. This must be so, since curriculum development involves intervention in children's learning, and it is important to have reasonable confidence, preferably based on contributory evidence, in the successful outcome of an experimental curriculum project before embarking on it. Not to have such confidence could be irresponsible, in terms of the effect on the children.

Yet at some time we need to tackle the difficulty of closing the gap between psychological theories of learning and educational action. The area of covert coding processes is perhaps especially difficult in this context. Yet the result of even a small improvement for each individual might be important, taking the population as a whole.

Some ideas for a specific curriculum development project are therefore also proposed as:

<u>Project 3</u> <u>An experimental Curriculum Development Project in the use of primary thinking processes</u>.

The three projects are presented in numerical order.

<u>PSYCHOLOGICAL RESEARCH: PROJECTS 1 AND 2</u>

The results from section A3/C2 appear to support the view that a hierarchy of dual-coding strategies may exist which is linked to performance in the measures of ability and creativity. No evidence from this research is identified which supports the view that the utilisation of dual-coding strategies linked to a concomitant relationship with performance, is a sex-related characteristic. Some questions, therefore, still remain for further research.

1. Is a preference for phonological word-mediated encoding, as opposed to visually-mediated word encoding, a sex-related factor, as Coltheart, Hull and Slater suggested (1975)?

2. Is the type of dual-coding process used a more, or less, important factor than the sex factor, in problem-solving, or are the cognitive differences sex-linked, as has been suggested by

Buffery and Gray (1972)?

The second question, involving as it does, interaction effects between different dual-coding strategies and the sex factor is more complex, but may yet be accessible to research.

Two proposals for further research are suggested.

PROJECT 1: SEX DIFFERENCES IN VISUAL OR VERBAL ANALYSIS OVER DIFFERENT AGE GROUPS

If males rely on visual analysis and females on verbal analysis of an apparently visual task as Colheart, Hull and Slater suggested, is this distinction repeated over different age-groups? A move towards answering this question might be made by utilising the research methods used by Coltheart, Hull and Slater with different age groups of children. Their studies at Reading University were with male and female undergraduates. If their researches were replicated with younger groups of children, a case might be made for suggesting that sex-related rather than environmental conditions were influencing the results.

The research hypothesis would be:
Male reliance on visual analysis and female reliance on verbal analysis of an apparently visual task is confirmed and repeated over different age groups.

Research Task

The task to be used might be one derived from that developed by Corcoran (1966). Subjects are asked to scan through a passage of prose, crossing out all occurrences of the letter 'e' and the letter 'h'. If females rely on verbal analysis then females should have more difficulty than males in detecting unpronounced letter 'e's (as in late), and 'h's (as in that).

The subjects are to be given three photographically enlarged pages of an appropriately chosen text and asked to complete the task within a threshold time for each page, with a one minute rest between pages. The criterion measure to be used would be comparison of error rates.

Research Population

Three age groups would be used: ages 10-11, 13-14, 15-16, each age group containing a sample of 10 boys and 10 girls, matched in intelligence. High numbers would be preferred but this would depend on accessibility of a research sample.

Statistics

The statistics to be used would be between group analysis of variance of scores on error rate, and cross-comparisons of mean scores and t-tests utilising one-tailed tests of significance.

PROJECT 2: CATEGORISING FROM WORDS AND PICTURES

Section A3/C3 of this research project has indicated the possible existence of a hierarchy of dual-coding processes, linked to performance in ability measures, which, it may be argued, are themselves linked to the capacity to utilise abstractions. A question arises: is the underlying representation of a concept abstract, or is it derived from its referent word and referent image? In other words, is the concept of 'table' an abstraction of table-like qualities or subject-specific to the perceptual information contained in original enactive or iconic representations?

Some work done by Potter and Faulconer (1975) supports the view that representations associated with categories are more rapidly reached from drawings than from words. Their research with adults, however, was not controlled either for the possibility that subjects may utilise different dual-coding strategies, nor was it controlled for the possibility of sex differences in coding performance.

A research could be designed, using similar methods to the Potter and Faulconer study but controlling for both differences of dual-coding processes and for sex. The questions to be resolved might be defined as follow:

(a) Is categorisation reached more rapidly from pictures or words for boys than for girls?

(b) Does the hierarchy of dual-coding strategies supported in this research, hold good in determining performance in terms of speed of categorisation from pictures and words?

A research design could be proposed which would consist of the following tasks and methods.

Research Task

Thirty coloured line drawings of objects, or their names, would be presented one at a time in a tachistoscope, preceeded and followed by a mask of haphazard lines and pieces of letters, to 'clear' the image.

Group 1

Each subject would see thirty items presented as pictures and thirty items presented as words.

Presentation would be as follows:-

The experimenter would name a category (into which the word or picture items will, or will not fall) before each presentation and a voice response key would be used to measure response time to correct solution from the onset of the item.

Research Population

A population of 13-14 year old children would be tested on the P/W Visual/Verbal Questionnaire in order to establish dual-coding groups as in section A3/C2 of this research, additionally establishing a group of boys and a group of girls for each strategy.

Subjects from each of the dual-coding strategy groups would be assigned to a 'Words' condition or a 'Pictures' condition by random process. In the Words condition, subjects would see items presented as words first and items presented as pictures second. In the 'Pictures' condition this process would be reversed.

The research design therefore would be:

Randomised Blocks Design (2X3X2)

	Group	Words (1)	Group	Pictures (2)
Boys	A1	Hi Vis/Hi Verb	A2	Hi Vis/Hi Verb
	B1	Hi Vis/Low Verb Low Vis/Hi Verb	B2	Hi Vis/Low Verb Low Vis/Hi Verb
	C1	Low Vis/Low Verb	C2	Low Vis/Low Verb
Girls	D1	Hi Vis/Hi Verb	D2	Hi Vis/Hi Verb
	E1	Hi Vis/Low Verb Low Vis/Hi Verb	E2	Hi Vis/Low Verb Low Vis/Hi Verb
	F1	Low Vis/Low Verb	F2	Low Vis/Low Verb

A major problem in undertaking a research of this nature would be in gaining access to the number of subjects that would be required to be tested in order to set up experimental groups of a sufficient size to give validity to the research. A further, associated problem would relate to the substantial testing time that would be required for the research in total. Assuming twelve experimental groups each of fifteen subjects, the estimated testing time would be 135 hours, allowing 45 minutes for each test. This time would, of course, be additional to that required for the testing to establish experimental groups.

Yet, if we are to learn more of the processes that underlie cognitive development, in order to improve the educational means at our disposal, then it must be argued that education officers, and heads of schools, who control the decision-making processes in the schools, must themselves become more convinced of the need to understand more of the cognitive developmental process. But that is another question.

Introduction to Project 3: Proposals for Curriculum Development

From the standpoint of the educationist, the discovery by psychological research of subleties of thinking processes must give way at some time to a more direct approach which seeks to incorporate what we know of the primary coding processes that children use when problem-solving, into a framework which has as a specific objective the improvement of those primary coding processes.

Part of the problem may be that evidence of the existence of the coding processes has been published in psychological journals and books which, all too frequently, do not form a part of the regular reading of many teachers.

A further difficulty is in the nature of the processes themselves. The idea that we should consciously advocate the possibility of improving our visual, imaginal and inner speech processes is, perhaps, threatening to us because we are unsure that the visualising process that we possess is similar to the process that others possess, or even whether or not it may be useful in problem-solving.

Similarly a problem exists about advocating that people should make more use of inner verbal processes. Indeed, there may be something in our culture that suggests that people who 'talk to themselves' are strange in some way, and that verbalising is something to avoid.

Despite the fact that quantity of visual or verbal process has been a criterion of this research, this is not to suggest, of course, that merely extending the quantity of verbalising or visualising will ipso facto, be useful; but it may well be that extending a within-person discussion of visual and verbal strategies when needing to solve a problem, may contribute to a better evaluation of those alternatives and a better consequent choice or decision when there is a problem to solve. These are issues that need to be explored further.

It may be that a programme of deliberate use of covert coding processes may be devised which operates at the levels of both input and output of ideas. If such a programme can be found to improve the articulacy of thought, then it will be justified.

PROJECT 3: An experimental Curriculum Development Project in the use of primary thinking processes: some ideas and possibilities

Aims

The establishment of a project which would aim at encouraging children to inspect and develop the primary, covert visual and verbal processes which they use in problem-solving.

Methods

The teachers in the experimental project would need to be both open-minded about the possible results and value of the project, and objective in working on it. This would clearly be a source of difficulty, and in view of the seemingly esoteric nature of the project could possibly only be achieved in a school or schools which already have teachers with some commitment to experimenting with psychological/educational method.

Furthermore, the type of commitment needed to carry out such a programme in an objective way would only be likely to be achieved through a period of in-service training for the teachers.

The training itself would need to involve the teachers in:-

(a) reading and discussion of literature relevant to the psychological and educational processes under consideration.

(b) The option to be involved or not. The criterion for continuing to be involved would be willingness to defer scepticism or doubt until the project had been carried out and evaluated.

Such a willingness to deliberately suspend judgement is reasonable to expect of professionals and, for example, has been a feature of projects such as that run by Edward de Bono and the Cognitive Research Trust (1976). Indeed the way in which that Trust has developed teacher-involvement in consideration of how children's thinking might be improved might form a useful model of procedure to follow.

(c) It would be wise to involve the teachers in the experiment in the creation of <u>educational material</u> which would form the basis of help to children in the inspection and use of the coding strategies that they use.

Such material might well include the devising of games, or the utilisation of existing games, for the inspection of thought processes used. For example, the game of chess may well contain aspects of visual and verbal operation that could be improved by consideration of the primary coding strategies used in play taken over a period of time. Other material that might be developed could include the making of short films that set a problem and then ask the children to think out some solutions, using a combination of visual and verbal strategies. For example, the paper folding exercises that form part of the P/W Spatial Visualisation Test (Appendix B) might be adapted into a moving form that would ask for some extrapolation of the information given. Another adaptation, perhaps in cartoon form, of the visual imagery problem used by Grey Walter (1968) in which a cube which is painted red on the outside, is cut in half vertically and then the two halves are again cut horizontally; the question for solution being:

'How may unpainted sides have now been formed?'

An attempt to create improvement in the use of visual strategies might be made by:

1. First proposing the problem in its imagery form and seeking an answer.

2. Then presenting a film of the cube being cut, perhaps in slow motion, and again seeking the answer.

3. Then re-presenting a similar problem but using a different shape of block and styles of cut. For example, a pyramid shaped block, the cuts being from apex to the diagonals on the base, and them from apex to the other diagonals on the base. The film of the process could then be shown as in steps 1 and 2.

4. A verbalising extension of this activity might be made by getting the child to record his solution of the problem on

a tape recorder.

It seems likely that a large number of varied learning opportunities would need to be devised. Among activities which might fit readily into the learning opportunities required is the technique of requiring the child to complete some form of dramatic incident,

either a) In role play

or b) In visual/verbal description of what he 'sees' as continuing to happen in the incident.

Again, an adaptation of this might require a child to offer a selection of visual/verbal descriptions of the completion of the dramatic activity. For example, a filmed excerpt that might be used in this way could have a brief sequence of a policeman in a panda car, driving past a telephone box, and stopping almost immediately outside a house which has smoke billowing from the fround floor windows, and a child's face at the upstairs window.

Children viewing this might be asked to rapidly 'see', and say what they see, as happening immediately after the film stops. Then to review and present alternatives.

Imaginative activities are, of course, undertaken in schools, but the extent to which children are helped to an awareness of the primary coding processes that they use, during such activities, is open to question, and it does seem from the evidence of the research reported here that some of the low-achieving children may not be aware of the processes that can be used.

We cannot, of course, be <u>sure</u> that such activities <u>will</u> develop or improve the children's use of visual/verbal processes.

The problems for a curriculum development project would thus include finding out:

1. Whether frequent and extended exposure to activities of the sort described would improve the children's awareness of strategies.

2. Whether in doing so it would sensitise them to use their visual/verbal processes of <u>their own volition</u> in problem-solving.

3. Whether such extended use of the visual/verbal processes would improve their cognitive performances at other times.

Crucial to the possible success of such a curriculum project would be the extent to which children were involved in understanding the aims of the activities in which they would be involved.

A methodology developed by the author and a colleague (Potter, F.W. and Hills, P.J., 1976*) might well be adapted for use in this respect.

In a development project involving in one sample, undergraduates, and in another sample sixteen-year old school students, the aim was to evolve a way of helping the students inspect and modify their attitudes and behaviour in developing autonomous learning skills. The methodology included the creation of a number of separate learning packages, each related to an aspect of study skills development. Each

---

*Potter, F.W. and Hills, P.J., 'Self-directed learning for 16-19 year olds', <u>Trends in Education</u>, H.M.S.O., pp.20-25, June 1976/2.

package was designed to be capable of being used by the student, working on his own. The use of learning packages was interspersed with group counselling sessions in which each participant was encouraged to share with the rest of the group the problems and insights into the learning process, encountered while working on each package.

A concurrent evaluation of the group counselling method interspersed with learning packages (to be published on completion of the project) is indicating that the method has had considerable success in meeting the aim of developing self-directed learning. It is considered that the use of appropriately designed packages, interspersed with group counselling sessions, would be a useful method to be included in a development programme aimed at improving primary coding strategies. However, it is realised that variables such as the age of the subjects, degree of motivation, and group size would all be important in determining the usefulness of such a programme. Furthermore, the materials and packages would need to be designed with an authority of presentation suitable to the age range chosen.

Target Population

Choice of a target population for a curriculum experiment of this sort would not be easy, since theoretically the project could operate over a range of ages, perhaps from 9 or 10 year olds upwards, and for a wide ability range of pupils.

It might well be that the age-range of the research could best be defined in the first instance at 12 to 13 year old groups. Children of this age often tend to be inquisitive and curious about themselves, and keen to find new ways of improving their personal performance. As to ability range, it seems likely that a range of material incorporating different difficulty levels would need to be created, if mixed ability classes were used. On the other hand, a main conclusion of the research has been that the under-achievers may be not realising the potency of the dual-coding strategies. If this is so, then a research with a group of low-achieving pupils using materials appropriately designed in order to give them success, might prove of considerable value, both to the children concerned and in developing expertise in the curriculum project.

Experimental Design and Evaluation

Although consideration might be given to the possibility of using a matched group as a control, it seems likely that the variables under consideration would be too many to control for effectively.

Consequently an independent, concurrent study would need to be incorporated which would evaluate the reactions of the experimenters, the teachers, and the pupils, to the programme.

The results of the evaluation process would need to be available to the experimental team at pre-determined intervals, these to depend on the scale of the project attempted.

Scale and Length of the Project

The reader will have formed some idea of the difficulties likely to be encountered in a proposed project of this sort, and the difficulties are obviously a factor in the scale of project to be attempted. Among these will be:

a) Problems of convincing administrators, teachers, pupils, parents and a funding authority of the validity of such a project. This would be difficult at any scale of project envisaged, and more difficult as the proposed scale increases.

b) Problems of devising appropriate materials. At a subjective level of judgement this does not seem insuperable. It would be necessary to gather a team of imaginative and committed teachers.

c) Teacher/child rapport would need to be of a high order, and teacher/pupil ratio would need to be low, perhaps as low as 1/15, depending on the type of child population.

d) Problems of testing whether the objectives of the programme are achieved. However, if the objectives can be operationalised, they can be the subject of tests designed for the purpose.

What then might be the optimum scale of operation at which to aim.

Again, as a matter of subjective judgement, a relatively small scale project, of a pilot nature but well-supported by resources, would be prudent. Ideally such a project might consist of a research team of two, 3/4 teachers in each of two schools, with a research population in each of the schools, of thirty children; the project lasting two and a half years. This would include finding the research population, motivating the teachers, appointing an evaluator, designing research materials and carrying out a trial learning period of at least one academic year. Given appropriate resources, it is believed that such a project would be worth undertaking.

BIBLIOGRAPHY

Amster, H. and Marschilo, L. — Effect of type of pretraining and variety of instances on children's concept learning. Journal Expt. Child Psychology, 1965, 2, p.192-204.

Angell, J.H. — Methods for the determination of mental imagery. Psychological Monographs 1910. 13, p.61-107.

Antrobus, J.S. and Singer, J.L. — Visual signal detection as a function of sequential variability of simultaneous speech. Journal of Experimental Psychology, 1964, 68, 603-610.

Antrobus, J.S. and Singer, J.L. — Eye Movements accompanying daydreaming, visual imagery and thought suppression. J. Abn. Soc. Psychol. 1964, 69, pp.255-252.

Antrobus, J.S., Singer, J.L., and Greenberg, S. — Studies in the stream of consciousness: Experimental enhancement and suppression of spontaneous cognitive processes. Perceptual and Motor Skills, 1966, 23, 399-417.

Ausubel, D.P. — The psychology of meaningful verbal learning. Grune and Stratton, New York, 1963.

Attneave, F. — Some Informational Aspects of Visual Perception. Psychological Review, 1954, 61, p.183-193.

Baddeley, A.D. — The Psychology of Memory, Harper and Row, Inc. London, 1976.

Bahrick, H.P. and Boucher, B. — Retention of visual and verbal codes of the same stimuli. Journal of Experimental Psychology, 1968, 78, pp.417-22.

Barber, T.X. — The after images of hallucinated and imagined colours. Journal of Abnormal and Social Psychology, 1959, 59, p.136-139.

Barratt, P. — Imagery and Thinking. Australian Journal of Psychology, 1953, 59, p.134-164.

Barratt, P.E. — Use of the E.E.G. in the study of imagery. Brit. J. Psychol., 1956, 47, pp.101-14.

Bartlett, R.C. — Remembering. Cambridge University Press, London, 1932.

Beard, R.M. — The Structure of Perception: a factorial study. British Journal of Educational Psychology, June 1965,(35) 2, p.210-220.

Benjamin, H. — The Sabre-Tooth Curriculum by Peddiwell, J.A. Foreward by Benjamin, H., McGraw Hill, 1939.

Berlyne, D.E. — Recent developments in Piaget's works. British Journal of Educational Psychology, 1957, 27, p.1-12.

Berlyne, D.E., — Structure and Direction in Thinking, J. Wiley, N.Y., 1965.

Bernstein, B. — Social structure, language and learning. Educational Research. 1961, June, Vol. III, p.163-176.

Bernstein, B. — Socio-linguistic approach to Social Learning in 'Readings in the Foundation of Education'. Connell, .F., Debus, R.B. and Niblett, N.R. Routledge, Kegan & Paul, 1967, p.232.

Betts, G.H. — The distribution and functions of mental imagery. Teachers College, Columbia University, 1909.

Bitterman, M.E. and Soloway, E. — The relation between frequency of blinking and effort expended in mental work. Journal of Expt. Psychology. April 1946, Vol. 36, p.134-136.

Bloom, B.S. and Broder, L.J. — Problem-solving processes of college students. Educational Monograph. University of Chicago Press, July 1958, 73.

de Bono, E. — Teaching Thinking, Maurice Temple Smith Ltd., London, 1976.

Bousfield, W.A., Cohen, B.H. and Whitmarsh, G.A. — Verbal generalization. A theoretical rationale and an experimental technique. University of Connecticut, Office of Naval Research, 1958, Technical Report No. 23.

Bower, G.H. — Mental imagery and associative learning, in L.W. Gregg (Ed.) 'Cognition in learning and memory'. J. Wiley, N.Y., 1972.

Brenner, M.W. and Gillman, S. — Verbal intelligence, Visuomotor ability and school achievement. British Journal of Educational Psychology. Feb. 1968, Vol. 38, Part I, p.75-78.

Brown, R.W. — Social Psychology. Free Press of Glencoe. New York, 1965, Chap. 7, 'From codability to coding ability'.

Brown, R.W. — Words and Things. Glencoe, The Free Press, 1958.

Bruner, J.S. — Going beyond the information given, in 'Contemporary approaches to cognition'. Harvard University Press, Cambridge, 1957. Symposium University of Colorado, May 12th-14th, 1955.

Bruner, J.S., Olver, R.R. and Greenfield, P.M. — Studies in cognitive growth. J. Wiley, New York, 1966.

Bruner, J.S. — Toward a theory of instruction. Harvard University Press, 1967.

Bruner, J.S. — Organisation of early skilled action, Child Development 1973, 44, 1-11.

Brunswik, E. — 1956 in Jordan N, Themes in Speculative Psychology, Tavistock, 1968.

Buffery, A.W.H. and Gray, J.A. — in Gender Differences, eds. Ounsted, C. and Taylor, D.C., Churchill 1972.

Bulgelski, B.R. — Words and things and images. American Psychologist, 1970, 25, 1002-1012.

Burt, C. — Brain and Consciousness. Brit. J. Psychol. 59, pp.55-69, 1962.

Carroll, J.B. — Language and thought. Prentice Hall, London, 1965.

Carver, C. — The aural analysis of sounds. British Journal of Educational Psychology, Nov. 1967, Vol. XXXVII, Part 3, p.379-380.

Case, D. and Collinson, J.M. — The Development of Normal Thinking in Verbal Comprehension. British Journal of Educational Psychology. June 1962, Vol. XXXII. Part II, p. 103-111.

Cattell, R.B., Sealy, A.P. and Sweney, A.B. — What can personality and motivation source trait measurements add to the prediction of school achievement? Brit. J. educ. Psychol., 1966, 36, 280-293.

Cattell, R.B. and Cattell, M.D.L. — Handbook for the Jr-Sr. High School Personality Questionnaire, H.S.P.Q. Inst. for Pers. and Abil. Testing, Illinois, 1969.

Cellerier, G. — Information Processing tendencies in recent experiments in cognitive learning - theoretical implications, in Farnham-Diggory,S. (Ed.), 1971 (ibid), pp.115-123.

Chase, W.G. (Ed). — Visual Information Processing. Academic Press, 1973.

Chomsky, N. — Current issues in Linguistic Theory, in Foder, J.A. and Katz, J.J. (Eds.): The structure of Language: readings in the philosophy of language. Englewood-Cliffs, N.J., Prentice Hall, 1964.

Chown, S.M. — The effect of age on the relationship between different types of rigidity. Quarterly Bulletin British Psychological Society, 1961, No. 44, A12.

Clark, L.V. — Effect of mental practice on the development of a certain motor skill. Research Quarterly 31, 1960, p.560-569.

Cohen, G. — The effect of codability of the stimulus on recognition reaction times. British Journal of Psychology, 1969, 60 (1), p.25-29.

Coltheart, M. Hull, E. and Slater, D. — Sex differences in imagery and reading, Nature, 253, pp. 438-440, 1975.

Cooper, J.C. and Geeth, J.H. — Interactions of modality with age and with meaningfulness in verbal learning. Journal Exp. Psychology, 1967, Vol. 58 (1), p.41-44.

Cooper, L.A. and Shepherd, R.N. — Chronometric studies of the rotation of mental images, in Chase, W.G., Visual Information Processing, 1973, ibid.

Corcoran, D.W.J. — An Acoustic Factor in Letter Cancellation, Nature, 1966, 210, p.658.

Cowan, E.L. — The influence of varying degrees of psychological stress on problem-solving rigidity. Journal Abn. and Social Psychology, 1952, 47, p.512-519.

Cross, P., Cattell, R.B. & Butcher, H.J. — The personality pattern of creative artists. Brit. J. Educ. Psychol., 1967, 37, 292-299.

Deese, J. — On the structure of associative meaning. Psychological Review, 1962, 69, p.161-175.

Deese, J. — The structure of associations in language and thought, Baltimore, The John Hopkins Press, 1965.

Deutsch, M. — The disadvantaged child and the learning process: some social psychological and developmental considerations, in Education in Depressed Areas (A.H. Passon, Ed.), Teacher's College Press. New York, 1963.

Dewey, J. — Democracy and Education. MacMillan, 1916.

Dienes, Z.P. — The growth of mathematical concepts in children through experience. Educational Research. Nov. 1959, Vol. II, No. 1, p.9-20.

Dietze, D. — The facilitating effect of words on discrimination and generalization. Journal of Educational Psychology, 1955, 50, p.235-260.

Donaldson, M. and Withrington, D. — A Study of Children's Thinking, Tavistock, London, 1963.

Drevdahl, J.E. and Cattell, R.B. — Personality and creativity in artists and writers, J. clin. Psychol., 1958, 14, 107-111.

Duncan, C.P. — Recent research on human problem-solving. Psychological Bulletin, 1959, 56, p.555-563.

Edfelt, A.W. — Silent speech and silent reading, Chicago, University of Chicago Press, 1960.

Ewert, P.H. and Lambert, J.F. — The effect of verbal instructions upon the formation of a concept. Part 2. Journal gen. Psychology, 1932, 6, p.400-413.

Eysenck, H.J. — Experiments in Personality, Vol. 2 (Chap. 9), Routledge and Kegan Paul, 1960.

Farnham-Diggory, S. (Ed.) — Information Processing in Children, Academic Press, 1972.

Fornald, M.R. — The diagnosis of mental imagery. Psychological Monographs, 1912, 14, p.1-169.

Fowler, W. — Cognitive learning in infancy and early childhood. Psychological Bulletin 1962 (59), p.116-152.

Freeman, J., Butcher, J.J. and Christie, T. — Creativity: A Selective Review of Research, Soc. Res. into Higher Educ. Ltd., London, 1968.

Furth, H.G. — Thinking without Language. Collier Macmillan, London, 1966.

Gagne, R.M. and Smith, E.C.	A study of the effects of verbalization on problem-solving. Journal of Expt. Psychology, 1962, 63, p.12-18.
Galperin, P.Y.	A method, fact and theories in the psychology of mental action and concept formation. Paper read at: Eighteenth International Congress of Psychology, Moscow. 1966.
Galton, F.	Inquiries into Human Faculty and its Development. Dent. (Everyman's Edition, London) 1919, first published in 1883.
Getzels, J.W. and Jackson, P.W.	Creativity and Intelligence: Explorations with Gifted Students. J. Wiley, N.W., 1962.
Glanzer, M. Huttenlocher, J. and Clark, W.H.	Systematic operations in solving concept problems. A parametic study of a class of problems. Psychological Monographs, 1963, 77 (1. Whole No. 569)
Goldman, R.J.	The Minnesota Tests of Creative Thinking. Educational Research, Nov. 1964, Vol. VII, No. 1, p.3.
Golla, P.L. Hutton, E.L. and Grey-Walter, W.	The objective study of mental imagery. Journal Ment. Science, 1943, 89, p.216-223.
Goodnow, J.J. and Pettigrew, T.P.	Effects of prior patterns of experience on strategies and learning sets. Journal Experimental Psychology, 1955, 49, p.381-389.
Gordon, R.	An investigation into the factors that favour the formation of stereotyped images. British Journal of Psychology, 1949, 39.3, p.156-157.
Grey-Walter, W.	The Social Organ. Impact of science on society. 1968 (18), Pt. 3, p.179-186.
Gruen, A.	A critique and re-evaluation of Witkin's perception and perception-personality work. Journal Gen. Psychology, 1957, 56, p.73-93.
Guilford, J.P.	Intellectual resources and their values as seen by scientists, in Taylor, C.W. and Barron, F. (Eds.) Scientific Creativity: Its Recognition and Development, 1963, Wiley, New York.
Guilford, J.P.	Fundamental statistics in psychology and education. McGraw Hill, 1965 (p.173)

Guilford, J.P. and Hoepfner, R. — Structure of intellect factors and their tests. Rep. Psychol. Lab., Univ. S. California, No.36, Los Angeles, 1966.

Harris, D.B. — Children's drawings as measures of intellectual maturity. George C. Harrop, 1964.

Harvey, O.J., Hunt, D.E. and Schroder, H.M. — Conceptual systems and personality organisation, Wiley, N.Y. London, 1961.

Hasan, P. and B Butcher, H.J. — Creativity and Intelligence: a partial replication with Scottish children of Getzels and Jackson's study. Brit. Journal of Psychol., 1966, 57, pp. 129-35.

Hebb, D.O. — The Organisation of Behaviour, J. Wiley, New York, 1949.

Hebb, D.O. — Concerning Imagery. Psychol. Rev., 1968, 75, (pp. 466-77).

Hebb, D.O. — The Mind's Eye, Psychology Today, 1969, 2, pp. 54-7, 67-8.

Hebron, M.E. — A factorial study of learning a new number system and its relation to attainment intelligence and temperament. British Journal of Educational Psychology. Feb. 1962, Vol. XXXII. Part 1, p.38-45.

Hitchman, P.J. — The testing of spoken English - a review of research, Educ. Res. pp. 55-72, 1964.

Hochberg, J.E. — Perception, Prentice-Hall Inc. 1964.

Hochberg, J.E. — In the mind's eye, in R.N. Haber (Ed) Contemporary theory and research in visual perception, N.Y. Holt, Rinehart and Winston, 1968.

Holt, R.R. — Imagery: The return of the ostracised. American Psychologist, 1964, 19, p.254-264.

Hudson, L. — Contrary Imaginations, Methuen, London, 1966.

Hudson, L. — Frames of Mind. Methuen, 1968.

Hunt, E.B. — Concept learning: an information processing problem. Wiley, N.Y. London, 1962.

Husen, T. and Dahllof, U. — Mathematics and communication skills in secondary schools. Educational Research, June 1965, Vol. VII, No. 3, p.167.

Inhelder, B, and Piaget — The growth of logical thinking from Childhood to Adolescence. Routledge and Kegan Paul, 1958.

Inhelder, B., Boret, M., and Smock, C.D. — On cognitive development. Am. Psychol., 1966, 21, 160-4.

Jackson, J.J. — The growth of logical thinking in normal and sub-normal children. British Journal of Educational Psychology. June 1965, (35), 2, p.255-258.

Jackson, P.W. and Messick, S. — The person, the product and the response: conceptual problems in the assessment of personality. Journal of Personality, 1965, 33, p.1-19.

Johnson, D.M. and O'Reilly, C.A. — Concept attainment in children. Classifying and defining. Journal of Educational Psychology. 1964, 55, p.71-74.

Kamin, L.J. — The Science and Politics of I.Q., J. Wiley, 1975.

Kates, S.L. Yudin, L. and Tiffany, R.K. — Concept attainment by Deaf and Hearing Adolescents. Journal of Educational Psychology. 1962, 52, 3, p.119-126.

Kendler, H.H. and Kendler, T.S. — Vertical and horizontal processes in problem-solving. Psychological Review, 1962, 69, p.1-17.

Kendler, H.H. and Kendler, T.S. — Mediated response to size and brightness as a function of age. American Journal of Psychology, 1962, 75, p.571-586.

Kerlinger, F.N. — Foundations of Behaviour Research. Holt, Rinehart and Winston, 1964.

Kidd, A.J. and Rivoire, J.L. — Perceptual Development in Children. U.I.P. London, 1967.

Kirk, R. — Experimental Design: Procedures for the Behavioural Sciences, Belmont, Calif. Brooks, 1968.

Klein, G.S. — Personal world through perception, in Blake, R.W. and Ramsay, G. (Eds.) - Perception: an approach to personality. Ronald, New York, 1950.

Klein, J. — Levels of perceptual organisation and of performance after time for reflection. British Journal of Educational Psychology. Feb. 1965, 35, 1, p.60-62.

Koltsova, M.M. Physiological conditions of the development of the word as a signal. Paper read at Eighteenth International Congress of Psychology, Moscow, 1966.

Koussy El, A.A.H. The visual perception of space. British Journal of Psychology, Monograph Supplement, 20, 1935.

Kueene, M.R. Experimental investigation of the relation of language to transposition behaviour in young children. Journal Expt. Psychology, 36, p.471-490.

Kuhlmann, F. On the analysis of the memory consciousness for pictures of familiar objects. American Journal of Psychology, 1907, 18, p.389-420.

Kurtz, K.H. and Hovland, C.I. The effect of verbalization during observation of stimulus objects upon accuracy of recognition and recall. Journal of Educational Psychology, 1953, 45, 1957-64.

Lennenberg, E.H. Understanding language without ability to speak: a case study. Journal Abnorm. Soc. Psychology, 1962, 65, p.419-425.

Lewis, M.M. Language, thought and personality in infancy and childhood. Harrap, London, 1963.

Luria, A.R. and Vinogradova, F.I. Speech and the development of mental processes in the child. Stables, London, 1959.

Luria, A.R. In 'Educational Psychology in the Soviet Union'. Eds: Simon, B. and Simon, J. Routledge & Kegan Paul, London, 1963.

Lynn, R. Reading readiness and the perceptual abilities of young children. Educational Research, Nov. 1963, (6), p.10-14.

Maccoby, E. (Ed) The Development of Sex Differences. Tavistock, 1967.

MacFarlane Smith Spatial Ability. University of London Press, 1964.

McGuigan, F.J. Covert oral behaviour during the silent performance of language tasks. Psychol. Bulletin, 74, pp. 309-26, 1970.

McGuigan, F.J. and Pinkney, K.B. Effects of increased reading rote on covert processes. Paper at XIII Congress of Psychology, 1971, in McGuigan, F.J. and Schoonover, R.A. 1973, p.360, ibid.

McGuigan, F.J. and Schoonover, R.A. (eds) — The Psychophysiology of Thinking. Academic Press, N.Y., 1973.

McKellar, P. and Simpson, L. — Between wakefulness and sleep - hypnagogic imagery. British Journal of Psychology, Nov. 1954. Vol. XLV. Part IV, p.266-276.

Mackinnon, D.W. — The highly effective individual. Teachers Coll. Rec., 61, pp. 367-78, 1960.

Mackinnon, D.W. — The personality correlates of creativity: a study of American architects, in Neilson, G.S. (ed) Proceedings of the Fourteenth Congress on Applied Psychology, 1962, 2, pp.11-39.

Mackinnon, D.W. — The Nature and Nature of Creative Talent. American Psychologist, Vol. 17, 1962.

McNeill, J.D. and Keislar, L.R. — Value of the Oral Response in beginning reading: an experimental study using programmed instruction. British Journal of Educational Psychology, June 1963, 33, 2, p.162-167.

Magne, O. and Parknas, D. — The learning effect of pictures. British Journal of Educational Psychology, Nov. 1963, 33, Pt. 3, p.265-275.

Marks, M.R. — Problem solving as a function of the situation. Journal of Expt. Psychology, 1951, 41, p.74-80.

Marshall, G.R. — Sequential probability, pronounceability, content and function words: their relation to response acquisition. American Psychologist. (20). Abstract, 1965.

Milgram, N.A. and Nooe, J.S. — Relevant and irrelevant verbalization in discrimination and reversal learning by normal and retarded children. Journal of Educational Psychology, 1968, Vol. 59, No. 3, p.169-175.

Miller, D.K. — A study of differences between auditory and visual learners in respect to extra-version-introversion. 'Dissert. Abstr', 1966, 26, 1-4.

Ministry of Education	Half our Future. A report of the Central Advisory Council for Education (England), H.M.S.O., 1963, iv.
Moore, T.V.	Image and meaning in memory and perception. Psychological Monographs. 1919, p.67-296.
Morrisby, T.V.	The Morrisby Shapes Test Handbook. Educational Tests Ltd., 1967.
Musgrove, F.	Personal problems in learning environments. Educational Research. June 1968, Vol. 10, No. 3, p.255-238.
Neisser, U.	Cognitive Psychology. Appleton Century Crafts, 1966.
Newell, A., Shaw, J.C. and Simon, H.A.	Elements of a theory of human problem solving. Psychological Review. 1958, Vol. 65, No. 3, p.151-166.
Newell, A. and Simon, H.A.	Computer simulation of Human Thinking. Screvet, 1961, 134, p.2011-2017.
Nie, N.H., Hull, C.H., Jenkins, J.G., Steinbrenner, K. and Bent, D.H.	Statistical Package for the Social Sciences, McGraw Hill, 1975.
Norman, D.A. and Rumelhart, D.E.	Explorations in Cognition, Freeman, 1975.
Osborn, A.E.	Applied Imagination. Principles, procedures and creative problem-solving. Charles Scribners and Sons, New York 1963.
Paivio, A.	Imagery and Verbal Processes. Holt Rinehart and Winston, 1971.
Paivio, A.	Imagery and Long Term Memory. A paper presented at Psychological Symposium, University of Aberdeen, 1973.

Paivio, A. — Psychophysiological Correlates of Imagery. Chap. Eight in McGuigan, F.J. and Schoonover, R.A., 1973, ibid.

Paivio, A. and Csapo, K. — Concrete image and verbal memory codes. J. Exp. Psychol., 80, pp. 279-85, 1969.

Paivio, A. and O'Neill, B.J. — Visual recognition thresholds and dimensions of word meaning. Perception and Psychophysics, 1970, 8, 137-138.

Peel, E.A. — Experimental examination of some of Piaget's schemata concerning children's perception and thinking. British Journal of Educational Psychology, 1959, 29, p.89-103.

Perky, C.W. — An experimental study of imagination. Amer. J. Psychol., 21, pp. 422-52, 1910.

Peters, R.S. — Brett's History of Psychology. George Allen and Unwin Ltd., London, 1953.

Piaget, J. and Inhelder, B. — Mental Imagery in the Child. Routledge and Kegan Paul, 1971.

Piaget, J. — Play, drama and imitation in childhood. Heineman, London, 1951.

Pimsleur, P. et al — Further Study of the transfer of Verbal Materials across sense modalities. Journal of Educational Psychology. 1964, 55, 2, p.96-102.

Postman, L. — Perception, Motivation and Behaviour. Journal of Personality, 1953, 22, p.17-32.

Potter, F.W. — An experimental study of the interaction between examiners, candidates and criteria used in the examining of talks and essays at C.S.E. level; with special reference to the examining of talks. Unpub. Dip. thesis. University of Bristol, 1968.

Potter, F.W. and Hills, P.J. — Self-directed Learning for 16-19 year olds. Trends in Education, June 1976.

Potter, F.W. and Kilty, J.M. — Nursing Education Research Management; establishing priorities and optimising the use of resources: a methodology. Journal of Advanced Nursing. March, 1976.

Potter, F.W. and Walsh B.M. — An experimental study of representational modes of thinking, and their relationships: (1) Performance in standardised tests of ability; (2) Performance in special problems presented visually and verbally. Unpub. M.A. Thesis, Univ. Lancaster 1969.

Potter, M.C. and Faulconer, B.A. — Time to understand pictures and words. Nature, 1975, pp.437-88.

Pylyshyn, Z.W. — What the mind's eye tells the mind's brain: a critique of mental imagery. Psychological Bulletin, 1973, 80, 1-4.

Radford, J. — Verbalization effects in a 'non-verbal' intelligence test. British Journal of Educational Psychology. Feb. 1966.

Radford, J. and Burton, A. — Thinking: Its Nature and Development. J. Wiley and Sons, 1974.

Reese, H.W. — Verbal mediation as a function of age level. Psychological Bulletin, 1962, 59, p.502-509.

Reynolds, J.H. — Cognitive Transfer in Verbal Learning. Journal of Exp. Psychology, 1968, 59, 2, p.133-138.

Richardson, A. — Mental Imagery. Routledge and Kegan Paul, London, 1969.

Richardson, K. and Spears, D. — Race, Culture and Intelligence, Penguin 1972.

Roe, A. — A psychological study of eminent biologists. Psychol. Monogr., 64, (14), 1951.

Roe, A. — A psychological study of eminent psychologists and anthropologists and a comparison with biological and physical scientists. Psychological Monograph 76, No. 352, 1953.

Rooper, A. and Sigel, I. — in 'Young Children' 1966. Vol. 21 (6) p.335-349. Finding the clue to young children's thought processes.

Rokeach, M. — Rigidity and concreteness in thinking. Journal of Expt. Psychology, 1950, 40, No. 2 p.206.

Rumelhart, D.E., Lindsay, P.H., and Norman, D.A. — A process model for long-term memory. In Tulving, E. and Donaldson, W. (eds), Organisation of memory. N.Y. Academic Press, 1972.

Sartre, J.P. — The Psychology of Imagination, Methuen & Co., 1972.

Satterly, D. — Perceptual representational and conceptual characteristics of primary school children. British Journal of Educational Psychology, Feb. 1968, Vol. 38, Part I, p.78-82.

Schaeffer, B. — Skill Integration during Cognitive Development. Paper presented at Psychological Symposium, University of Aberdeen, 1973.

Schaffer, J., Mednick, S. and Seder, J. — Some developments; factors related to field independence in children. American Psychology, 1957, 12, p.399.

Scheerer, M. — Problems of performance analysis in the study of personality. Ann: New York Academy of Science, 1946, 46, Art:7, p.653-678.

Schwab, J. — College Curriculum and Student Protest, Univ. Chicago Press, 1969.

Segal, S.J. — Imagery: Current Cognitive Approaches, Academic Press, London, 1971.

Segal, S.J. and Gordon, P. — The Perky effect revisited: Paradoxical thresholds at signal detection error? 1968, in Paivio, A., 1971, p.143, ibid.

Segal, S.J. and Fusella, V. — Influence of imaged pictures and sounds on detection of visual and auditory signals, 1970, in Paivio, A., 1971, p.143, ibid.

Sheehan, P.W. — The investigation of visual imagery and some of its correlates. Unpublished Ph.D. University of Sydney, Australia, 1965.

Sheehan, P.W. — Functional similarity of imaging to perceiving. Individual differences in vividness of imagery, in: Perceptual and Motor Skills, 23, 1966, p.1011-1033.

Sheehan, P.W. — A shortened form of Betts Questionnaire upon mental imagery. Journal of Clinical Psychology, 1967 (a) Vol. 1, 23, p. 386-389.

Sheehan, P.W. — Visual imagery and the organizational properties of perceived stimuli. British Journal of Psychology, 1967 (b), 58, p.247-252.

Sheehan, P.W. — The function and nature of imagery. Academic Press, 1972.

Sheehan, P.W. and Neisser, U.	Some variables affecting the vividness of imagery in recall. British Journal of Psychology, 1969, 60, Part I, p.71-80.
Short, P.L.	The objective study of mental imagery. British Journal of Psychology, 1953, 44, p.38-51.
Siegel, S.	Nonparametric Statistics for the behavioural sciences. McGraw Hill, 1956.
Sigel, I.R.	Development trends in the abstraction ability of children. Child Development, 1953, 24.
Singer, J.L.	Daydreaming, an introduction to the experimental study of inner experience. Random House, N.Y., 1966.
Singer, G. and Sheehan, P.W.	The effect of demand characteristics on the figural after-effect with real and image-inducing figures. American Journal of Psychology, 1965, 78, p.96-101.
Skemp, R.R.	The need for a schematic learning theory. British Journal of Educational Psychology, June 1962, Vol. XXXII, Part II, p.133-142.
Skinner, B.F.	Verbal Behaviour, Appleton Century Crofts, 1957.
Slater, P. and Bennett, H.	The development of spatial judgement and its relation to some educational problems. Occup: Psychology, 1943, 17, p.139-155.
Sokolov, A.N.	Inner Speech and Thought. Plenum Press, N.Y. 1975.
Sokolov, A.N.	Studies of the speech mechanisms of Thinking, in McGuigan, F.J. and Schoonover, R.A., 1973, p.351, ibid.
Soltis, J.F.	Seeing, Knowing and Believing. George Allen and Unwin, 1966.
Sperling, G.	The information available in brief visual presentations. Psychological Monographs, 1960, 74, No. 11.
Spotts, J.V. and Mackler, B.	Relationships of field dependent and field independent cognitive styles to creative test performance. Perc. Motor Skills, 24, pp. 239-68, 1967.

Staats, C.K.
Staats, A.W. and
Schutz, R.W. — The effects of discrimination pretraining on textural behaviour. Journal of Educational Psychology, 1962, 53, p.32-37.

Start, K.B. — Kineaesthesis and Mental Practice. Research Quarterly 35, (3 Pt. 1), 1964.

Start, K.B. — Intelligence and the improvement in a gross motor skill after mental practice. British Journal of Educational Psychology, Feb. 1964, Vol. XXXIV, Part I, p.85-90.

Start, K.B. and
Richardson, A. — Imagery and mental practice. British Journal of Educational Psychology, Nov. 1964, Vol. XXXIV, Part 3, p.280-284.

Steel, G.D. and
Torrie, J.H. — Principles and Procedures of Statistics, McGraw Hill, 1960.

Stern, C. — Labelling and variety in concept identification with young children. Journal of Educational Psychology, 1965, 56, 5, p.235-248.

Stern, C. — Acquisition of problem-solving strategies in young children and its relation to verbalization. Journal of Educational Psychology, 1967, Vol. 58, p.245-252.

Sutherland, M. — Everyday Imagining and Education. Routledge and Kegan Paul, 1971.

Taylor, I.A.(1959) — The nature of the creative process, in Smith, P. (ed), Creativity, Hastings, New York.

Taylor, C.C. — A study of the nature of spatial ability and its relationship to attainment in geography. British Journal of Educational Psychology, Nov. 1960, Vol. XXX, Part III, p.266-270.

Thorndike, E.D. — On the function of visual images. Journal of Philosophy, Psychology and Scientific Method. 1907, Vol. 4, 12, p.324-327.

Torrance, E.P. — Non-test ways of identifying the creatively-gifted, in Gowan, C.J. et al, 'Creativity: Its Educational Implications', N.Y. John Wiley, 1967.

Vernon, P.E. — Creativity and Intelligence, Educ. Res., 6, pp. 163-9, 1964.

Vernon, P.E. — The development of current ideas about intelligence tests. Hugenics Society Conference, 1965.

Vernon, P.E. — Culture and Intelligence, Methuen, 1968.

Vygotsky, L.S. — Thought and Language. ed. H. Haufmann and G. Vakas. John Wiley, New York, 1962.

Walkup, L.R. — Creativity in science through visualisation. Journal of Perceptual and Motor Skills, 1965, 21, p.35-41.

Wallace, J.G. — Concept growth and the education of the child. N.F.E.R., 1965.

Wallach, M.A. and Kogan, N. — Modes of Thinking in Young Children: a study of the Creativity-Intelligence Distinction. Holt, Rinehart and Winston, Inc., N.Y., 1965.

Wallach, H. and Averback, E. — On memory modalities. American Journal of Psychology, 1955, 68, 249-257, in Paivio, A., 1971, p.240, ibid.

Watson, J.D. — The double helix. London, Weidenfeld and Nicholson, 1968.

Whitely, G. — The effects of mental rehearsal upon a motor skill. Dip.Ed. Thesis, Manchester University, 1962.

Whorf, B.L. — In: Carroll, J.B. (ed.) Language, thought and reality. Wiley, New York, 1956.

Wilgosh, L.R. — Interaction between pictures and their labels in four-year old children, in Sheehan, 1972, p.278, ibid.

Williams, J.D. — Teaching problem-solving. Educational research, Nov. 1960, Vol. III, p.12-36.

Williams, J.D. — Teaching arithmetic by concrete analogy. (1) Miming devices (cont'd). Educational Research, June 1961, Vol. III p. 195-213.

Williams, J.D. — The teaching of mathematics IV: teaching arithmetic by concrete analogy. II. Structural systems. Educational Research, June 1962, Vol. IV, No. 3, p.163.

Winer, B.J. — Statistical Principles in Experimental Design. Second Edition, N.York, McGraw-Hill, 1971.

Witkin, H.A. — Cognitive development and growth of personality. 'Acta Psychol. Amst.,' 1961, 18, 245-257.

Witkin, H.A.	A cognitive style approach to cross-cultural research. Int. J. Psychol. 2, 1967, pp.233-50.
Witkin, H.A., Lewis, H.B., Hertzman, M., Machover, K., Meissner, P.B., and Wapner, S.	Personality through Perception, Harper and Row, N.Y., 1954.
Wohlwill, J.F.	Developmental studies of perception. Psychological Bulletin, 1960, Vol. 57, No. 4, July.
Wolff, J.L.	Effects of verbalization and pretraining on concept attainment by children in two mediation categories. Journal of Educational Research, 1967, 58, 1. p.19-26.
Wood, D.J.	Topological representations of the structure of verbal problems. Personal communication. Department of Psychology, University of Nottingham, 1963.
Zachariah, E.	A study of accuracy of reproduction of visual images at various age levels. Journal of Psychological Research, 1958, 2, p.42-49.
Zikmund V.	Oculomotor activity during Visual Imagery of a Moving Stimulus Pattern', Studio Psychologica, 1966, 8, p.254-274

<u>In addition</u>

Arnold, M.	Brain function and emotion, American Psychologist, 1947, 2, p.344-345
Brown, R.W. and Lenneberg, E.H.	A study of language and cognition. Journal of Abnormal Soc. Psych. 1954, 49. p.454-462
Haygood, D.H.	Audio-visual concept formation, Journal of Educational Psychology, 1965, 56, p.126-132.
Jenkin, M.	Affective processes in perception. Psychological Bulletin, 1957, 54, p.100-127
Stroud, J.	The fine structure of psychological time. in Quastler H. (Ed), Information theory in psychology. Free Press. N.Y. 1955.

APPENDICES

APPENDIX A

References to Standardised test references (* copies included)

Visual Perception

Morrisby Perceptual Test, from the General Ability Tests, N.F.E.R., 79 Wimpole St., London, W.1.

Field Independence Test

Hidden Figures Test (Cf.1) Educational Testing Service

Reading

1. *National Reading Survey, England and Wales, 1970, N.F.E.R.

2. *Reading Comprehension

   Booklet 7 of the International Educational Achievement Survey distributed by N.F.E.R. Reference 7C/7D/7E/7P, Section C and D

Personality

High School Personality Questionnaire 'HSPQ', the Institute for Personality and Ability Testing, 1602-04, Coronada Drive, Champaign, Illinois, U.S.A.,

Intelligence (Scale B)
Self-sufficiency (Scale Q2)
Self-concept (Scale Q3)

Aston University

Content has been removed for copyright reasons

Aston University

Content has been removed for copyright reasons

THE NATIONAL FOUNDATION FOR EDUCATIONAL RESEARCH IN ENGLAND AND WALES AND THE SCOTTISH COUNCIL FOR RESEARCH IN EDUCATION IN ASSOCIATION WITH THE INTERNATIONAL ASSOCIATION FOR THE EVALUATION OF EDUCATIONAL ACHIEVEMENT

I.E.A. 7C/7D/7E/7P

I.E.A.

Booklet 7

READING COMPREHENSION

SECTIONS C AND D ONLY

Aston University

Content has been removed for copyright reasons

Aston University

Content has been removed for copyright reasons

APPENDIX B

Non-standardised Tests (*typescript copies included)

Creativity Tests

*Plot Titles (O1), *Symbol Production (O2), *Consequences (O3), *Topics (F1), *Themes (F2), *Things (F3).

*P/W Spatial Visualisation Test

*P/W Visual/Verbal Questionnaire

*Modified Short Form of Betts Imagery Questionnaire, Sheehan (1967)

Examples and example of answer sheet

N.B.

The rationale for the latter three tests** is discussed in Appendix D.

Aston University

Content has been removed for copyright reasons

APPENDIX C

Summary Tables not included in main text

Tables 22-24	Multiple Correlation and Multiple Regression Coefficients
Table 58 a-m	Between-groups analyses of variance on thirteen variables

Tables of computer results

Tables 59-60

Table 22 Multiple Correlation coefficients, Multiple Regression coefficients and beta weights of seven variables with Recall Imagery (BETTS) and separate dual-coding strategies. 163 Second and third year boys

DEPENDENT VARIABLE	INDEPENDENT VARIABLES	R	R^2	B	F	Sig.
Creativity (CREATI)	BETTS (3)	.082	.006	.04	.35	.78
	VISQ (1)	.058	.003	.02	.55	.45
	VERBQ (2)	.075	.005	.03	.45	.63
Field Independence (HID FIG)	BETTS (2)	.367	.135	.17	12.51	.01
	VISQ (1)	.336	.112	.23	20.50	.01
	VERBQ (3)	.367	.135	.01	8.29	.01
Perceptual Ability (MORPER)	BETTS (3)	.207	.04	.23	2.37	.07
	VISQ (1)	.099	.009	-.01	1.59	.20
	VERBQ (2)	.099	.009	-.068	.79	.45
Intelligence (B)	BETTS (3)	.240	.058	.07	3.23	.02
	VISQ (2)	.194	.037	.09	3.14	.04
	VERBQ (1)	.097	.009	-.016	1.56	.21
Reading (READIN)	BETTS (3)	.233	.054	.13	3.05	.03
	VISQ (2)	.207	.043	.15	3.60	.03
	VERBQ (1)	.019	.000	-.13	.06	.80
Self-sufficiency (Q2)	BETTS (3)	.248	.061	.11	3.48	.01
	VISQ (2)	.23	.053	.07	4.51	.01
	VERBQ (1)	.199	.039	.12	6.68	.01
Self-concept (Q3)	BETTS (3)	.263	.069	.03	3.94	.01
	VISQ (2)	.261	.069	-.01	5.88	.01
	VERBQ (1)	.261	.068	.24	11.81	.01

...indicate order entered into equation

Table 23 Multiple Correlation coefficients, Multiple Regression coefficients and beta weights of seven variables with Recall Imagery (BETTS) and separate dual-coding strategies. Second and third year girls.

DEPENDENT VARIABLE	INDEPENDENT VARIABLES	R	R^2	B	F	Sig.
Creativity (CREATI)	BETTS (3)	.152	.023	-.03	1.53	.20
	VISQ (1)	.148	.021	.17	4.38	.03
	VERBQ (2)	.150	.022	-.01	2.24	.10
Field Independence (HID FIG)	BETTS (2)	.328	.10	-.05	11.71	.01
	VISQ (1)	.166	.027	.31	5.50	.02
	VERBQ (3)	.338	.11	.09	8.33	.01
Perceptual Ability (MORPER)	BETTS (3)	.048	.002	-.01	.15	.92
	VISQ (1)	.039	.001	.03	.30	.58
	VERBQ (2)	.045	.002	.02	.20	.81
Intelligence (B)	BETTS (3)	.168	.02	.10	1.88	.13
	VISQ (2)	.148	.02	.06	2.17	.18
	VERBQ (1)	.105	.01	.03	2.21	.13
Reading (READIN)	BETTS (3)	.186	.03	.08	2.30	.08
	VISQ (2)	.174	.03	.06	3.03	.05
	VERBQ (1)	.146	.02	.09	4.25	.04
Self-sufficiency (Q2)	BETTS (3)	.242	.05	.12	4.02	.01
	VISQ (2)	.223	.05	.11	5.08	.01
	VERBQ (1)	.164	.027	.07	5.44	.02
Self-concept (Q3)	BETTS (3)	.260	.067	.17	4.66	.01
	VISQ (2)	.217	.047	.03	4.82	.01
	VERBQ (1)	.188	.035	.10	7.14	.01

Numbers in parentheses indicate order entered into equation

Table 24 Multiple Correlations coefficients, Multiple Regression coefficients and beta weights of seven variables with Recall Imagery (BETTS) and separate dual-coding strategies (VISQ and VERBQ).

All second and third year subjects.

DEPENDENT VARIABLE	INDEPENDENT VARIABLES	R	R^2	B	F	Sig.
Creativity (CREATI)	BETTS (3)	.106	.011	.09	1.35	.25
	VISQ (1)	.105	.011	.009	4.03	.04
	VERBQ (2)	.106	.011	.003	2.02	.13
Field Independence (HID FIG)	BETTS (2)	.328	.107	.25	21.3	.01
	VISQ (1)	.237	.056	.07	21.3	.01
	VERBQ (3)	.331	.110	.05	14.6	.01
Perceptual Ability (MORPER)	BETTS (3)	.098	.009	.08	1.15	.32
	VISQ (1)	.068	.004	.02	1.69	.19
	VERBQ (2)	.069	.004	.01	.86	.42
Intelligence (B)	BETTS (3)	.197	.039	.13	4.83	.01
	VISQ (2)	.168	.028	.08	5.21	.01
	VERBQ (1)	.104	.011	.01	3.92	.04
Reading (READIN)	BETTS (3)	.181	.032	.10	4.04	.08
	VISQ (2)	.162	.026	.10	4.81	.01
	VERBQ (1)	.073	.005	-.01	1.91	.16
Self-sufficiency (Q2)	BETTS (3)	.234	.05	.12	6.90	.01
	VISQ (2)	.211	.044	.07	8.37	.01
	VERBQ (1)	.172	.029	.09	11.03	.01
Self-concept (Q3)	BETTS (3)	.249	.062	.11	7.86	.01
	VISQ (2)	.231	.053	.016	10.15	.01
	VERBQ (1)	.222	.049	.16	18.6	.01

Numbers in parentheses indicate order entered into equation

In the multiple regression analyses reported in Tables 22, 23,24 the following results were observed. (N.B. where r^2 is less than 1% this is indicated by an asterisk).

Boys (Second and Third Year)

Creativity is positively related to recall imagery, applied imagery and covert verbalising, but the variation is not explained* by these variables.

Field Independence is positively related to the following variables, the variation being explained by recall imagery (11%), applied imagery (13%), covert verbalising (11%).

Perceptual Ability is positively related to the following variables, the variation being partly explained by recall imagery (4%) but not by applied imagery* or covert verbalising*.

Intelligence is positively related to the following variables, the variation being partly explained by recall imagery (5%), applied imagery (4%), but not by covert verbalising.

Reading Ability is positively related to the following variables, the variation being partly explained by recall imagery (5%), applied imagery (4%), but not by covert verbalising.

Self-sufficiency is positively related to the following variables, the variation being partly explained by recall imagery (6%), applied imagery (5%), and covert verbalising (.4%).

Self-concept is positively related to the following variables, the variation being partly explained by recall imagery (7%), applied imagery (7%), and covert verbalising (7%).

Girls (Second and Third Year)

Creativity is positively related to the following variables, the variation being partly explained by recall imagery (2%), applied imagery (2%) and covert verbalising (2%).

Field Independence is positively related to the following variables, the variation being partly explained by recall imagery (10%), applied imagery (2%) and covert verbalising (11%).

Perceptual Ability is positively related to the following variables, but the variation is not explained by them, recall imagery, applied imagery and covert verbalising.

Intelligence is positively related to the following variables, the variation being partly explained by recall imagery (2%), applied imagery (2%) and covert verbalising (1%).

Reading Ability is positively related to the following variables, the variation being partly explained by recall imagery (3%), applied imagery (3%) and covert verbalising (2%).

Self-sufficiency is positively related to the following variables, the variation being partly explained by recall imagery (5%), applied imagery (5%) and covert verbalising (3%).

Self-concept is positively related to the following variables, the variation being partly explained by recall imagery (7%), applied imagery (4%) and covert verbalising (3%).

Table 58. Between groups analysis of variance on thirteen variables for dual-coding groups, High Visual/High Verbal, High Visual/Low Verbal Low Visual/High Verbal, Low Visual/Low Verbal. All second and third year subjects.

Table 58a. Perceptual ability (MORPER)

Source	df	S. of squares	Mn. square	F	Sig.
Between groups	3	3728.1	1242.7		
Within groups	272	12170.1	465.3		
		128898.2		2.67	.05

Table 58b. Field Independence (HIDFIG)

Source	df	S. of squares	Mn. square	F	Sig.
Between groups	3	32.81	10.93		
Within groups	272	4602.7	17.11		
		4635.47		.639	N.S.

Table 58c. Reading ability (NATRS)

Source	df	S. of squares	Mn. square	F	Sig.
Between groups	3	740.2	246.7		
Within groups	272	14030.8	52.2		
		14771.0		4.73	.01

Table 58d. Reading comprehension (READCO)

Source	df	S. of squares	Mn. square	F	Sig.
Between groups	3	1172.0	390.7		
Within groups	272	20951.5	77.9		
		22123.5		5.01	.01

Table 58e. Originality (SYMPRO)

Source	df	S. of squares	Mn. square	F	Sig.
Between groups	3	253.9	84.6		
Within groups	272	29688.6	110.4		
		29942.5		.766	N.S.

Table 58f. Originality (CONSEQ)

Source	df	S. of squares	Mn. square	F	Sig.
Between groups	3	972.1	324.1		
Within groups	272	26435.2	358.5		
		97407.3		.904	N.S.

Table 58g. Originality (PLOTTI)

Source	df	S. of squares	Mn. square	F.	Sig.
Between groups	3	152.1	50.70		
Within groups	272	6508.0	24.2		
		6660.1		2.095	N.S.

Table 58h. Ideational Fluency (TOPICS)

Source	df	S. of squares	Mn. square	F.	Sig.
Between Groups	3	3291.1	1097.0		
Within groups	272	63244.4	235.1		
		66535.5		4.666	.01

Table 58i. Ideational Fluency (THEMES)

Source	df	S. of squares	Mn. square	F.	Sig.
Between groups	3	1180.0	393.6		
Within groups	272	462674.5	1719.9		
		413855.3		.228	N.S.

Table 58j. Ideational Fluency (THINGS)

Source	df	S. of squares	Mn. square	F.	Sig.
Between groups	3	314.	104.85		
Within groups	272	8875.1	32.9		
		9189.7		3.175	.05

Table 58k. Intelligence (B)

Source	df	S. of squares	Mn. square	F.	Sig.
Between Groups	3	26.87	8.96		
Within groups	272	726.03	2.70		
		752.9		3.318	.05

Table 58l. Self-sufficiency (Q2)

Source	df	S. of squares	Mn. square	F.	Sig.
Between groups	3	6.65	2.216		
Within groups	272	2152.4	8.001		
		2159.05		.277	N.S.

Table 58m. Self-concept (Q3)

Source	df	S. of squares	Mn. square	F.	Sig.
Between groups	3	32.04	10.68		
Within groups	272	2393.03	8.90		
		2425.07		1.20	N.S.

Table 59 Computer results. Basic statistics. First year Boys

ENTER 1ST YR 14/07/76 PAGE 2

FILE NONAME (CREATION DATE = 14/07/76)
SUBFILE CHIBOYS

VARIABLE BETTS

MEAN	86.259	STD ERROR	3.695	STD DEV	33.252
VARIANCE	1105.669	KURTOSIS	.165	SKEWNESS	.563
RANGE	176.000	MINIMUM	11.000	MAXIMUM	187.000

VALID OBSERVATIONS = 81
MISSING OBSERVATIONS = 0

- -

VARIABLE VISO

MEAN	2.346	STD ERROR	.124	STD DEV	1.120
VARIANCE	1.254	KURTOSIS	-.391	SKEWNESS	.471
RANGE	4.000	MINIMUM	1.000	MAXIMUM	5.000

VALID OBSERVATIONS = 81
MISSING OBSERVATIONS = 0

- -

VARIABLE VERBO

MEAN	3.123	STD ERROR	.145	STD DEV	1.308
VARIANCE	1.710	KURTOSIS	-.836	SKEWNESS	-.162
RANGE	4.000	MINIMUM	1.000	MAXIMUM	5.000

VALID OBSERVATIONS = 81
MISSING OBSERVATIONS = 0

Computer Results Basic Statistics First Year Girls

Table 60

ENTER 1ST YR 14/07/76 PAGE 3

FILE NONAME (CREATION DATE = 14/07/76)
SUBFILE CH1GIRLS

VARIABLE BETTS

MEAN	77.110	STD ERROR	3.257	STD DEV	29.494
VARIANCE	869.877	KURTOSIS	1.571	SKEWNESS	1.094
RANGE	147.000	MINIMUM	35.000	MAXIMUM	182.000

VALID OBSERVATIONS = 82
MISSING OBSERVATIONS = 0

- -

VARIABLE VISQ

MEAN	2.451	STD ERROR	.138	STD DEV	1.249
VARIANCE	1.559	KURTOSIS	-.418	SKEWNESS	.590
RANGE	4.000	MINIMUM	1.000	MAXIMUM	5.000

VALID OBSERVATIONS = 82
MISSING OBSERVATIONS = 0

- -

VARIABLE VERBQ

MEAN	3.012	STD ERROR	.145	STD DEV	1.310
VARIANCE	1.716	KURTOSIS	-.941	SKEWNESS	.210
RANGE	4.000	MINIMUM	1.000	MAXIMUM	5.000

VALID OBSERVATIONS = 82
MISSING OBSERVATIONS = 0

Table 61 Computer results: Multiple Regression. Second and Third Year Subjects

SINGLE STRATEGIES MULT REGRESSION 07/09/76 PAGE 2

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH2GIRLS CH3BOYS CH3GIRLS

* M U L T I P L E R E G R E S S I O N *

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	BETTS	VISO	VERBO	MORPER	HIDFIG	READIN	CREATI	B	Q2
VISO	.56410								
VERBO	.43008	.37357							
MORPER	.09620	.06863	.03594						
HIDFIG	.32151	.23733	.19011	.25308					
READIN	.15008	.16154	.07288	.45312	.22978				
CREATI	.06425	.10560	.04827	.48340	.14002	.51178			
B	.18435	.16175	.10411	.52429	.25698	.72803	.36582		
Q2	.20738	.17794	.17289	.32023	.15127	.49831	.23292	.55635	
Q3	.19676	.14427	.22240	.34601	.22760	.51893	.23705	.60042	.65923

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 07/09/76 PAGE 4

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH2GIRLS CH3BOYS CH3GIRLS

* M U L T I P L E   R E G R E S S I O N *

DEPENDENT VARIABLE.. R

S U M M A R Y   T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.11206	.738	.18435	.03398	.03398	.18435	70.50467	.000
	CREATI		3.44363	.064	.39975	.15980	.12582	.36582		
	Q3		19.68025	.000	.64609	.41743	.25763	.60042		
	HIDFIG		.97865	.323	.65373	.42737	.00993	.25698		
	VERBO		.29569	.587	.65683	.43142	.00406	.10411		
	MORPER		31.38888	.000	.70067	.49094	.05951	.52429		
	VISO		.17161	.679	.70195	.49274	.00180	.16175		
	Q2		7.17062	.008	.72025	.51876	.02602	.55635		
	READIN		123.79998	0	.80281	.64450	.12574	.72803		

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 07/09/76 PAGE 6

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH2GIRLS CH3BOYS CH3GIRLS

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE.. CREATI

S U M M A R Y T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.72413	.395	.06425	.00413	.00413	.06425	21.66679	0
	MORPER		50.01306	.000	.48373	.23400	.22987	.48342		
	Q2		.11750	.732	.49039	.24049	.00649	.23292		
	HIDFIG		.15986	.690	.49054	.24062	.00014	.14002		
	VERBO		.40737	.524	.49083	.24091	.00029	.04827		
	VISO		1.05410	.305	.49543	.24545	.00454	.10560		
	READIN		55.49551	.000	.59065	.34887	.10342	.51178		
	Q3		.52130	.471	.59286	.35148	.00261	.23705		
	B		3.44363	.064	.59816	.35780	.00632	.36582		

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 07/09/76 PAGE 8

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH2GIRLS CH3BOYS CH3GIRLS

* M U L T I P L E   R E G R E S S I O N *

DEPENDENT VARIABLE.. READIN

S U M M A R Y   T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.02321	.879	.15908	.02531	.02531	.15908	62.37285	0
	CREATI		55.49551	.000	.52717	.27791	.25260	.51178		
	Q3		2.98171	.085	.65727	.43200	.15409	.51893		
	HIDFIG		.70686	.401	.66158	.43769	.00568	.22978		
	VERBO		1.56747	.211	.66538	.44273	.00535	.07288		
	MORPER		.47535	.491	.67460	.45508	.01235	.45312		
	VISQ		.41540	.520	.67631	.45739	.00231	.16154		
	G2		3.65602	.057	.69290	.48012	.02272	.49831		
	B		123.79998	0	.78483	.61596	.13584	.72803		

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 07/09/76 PAGE 10

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH2GIRLS CH3BOYS CH3GIRLS

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE.. MORPER

S U M M A R Y T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.00116	.973	.09620	.00925	.00925	.09620	27.97077	.000
	CREATI		54.35258	0	.48779	.23794	.22869	.48340		
	03		.23020	.632	.53932	.29086	.05292	.34601		
	HIDFIG		7.49488	.007	.55892	.31240	.02153	.25308		
	VERBO		.47864	.489	.56202	.31587	.00347	.03594		
	VISO		.93037	.335	.56268	.31660	.00074	.06863		
	B		37.87774	0	.62372	.38903	.07243	.52429		
	02		.16528	.685	.62395	.38932	.00029	.32023		

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 07/09/76 PAGE 12

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH2GIRLS CH3BOYS CH3GIRLS

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE.. HIDFIG

S U M M A R Y T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		13.76351	.000	.32151	.10337	.10337	.32151	8.18229	.000
	CREATI		.15986	.690	.34303	.11767	.01431	.14002		
	Q3		.74639	.388	.36444	.13282	.01515	.20760		
	VERBO		.83097	.363	.36623	.13412	.00130	.19011		
	MORPER		7.62314	.006	.40163	.16131	.02718	.25308		
	VISO		1.05652	.305	.40517	.16416	.00286	.23733		
	Q2		1.49953	.222	.40702	.16567	.00150	.15127		
	READIN		.70686	.431	.41415	.17152	.00585	.22978		
	B		.97865	.323	.41693	.17383	.00231	.25698		

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION   07/09/76   PAGE 14

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH2GIRLS CH3BOYS CH3GIRLS

* M U L T I P L E   R E G R E S S I O N *

DEPENDENT VARIABLE.. 02

S U M M A R Y   T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.95320	.330	.20738	.04301	.04301	.20738	37.05589	0
	CREATI		.11750	.732	.30238	.09143	.04842	.23292		
	03		95.51116	.000	.66847	.44686	.35543	.65923		
	HIDFIG		1.49953	.222	.66867	.44712	.00026	.15127		
	VERBO		.07562	.783	.66868	.44714	.00002	.17289		
	MORPFR		.22439	.636	.67261	.45241	.00527	.32323		
	VISO		.78671	.376	.67424	.45460	.00220	.17794		
	READIN		3.65602	.057	.69097	.47744	.02284	.49831		
	B		7.17062	.008	.69852	.48793	.01049	.55635		

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 07/09/76 PAGE 16

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH2GIRLS CH3BOYS CH3GIRLS

* M U L T I P L E   R E G R E S S I O N *

DEPENDENT VARIABLE.. Q3

S U M M A R Y   T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.00404	.949	.19676	.03872	.03872	.19676	44.24501	.000
	CREATI		.52130	.471	.29880	.08928	.05057	.23705		
	Q2		95.51116	.000	.66749	.44555	.35627	.65923		
	HIDFIG		.74639	.388	.67306	.45301	.00746	.20760		
	VERBO		8.57791	.004	.67886	.46085	.00784	.22240		
	MORPER		.29176	.589	.68693	.47187	.01102	.34601		
	VISO		1.08562	.298	.68754	.47271	.00084	.14427		
	READIN		2.98171	.085	.71127	.50591	.03320	.51893		
	B		19.68025	.000	.72953	.53221	.02630	.60042		

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 08/09/76 PAGE 2

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH3BOYS

* M U L T I P L E R E G R E S S I O N *

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	BETTS	VISQ	VERRQ	HORPER	HIDFIG	READIN	CREATI	B	Q2
VISQ	.57184								
VERRQ	.44609	.35861							
HORPER	.19727	.09919	.03229						
HIDFIG	.31460	.33602	.17240	.20320					
READIN	.16522	.18585	-.01949	.42181	.17774				
CREATI	.07154	.05855	.06480	.50671	.18449	.58925			
B	.22732	.19184	.09790	.45501	.22525	.64257	.40292		
Q2	.21125	.18016	.19956	.24622	.06217	.48036	.25061	.54695	
Q3	.14412	.10397	.26151	.29691	.15531	.45897	.24100	.57121	.64919

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 08/09/76 PAGE 4

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH3BOYS

* M U L T I P L E   R E G R E S S I O N *

DEPENDENT VARIABLE.. B

S U M M A R Y   T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.50920	.477	.22732	.05167	.05167	.22732	21.67681	0
	CREATI		.03126	.860	.44938	.20194	.15027	.40292		
	03		9.53187	.002	.64770	.41951	.21757	.57121		
	HIDFIG		1.22750	.270	.65045	.42308	.00357	.22525		
	VERBQ		.27341	.602	.66233	.43868	.01560	.09790		
	MORPER		6.94365	.009	.67983	.46217	.02349	.45531		
	VISQ		.04066	.840	.68329	.46689	.00472	.19184		
	Q2		5.09894	.025	.70661	.49930	.03241	.54695		
	READIN		21.28916	.000	.74864	.56046	.06116	.64257		

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 08/09/76 PAGE 6

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH3BOYS

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE.. CREATI

S U M M A R Y T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		2.15165	.144	.07154	.00512	.00512	.07154	14.62246	0
	Q3		2.20927	.139	.24386	.05947	.05435	.24100		
	HIDFIG		1.42505	.234	.28338	.08030	.02084	.18449		
	MORPER		23.38817	.000	.52434	.27494	.19463	.50671		
	VERBO		5.40924	.021	.52612	.27680	.00186	.06480		
	READIN		42.87964	0	.67708	.45844	.18164	.58925		
	VISQ		1.08528	.299	.67993	.46230	.00386	.05855		
	Q2		.00058	.981	.67993	.46230	.00000	.25061		
	B		.03106	.860	.68001	.46241	.00011	.40292		

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 08/09/76 PAGE 8

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH3BOYS

* M U L T I P L E   R E G R E S S I O N *

DEPENDENT VARIABLE.. READIN

S U M M A R Y   T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	RETTS		.44457	.506	.16522	.02730	.02730	.16522	25.10638	0
	CREATI		42.87964	0	.60203	.36244	.33514	.58925		
	Q3		2.89972	.091	.67859	.46048	.09804	.45897		
	HIDFIG		.07369	.786	.67864	.46056	.00008	.17774		
	VERBQ		10.26969	.002	.70738	.50039	.03983	-.01949		
	MORPER		.06060	.806	.70825	.50161	.00123	.42181		
	VISQ		2.97890	.086	.71872	.51655	.01494	.18585		
	Q2		3.08462	.081	.73490	.54008	.02353	.48036		
	B		21.28916	.000	.77218	.59626	.05618	.64257		

Table 61 (contd.)

SINGLE STRATEGIES MULT REGRESSION 08/09/76 PAGE 10

FILE VCH23YR (CREATION DATE = 12/05/76)
SUBFILE CH2BOYS CH3BOYS

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE.. MORPER

S U M M A R Y T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		3.91211	.050	.19727	.03892	.03892	.19727	10.70446	.000
	CREATI		29.60668	.000	.53181	.28282	.24390	.50671		
	O3		1.22935	.269	.55545	.30852	.02571	.29691		
	HIDFIG		.37048	.544	.55792	.31127	.00275	.20320		
	VERBO		1.65368	.200	.57057	.32556	.01428	.03229		
	VISO		.31010	.578	.57115	.32621	.00065	.09919		
	B		7.46384	.007	.59614	.35538	.02917	.45501		
	O2		.47353	.492	.59779	.35736	.00198	.24622		

Table 61 (contd.)

```
-INGLE STRATEGIES MULT REGRESSION                                        08/09/76      PAGE   12

:ILE    VCH23YR  (CREATION DATE =  12/05/76 )
·UBFILE   CH2BOYS     CH3BOYS

* * * * * * * * * * * * * * * * * * * * * * *  M U L T I P L E   R E G R E S S I O N  * * * * * * * * * * * * * * * * * * * * * * *

EPENDENT VARIABLE..      HIDFIG
```

S U M M A R Y   T A B L E

TEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		2.81303	.096	.31460	.09897	.09897	.31460	4.06960	.000
	CREATI		1.42505	.234	.35404	.12535	.02637	.18449		
	Q3		1.65194	.201	.36195	.13101	.00566	.15531		
	VERBQ		.00081	.977	.36221	.13120	.00019	.17240		
	MORPER		.36121	.549	.36737	.13496	.00376	.20320		
	VISQ		6.77268	.010	.41195	.16970	.03474	.33602		
	Q2		3.74182	.055	.43197	.18660	.01690	.06217		
	B		1.22750	.270	.43905	.19277	.00616	.22525		
	READIN		.07369	.786	.43949	.19315	.00039	.17774		

Table 61 (contd.)

INGLE STRATEGIES MULT REGRESSION 08/09/76 PAGE 14

ILE VCH23YR (CREATION DATE = 12/05/76)
UBFILE CH2BOYS CH3BOYS

* M U L T I P L E R E G R E S S I O N *

EPENDENT VARIABLE.. Q2

S U M M A R Y T A B L E

TEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.09210	.321	.21125	.04463	.04463	.21125	17.14747	0
	CREATI		.00058	.981	.31681	.10037	.05574	.25061		
	Q3		40.83947	0	.66645	.44416	.34379	.64919		
	HIDFIG		3.74182	.055	.67292	.45282	.00866	.06217		
	VERBO		.15461	.695	.67319	.45319	.00037	.19956		
	MORPER		.41497	.520	.67321	.45321	.00002	.24622		
	VISQ		.61724	.433	.67768	.45925	.00604	.18016		
	B		5.09894	.025	.70151	.49212	.03287	.54695		
	READIN		3.08462	.081	.70863	.50216	.01004	.48036		

Table 61 (contd.)

INGLE STRATEGIES MULT REGRESSION 08/09/76 PAGE 16

ILE VCH23YR (CREATION DATE = 12/05/76)
UBFILE CH2BOYS CH3BOYS

* M U L T I P L E   R E G R E S S I O N *

EPENDENT VARIABLE.. Q3

S U M M A R Y   T A B L E

TEP	VARIABLE ENTERED	REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		2.13498	.146	.14412	.02077	.02077	.14412	19.77956	0
	CREATI		2.20927	.139	.27251	.07426	.05349	.24100		
	Q2		40.83947	0	.65424	.42802	.35376	.64919		
	HIDFIG		1.65194	.201	.66279	.43929	.01127	.15531		
	VERBO		12.23112	.001	.67755	.45907	.01978	.26151		
	MORPER		1.27352	.261	.68916	.47494	.01587	.29691		
	VISO		1.97137	.162	.69148	.47814	.00320	.10397		
	B		9.53187	.002	.72734	.52903	.05088	.57121		
	READIN		2.89972	.091	.73334	.53779	.00876	.45897		

Table 61 (contd.)

```
,INGLE STRATEGIES MULT REGRESSION                                          08/09/76      PAGE   17

 ILE    VCH23YR  (CREATION DATE =  12/05/76 )
,UBFILE    CH2GIRLS    CH3GIRLS

 * * * * * * * * * * * * * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * * * * * * * * * * *


 ORRELATION COEFFICIENTS.

 : VALUE OF 99.00000 IS PRINTED
 'F A COEFFICIENT CANNOT BE COMPUTED.
```

ISQ	.56131								
ERBQ	.41806	.38210							
ORPER	.01472	.03068	.03631						
IDFIG	.32748	.16564	.20732	.29711					
EADIN	.15431	.14355	.14616	.47931	.27163				
REATI	.05809	.14822	.03362	.46340	.10010	.44436			
	.15379	.13573	.10596	.57664	.28405	.79231	.33947		
2	.20969	.20209	.16487	.40601	.22643	.52601	.21991	.59267	
3	.23979	.17320	.18805	.38639	.25385	.56909	.23403	.62363	.60335
	BETTS	VISQ	VERBQ	MORPER	HIDFIG	READIN	CREATI	B	Q2

Table 61 (contd.)

INGLE STRATEGIES MULT REGRESSION 08/09/76 PAGE 19

ILE VCH23YR (CREATION DATE = 12/05/76)
JBFILF CH2GIRLS CH3GIRLS

* M U L T I P L E   R E G R E S S I O N *

PENDENT VARIABLE.. B

S U M M A R Y   T A B L E

IEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.09802	.755	.15379	.02365	.02365	.15379	54.10369	0
	MORPER		23.59326	.000	.59467	.35363	.32998	.57664		
	VERBQ		.99065	.321	.59527	.35435	.00072	.10596		
	HIDFIG		.00903	.924	.59953	.35944	.00509	.28405		
	Q2		3.72236	.055	.70215	.49302	.13358	.59257		
	CREATI		3.62465	.058	.70537	.49754	.00452	.33947		
	VISQ		.10899	.742	.70538	.49756	.00001	.13573		
	READIN		116.56839	0	.84401	.71236	.21480	.79231		
	Q3		6.84960	.010	.85001	.72252	.01016	.62363		

Table 61 (contd.)

NGLE STRATEGIES MULT REGRESSION 08/09/76 PAGE 21

LE VCH23YR (CREATION DATE = 12/05/76)
RFILE CH2GIRLS CH3GIRLS

* M U L T I P L E R E G R E S S I O N *

-PENDENT VARIABLE.. CREATI

S U M M A R Y T A B L E

EP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.00233	.962	.05809	.00337	.00337	.05809	9.79194	0
	MORPER		29.51153	0	.46623	.21737	.21399	.46340		
	VERBO		.55344	.458	.46626	.21740	.00003	.03362		
	HIDFIG		1.53744	.217	.47011	.22100	.00361	.10012		
	Q2		.46591	.496	.47089	.22174	.00073	.21991		
	VISO		3.67634	.057	.48612	.23632	.01458	.14822		
	READIN		21.06057	.000	.55359	.30646	.07015	.44436		
	Q3		.00370	.952	.55420	.30714	.00068	.23403		
	R		3.62465	.058	.56596	.32031	.01317	.33947		

Table 61 (contd.)

```
NGLE STRATEGIES MULT REGRESSION                                        08/09/76        PAGE   23

_E    VCH23YR   (CREATION DATE =  12/05/76 )
3FILE    CH2GIRLS    CH3GIRLS

* * * * * * * * * * * * * * * * * * * * * * *   M U L T I P L E   R E G R E S S I O N   * * * * * * * * * * * * * * * * * * * * * *

PENDENT VARIABLE..     READIN
```

S U M M A R Y   T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	BETTS		.08799	.767	.15431	.02381	.02381	.15431	43.66291	0
	MORPER		1.63589	.202	.50142	.25142	.22761	.47931		
	VERBQ		1.20599	.274	.50686	.25691	.00549	.14616		
	HIDFIG		1.05733	.305	.51403	.26422	.00731	.27163		
	Q2		.38787	.534	.61083	.37312	.10890	.52631		
	CREATI		21.06057	.030	.65610	.43047	.05735	.44436		
	VISQ		.12249	.727	.65640	.43086	.00039	.14355		
	B		116.56839	0	.82108	.67418	.24332	.79231		
	Q3		1.96583	.163	.82314	.67757	.00339	.56909		

Table 61 (contd.)

GLE STRATEGIES MULT REGRESSION   08/09/76   PAGE 25

E VCH23YR (CREATION DATE = 12/05/76)
FILE CH2GIRLS CH3GIRLS

* M U L T I P L E R E G R E S S I O N *

ENDENT VARIABLE.. MORPER

S U M M A R Y T A B L E

VARIABLE ENTERED	REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
BETTS		2.77774	.097	.01472	.00022	.00022	.01472	19.64897	.000
CREATI		27.94644	.000	.46356	.21489	.21467	.46340		
Q2		2.00425	.159	.56376	.31782	.10293	.40631		
HIDFIG		9.31809	.003	.60627	.36756	.04974	.29711		
VERBQ		.00322	.955	.60645	.36778	.00022	.03631		
VISQ		.37136	.543	.60771	.36931	.00153	.03968		
B		26.89131	.000	.67475	.45528	.08597	.57664		
Q3		.03205	.858	.67481	.45538	.00009	.38639		

Table 61 (contd.)

```
ILE STRATEGIES MULT REGRESSION                                    08/09/76     PAGE   27

 VCH23YR   (CREATION DATE =  12/05/76 )
ILE   CH2GIRLS    CH3GIRLS

* * * * * * * * * * * * * * * * * * * * * *   M U L T I P L E   R E G R E S S I O N   * * * * * * * * * * * * * * * * * * * * * *

INDENT VARIABLE..     HIDFIG
```

S U M M A R Y   T A B L E

VARIABLE ENTERED	REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
BETTS		13.44652	.000	.32748	.10724	.10724	.32748	5.79403	0
MORPER		9.76191	.002	.43897	.19270	.08545	.29711		
VERBO		.93017	.334	.44418	.19730	.00460	.20732		
Q3		.12485	.724	.44891	.20152	.00422	.25385		
CREATI		1.53744	.217	.45352	.20568	.00416	.10010		
VISQ		.34977	.555	.45526	.20726	.00158	.16564		
READIN		1.05733	.305	.46390	.21520	.00795	.27163		
Q2		.04085	.840	.46407	.21536	.00015	.22643		
B		.00903	.924	.46411	.21539	.00004	.28405		

Table 61 (contd.)

ILE STRATEGIES MULT REGRESSION 08/09/76 PAGE 29

VCH23YR (CREATION DATE = 12/05/76)
ILE CH2GIRLS CH3GIRLS

* M U L T I P L E R E G R E S S I O N *

NDENT VARIABLE.. 02

S U M M A R Y T A B L E

VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
BETTS		.02085	.885	.20969	.04397	.04397	.20969	23.87327	0
MORPER		2.14086	.145	.45426	.20635	.16238	.40601		
VERBO		.02616	.872	.45987	.21148	.00513	.16487		
HIDFIG		.04085	.840	.46154	.21302	.00153	.22643		
03		58.79601	0	.71198	.50692	.29390	.69335		
CREATI		.46591	.496	.71201	.50695	.00003	.21991		
VISO		1.53967	.216	.71504	.51129	.00433	.20209		
READIN		.38787	.534	.72485	.52540	.01411	.52601		
B		3.72236	.055	.73121	.53466	.00926	.59267		

Table 61 (contd.)

ILE STRATEGIES MULT REGRESSION 08/09/76 PAGE 31

VCH23YR (CREATION DATE = 12/05/76)
ILE CH2GIRLS CH3GIRLS

* M U L T I P L E R E G R E S S I O N *

NDENT VARIABLE.. Q3

S U M M A R Y T A B L E

VARIABLE ENTERED	REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
RETTS		1.71235	.192	.23979	.05750	.05750	.23979	27.09501	0
MORPER		.00220	.963	.45179	.20411	.14661	.38639		
VERBO		.64055	.425	.45953	.21116	.00705	.18805		
HIDFIG		.12485	.724	.46402	.21531	.00415	.25385		
Q2		58.79601	0	.71299	.50836	.29305	.69335		
CREATI		.00370	.952	.71395	.50972	.00137	.23403		
VISO		.37234	.542	.71469	.51079	.00106	.17320		
READIN		1.96583	.163	.74167	.55008	.03930	.56909		
R		6.84960	.010	.75232	.56598	.01590	.62363		

Table 62 Computer results: Comparison of means: dual-coding strategy groups Second and Third Year Subjects

HIVI-HIVE LOVI-LOVE ALL 28/05/76 PAGE 2

FILE NONAME (CREATION DATE = 28/05/76)

- T - T E S T -

GROUP 1 - FIRST 97 CASES
GROUP 2 - NEXT 32 CASES

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
MORPER												
GROUP 1	97	86.7526	21.828	2.216	1.40	.287	3.15	127	.002	3.43	62.00	.001
GROUP 2	32	73.2188	18.442	3.260					.001			
HIDFIG												
GROUP 1	97	7.8144	4.088	.415	1.27	.462	1.16	127	.249	1.23	58.97	.224
GROUP 2	32	6.8750	3.635	.642					.125			
NATRS												
GROUP 1	97	23.2577	9.301	.944	3.18	.000	1.38	127	.171	1.81	96.02	.074
GROUP 2	32	20.8750	5.216	.922					.08			
READCO												
GROUP 1	97	31.3196	9.151	.929	1.11	.693	2.85	127	.005	2.78	50.80	.008
GROUP 2	32	25.9375	9.622	1.701					.002			
SYMPRO												
GROUP 1	97	25.9897	10.840	1.101	1.01	.942	1.04	127	.300	1.04	52.82	.303
GROUP 2	32	23.6875	10.876	1.923					.15			
CONSEQ												
GROUP 1	97	55.4845	17.264	1.753	2.07	.008	.97	127	.335	.81	41.33	.423
GROUP 2	32	51.6563	24.833	4.390					.16			
PLOTTI												
GROUP 1	97	12.0000	4.653	.472	1.01	.924	2.37	127	.019	2.36	52.67	.022
GROUP 2	32	9.7500	4.684	.828					.009			

Table 62 (contd.)

HIVI=HIVE LOVI=LOVE ALL 28/05/76 PAGE 3

FILE NONAME (CREATION DATE = 28/05/76)

\- - - - - - - - - - - - - - - - - - T - T E S T - - - - - - - - - - - - - - - - - -

GROUP 1 - FIRST 97 CASES
GROUP 2 - NEXT 32 CASES

VARIABLE		NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
TOPICS	GROUP 1	97	36.5052	15.343	1.558	1.01	.946	1.98	127	.050	1.98	52.85	.053
	GROUP 2	32	30.3125	15.382	2.719					.025			
THEMES	GROUP 1	97	144.8247	41.737	4.238	1.45	.172	.39	127	.699	.35	45.89	.726
	GROUP 2	32	141.3438	50.335	8.898					.35			
THINGS	GROUP 1	97	18.3711	6.254	.635	1.26	.474	2.71	127	.008	2.87	58.79	.006
	GROUP 2	32	15.0000	5.576	.986					.004			
B	GROUP 1	97	6.5670	1.534	.156	1.63	.073	2.71	127	.008	2.40	44.19	.021
	GROUP 2	32	5.6563	1.961	.347					.004			
Q2	GROUP 1	97	9.7320	2.819	.286	1.47	.226	.87	127	.384	.96	63.46	.340
	GROUP 2	32	9.2500	2.328	.412					.192			
Q3	GROUP 1	97	9.9897	3.255	.330	1.28	.446	.18	127	.859	.19	59.19	.851
	GROUP 2	32	9.8750	2.882	.509					.43			

Table 62 (contd.)

HIVI-LOVE LOVI-HIVE ALL   28/05/76   PAGE 2

FILE NONAME (CREATION DATE = 28/05/76)

- - - - - - - - - - - - T - T E S T - - - - - - - - - - - -

GROUP 1 - FIRST 86 CASES
GROUP 2 - NEXT 61 CASES

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
MORPER												
GROUP 1	86	83.6512	18.392	1.983	1.62	.040	.55	145	.584	.53	109.17	.599
GROUP 2	61	81.7541	23.433	3.000								
									.29			
HIDFIG												
GROUP 1	86	7.5233	3.934	.424	1.12	.616	.12	145	.905	.12	124.62	.906
GROUP 2	61	7.4426	4.169	.534								
									.45			
NATRS												
GROUP 1	86	19.7907	5.766	.622	1.21	.420	-.40	145	.687	-.40	121.57	.692
GROUP 2	61	20.1967	6.337	.811								
									.34			
READCO												
GROUP 1	86	27.0814	8.116	.875	1.17	.497	-1.14	145	.255	-1.13	122.85	.262
GROUP 2	61	28.6885	8.785	1.125								
									.13			
SYMPRO												
GROUP 1	86	24.8488	10.791	1.164	1.36	.213	.89	145	.374	.92	139.70	.362
GROUP 2	61	23.3279	9.266	1.186								
									.18			
CONSEQ												
GROUP 1	86	57.2093	17.512	1.888	1.09	.718	-.54	145	.588	-.55	132.80	.586
GROUP 2	61	58.7705	16.742	2.144								
									.29			
PLOTTI												
GROUP 1	86	12.2093	5.102	.550	3.66	.000	-.69	145	.490	-.63	83.29	.532
GROUP 2	61	13.0656	9.762	1.250								
									.25			

Table 62 (contd.)

HIVI-LOVE LOVI-HIVE ALL 28/05/76 PAGE 3

FILE NONAME (CREATION DATE = 28/05/76)

\- - - - - - - - - - - - - - - - - - T - T E S T - - - - - - - - - - - - - - - - - -

GROUP 1 - FIRST 86 CASES
GROUP 2 - NEXT 61 CASES

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE T VALUE	POOLED VARIANCE ESTIMATE DEGREES OF FREEDOM	POOLED VARIANCE ESTIMATE 2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE T VALUE	SEPARATE VARIANCE ESTIMATE DEGREES OF FREEDOM	SEPARATE VARIANCE ESTIMATE 2-TAIL PROB.
TOPICS												
GROUP 1	86	31.1977	11.453	1.235	2.90	.000	-2.84	145	.005	-2.61	89.14	.011
GROUP 2	61	38.4754	19.516	2.499					.002			
THEMES												
GROUP 1	86	139.6860	40.242	4.339	1.18	.502	-.57	145	.571	-.58	135.45	.565
GROUP 2	61	143.3934	37.062	4.745					.29			
THINGS												
GROUP 1	86	17.3140	5.216	.562	1.17	.499	-.83	145	.407	-.82	122.87	.413
GROUP 2	61	18.0656	5.645	.723					.20			
B												
GROUP 1	86	6.0000	1.623	.175	1.01	.971	-.06	145	.952	-.06	129.15	.952
GROUP 2	61	6.0164	1.628	.208					[illegible]			
Q2												
GROUP 1	86	9.6744	2.809	.303	1.17	.496	.38	145	.708	.37	122.82	.712
GROUP 2	61	9.4918	3.042	.389					.35			
Q3												
GROUP 1	86	10.2093	2.762	.298	1.05	.815	1.78	145	.077	1.77	127.25	.079

Table 62 (contd.)

HIVI-HIVE HIVE-LOVI ALL   07/06/76   PAGE 2

FILE NONAME (CREATION DATE = 07/06/76)

\- T - T E S T -

GROUP 1 - FIRST 97 CASES
GROUP 2 - NEXT 61 CASES

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE: T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE: T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
MORPER												
GROUP 1	97	86.7526	21.828	2.216	1.15	.529	1.36	156	.175	1.34	120.85	.183
GROUP 2	61	81.7541	23.433	3.000					.09			
HIDFIG												
GROUP 1	97	7.8144	4.088	.415	1.04	.852	.55	156	.582	.55	125.76	.583
GROUP 2	61	7.4426	4.169	.534					.29			
NATRS												
GROUP 1	97	23.2577	9.301	.944	2.15	.002	2.26	156	.025	2.46	154.95	.015
GROUP 2	61	20.1967	6.337	.811					.01			
READCO												
GROUP 1	97	31.3196	9.151	.929	1.08	.741	1.79	156	.076	1.80	131.54	.074
GROUP 2	61	28.6885	8.785	1.125					.03			
SYMPRO												
GROUP 1	97	25.9897	10.840	1.101	1.37	.191	1.59	156	.115	1.64	141.99	.102
GROUP 2	61	23.3279	9.266	1.186					.06			
CONSEQ												
GROUP 1	97	55.4845	17.264	1.753	1.06	.807	-1.18	156	.240	-1.19	130.58	.237
GROUP 2	61	58.7705	16.742	2.144					.12			
PLOTTI												
GROUP 1	97	12.0000	4.653	.472	4.40	.000	-.92	156	.358	-.80	77.38	.428
GROUP 2	61	13.0656	9.762	1.250					.15			

Table 62 (contd.)

HIVI-HIVE HIVE-LOVI ALL 07/06/76 PAGE 3

FILE NONAME (CREATION DATE = 07/06/76)

T - T E S T

GROUP 1 - FIRST 97 CASES
GROUP 2 - NEXT 61 CASES

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
TOPICS												
GROUP 1	97	36.5052	15.343	1.558	1.62	.035	-.71	156	.481	-.67	105.72	.505
GROUP 2	61	38.4754	19.516	2.499					.29			
THEMES												
GROUP 1	97	144.8247	41.737	4.238	1.27	.322	.22	156	.827	.22	138.72	.822
GROUP 2	61	143.3934	37.862	4.745					.41			
THINGS												
GROUP 1	97	18.3711	6.254	.635	1.23	.394	.31	156	.757	.32	137.26	.751
GROUP 2	61	18.0656	5.645	.723					.38			
8												
GROUP 1	97	6.5670	1.534	.156	1.13	.596	2.15	156	.033	2.12	121.94	.036
GROUP 2	61	6.0164	1.628	.208					.02			
Q2												
GROUP 1	97	9.7320	2.819	.286	1.16	.501	.51	156	.614	.50	120.37	.620
GROUP 2	61	9.4918	3.042	.389					.33			
Q3												
GROUP 1	97	9.9897	3.255	.330	1.32	.250	1.21	156	.228	1.25	140.39	.214
GROUP 2	61	9.3770	2.835	.363					.11			

Table 62 (contd.)

HIVI-LOVE LOVI-LOVE ALL 07/06/76 PAGE 2

FILE NONAME (CREATION DATE = 07/06/76)

- T - T E S T -

GROUP 1 - FIRST 86 CASES
GROUP 2 - NEXT 32 CASES

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
HORPER												
GROUP 1	86	83.6512	18.392	1.983	1.01	.949	2.74	116	.007	2.73	55.42	.008
GROUP 2	32	73.2188	18.442	3.260					.004			
HIDFIG												
GROUP 1	86	7.5233	3.934	.424	1.17	.632	.81	116	.419	.84	59.78	.403
GROUP 2	32	6.8750	3.635	.642					.29			
NATRS												
GROUP 1	86	19.7907	5.766	.622	1.22	.538	-.93	116	.354	-.97	61.00	.333
GROUP 2	32	20.8750	5.216	.922					.18			
READCO												
GROUP 1	86	27.0814	8.116	.875	1.41	.224	.65	116	.519	.60	48.35	.553
GROUP 2	32	25.9375	9.622	1.701					.26			
SYMPRO												
GROUP 1	86	24.8488	10.791	1.164	1.02	.921	.52	116	.605	.52	55.17	.607
GROUP 2	32	23.6875	10.876	1.923					.30			
CONSEO												
GROUP 1	86	57.2093	17.512	1.888	2.01	.012	1.36	116	.177	1.16	43.00	.252
GROUP 2	32	51.6563	24.833	4.390					.09			
PLOTTI												
GROUP 1	86	12.2093	5.102	.550	1.19	.603	2.38	116	.019	2.47	60.14	.016
GROUP 2	32	9.7500	4.684	.828					.05			

Table 62 (contd.)

HIVI-LOVE LOVI-LOVE ALL   07/06/76   PAGE   3

FILE   NONAME   (CREATION DATE = 07/06/76)

- T - T E S T -

GROUP 1 - FIRST   85 CASES
GROUP 2 - NEXT   32 CASES

VARIABLE		NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
TOPICS	GROUP 1	86	31.1977	11.453	1.235	1.80	.035	.34	116	.735	.30	44.42	.768
	GROUP 2	32	30.3125	15.382	2.719					.36			
THEMES	GROUP 1	86	139.6860	40.242	4.339	1.56	.111	-.19	116	.853	-.17	46.54	.868
	GROUP 2	32	141.3438	50.335	8.898					.43			
THINGS	GROUP 1	86	17.3140	5.216	.562	1.14	.618	2.10	116	.038	2.04	52.44	.047
	GROUP 2	32	15.0000	5.576	.986					.02			
B	GROUP 1	86	6.0000	1.623	.175	1.46	.177	.97	116	.337	.89	47.69	.380
	GROUP 2	32	5.6563	1.961	.347					.17			
Q2	GROUP 1	86	9.6744	2.809	.303	1.46	.239	.76	116	.448	.83	66.57	.409
	GROUP 2	32	9.2500	2.328	.412					.22			
Q3	GROUP 1	86	10.2093	2.762	.298	1.09	.738	.58	116	.565	.57	53.52	.573
	GROUP 2	32	9.8750	2.882	.509					.28			

Table 62 (contd.)

HIVI=HIVE HIVI=LOV=ALL 04/06/76 PAGE 2

FILE NONAME (CREATION DATE = 04/06/76)

- T - T E S T -

GROUP 1 - FIRST 97 CASES
GROUP 2 - NEXT 86 CASES

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
MORPER												
GROUP 1	97	86.7526	21.828	2.216	1.41	.108	1.03	181	.303	1.04	180.55	.298
GROUP 2	86	83.6512	18.392	1.983					.15			
HIDFIG												
GROUP 1	97	7.8144	4.088	.415	1.08	.719	.49	181	.625	.49	179.77	.624
GROUP 2	86	7.5233	3.934	.424					.31			
NATRS												
GROUP 1	97	23.2577	9.301	.944	2.60	.000	2.98	181	.003	3.07	162.74	.003
GROUP 2	86	19.7907	5.766	.622					.002			
READCO												
GROUP 1	97	31.3196	9.151	.929	1.27	.259	3.30	181	.001	3.32	181.00	.001
GROUP 2	86	27.0814	8.116	.875					.001			
SYMPRO												
GROUP 1	97	25.9897	10.840	1.101	1.01	.969	.71	181	.477	.71	178.58	.477
GROUP 2	86	24.8488	10.791	1.164					.24			
CONSEQ												
GROUP 1	97	55.4845	17.264	1.753	1.03	.889	-.67	181	.504	-.67	177.75	.504
GROUP 2	86	57.2093	17.512	1.888					.25			
PLOTTI												
GROUP 1	97	12.0000	4.653	.472	1.20	.380	-.29	181	.772	-.29	173.19	.773
GROUP 2	86	12.2093	5.102	.550					.39			

Table 62 (contd.)

HIVI-HIVE HIVI-LOVE ALL 04/06/76 PAGE 3

FILE NONAME (CREATION DATE = 04/06/76)

- - - - - - - - - - - - - - - - - T - T E S T - - - - - - - - - - - - - - - - -

GROUP 1 - FIRST 97 CASES
GROUP 2 - NEXT 86 CASES

VARIABLE		NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
TOPICS	GROUP 1	97	36.5052	15.343	1.558	1.79	.006	2.62	181	.009	2.67	176.05	.008
	GROUP 2	86	31.1977	11.453	1.235					.005			
THEMES	GROUP 1	97	144.8247	41.737	4.238	1.08	.733	.85	181	.399	.85	179.71	.398
	GROUP 2	86	139.6860	40.242	4.339					.19			
THINGS	GROUP 1	97	18.3711	6.254	.635	1.44	.089	1.23	181	.219	1.25	180.35	.214
	GROUP 2	86	17.3140	5.216	.562					.11			
B	GROUP 1	97	6.5670	1.534	.156	1.12	.587	2.43	181	.016	2.42	175.47	.017
	GROUP 2	86	6.0000	1.623	.175					.008			
Q2	GROUP 1	97	9.7320	2.819	.286	1.01	.977	.14	181	.890	.14	178.53	.890
	GROUP 2	86	9.6744	2.809	.303					.45			
Q3	GROUP 1	97	9.9897	3.255	.330	1.39	.123	-.49	181	.626	-.49	180.66	.622
	GROUP 2	86	10.2093	2.762	.298					.31			

Table 62 (contd.)

LOVI-HIVE LOVI-LOVE ALL 04/06/76 PAGE 2

FILE NONAME (CREATION DATE = 04/06/76)

T - T E S T

GROUP 1 - FIRST 61 CASES
GROUP 2 - NEXT 32 CASES

VARIABLE	NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE: T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE: T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
MORPER												
GROUP 1	61	81.7541	23.433	3.000	1.61	.148	1.79	91	.077 .036	1.93	77.15	.058
GROUP 2	32	73.2188	18.442	3.260								
HIDFIG												
GROUP 1	61	7.4426	4.169	.534	1.32	.409	.65	91	.517 .26	.68	71.08	.499
GROUP 2	32	6.8750	3.635	.642								
NATRS												
GROUP 1	61	20.1967	6.337	.811	1.48	.240	-.52	91	.605 .30	-.55	74.51	.582
GROUP 2	32	20.8750	5.216	.922								
READCO												
GROUP 1	61	28.6885	8.785	1.125	1.20	.538	1.39	91	.168 .08	1.35	58.29	.183
GROUP 2	32	25.9375	9.622	1.701								
SYMPRO												
GROUP 1	61	23.3279	9.266	1.186	1.38	.286	-.17	91	.867 .43	-.16	54.98	.874
GROUP 2	32	23.6875	10.876	1.923								
CONSEQ												
GROUP 1	61	58.7705	16.742	2.144	2.20	.009	1.64	91	.104 .05	1.46	46.19	.152
GROUP 2	32	51.6563	24.833	4.390								
PLOTTI												
GROUP 1	61	13.0656	9.762	1.250	4.34	.000	1.81	91	.073 .03	2.21	90.49	.030
GROUP 2	32	9.7500	4.684	.828								

Table 62 (contd.)

LOVI-HIVE LOVI-LOVE ALL   04/06/76   PAGE 3

FILE NONAME (CREATION DATE = 04/06/76)

- T - T E S T -

GROUP 1 - FIRST 61 CASES
GROUP 2 - NEXT 32 CASES

VARIABLE		NUMBER OF CASES	MEAN	STANDARD DEVIATION	STANDARD ERROR	F VALUE	2-TAIL PROB.	POOLED VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.	SEPARATE VARIANCE ESTIMATE T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
TOPICS	GROUP 1	61	38.4754	19.516	2.499	1.61	.151	2.05	91	.043	2.21	77.07	.030
	GROUP 2	32	30.3125	15.382	2.719					.02			
THEMES	GROUP 1	61	143.3934	37.062	4.745	1.84	.042	.22	91	.824	.20	49.09	.840
	GROUP 2	32	141.3438	50.335	8.898					.21			
THINGS	GROUP 1	61	18.0656	5.645	.723	1.02	.965	2.50	91	.014	2.51	63.76	.015
	GROUP 2	32	15.0000	5.576	.986					.007			
B	GROUP 1	61	6.0164	1.628	.208	1.45	.216	.94	91	.348	.89	53.83	.377
	GROUP 2	32	5.6563	1.961	.347					.17			
Q2	GROUP 1	61	9.4918	3.042	.389	1.71	.107	.39	91	.695	.43	78.76	.671
	GROUP 2	32	9.2500	2.328	.412					.35			
Q3	GROUP 1	61	9.3770	2.835	.363	1.03	.891	-.80	91	.426	-.80	62.19	.429
	GROUP 2	32	9.8750	2.882	.509					.21			

Table 63 Computer results. Analyses of variance (BMDIV programme)

Second and Third Year Subjects

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

1 MORPER

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	86.884	82.523	81.593	74.909
STANDARD DEVIATION	22.025	20.091	23.379	20.586

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	
BETWEEN GROUPS	3728.0827	3	1242.6942	2.6706	.05
WITHIN GROUPS	125170.1444	269.	465.3165		
TOTAL	128898.2271	272.			

Table 63 (contd)

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

2

HIDFIG

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	7.8421	7.2674	7.1864	6.8485
STANDARD DEVIATION	4.1368	4.0422	4.5390	3.5805

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	
BETWEEN GROUPS	32.8079	3	10.9360	.6391	N.S.
WITHIN GROUPS	4602.6720	269.	17.1103		
TOTAL	4635.4799	272.			

Table 63 (contd.)

NATRS.

3

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	23.505	19.733	20.254	21.030
STANDARD DEVIATION	9.215	5.728	6.421	5.211

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	
BETWEEN GROUPS	740.1561	3	246.7187	4.7301	.01
WITHIN GROUPS	14030.7523	269.	52.1589		
TOTAL	14770.9084	272.			

Table 63 (contd.)

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

4

RENTCO

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	31.526	27.128	28.508	26.212
STANDARD DEVIATION	9.127	8.130	8.862	9.601

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	
BETWEEN GROUPS	1172.0003	3	390.6668	5.0158	.01
WITHIN GROUPS	20951.5381	269.	77.8868		
TOTAL	22123.5385	272.			

Table 63 (contd.)

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

5

SYMPRO

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	25.958	24.663	23.542	23.818
STANDARD DEVIATION	10.845	10.808	9.302	10.731

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	
BETWEEN GROUPS	253.8559	3	84.6186	.7667	N.S.
WITHIN GROUPS	29688.6057	269.	110.3666		
TOTAL	29942.4615	272.			

Table 63 (contd.)

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

6

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

CONSEQ

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	55.726	58.651	53.610	55.091
STANDARD DEVIATION	18.514	17.399	15.264	27.933

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	
BETWEEN GROUPS	972.2996	3	324.0999	.9041	N.S.
WITHIN GROUPS	96435.1803	269.	358.4951		
TOTAL	97407.4799	272.			

Table 63 (contd.)

7

PLOTTI

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	12.042	12.186	12.186	9.848
STANDARD DEVIATION	4.677	5.103	5.168	4.644

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	
BETWEEN GROUPS	152.0928	3	50.6976	2.0955	NS.
WITHIN GROUPS	6508.0464	269.	24.1935		
TOTAL	6660.1392	272.			

Table 63 (contd.)

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

TOPICS

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

8

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	36.579	30.942	38.083	30.212
STANDARD DEVIATION	15.472	11.382	19.646	15.151

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO
BETWEEN GROUPS	3291.1145	3	1097.0382	4.6661
WITHIN GROUPS	63244.3654	269.	235.1092	
TOTAL	66535.4799	272.		

Table 63 (contd.)

THEMES

9

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	145.25	140.59	143.36	140.52
STANDARD DEVIATION	42.07	39.88	37.57	49.77

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO
BETWEEN GROUPS	1180.8582	3	393.6194	.2289
WITHIN GROUPS	462674.4605	269.	1719.9794	
TOTAL	463855.3187	272.		

Table 63 (contd.)

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

THINGS

10

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	18.484	17.233	18.119	15.061
STANDARD DEVIATION	6.263	5.230	5.715	5.500

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO
BETWEEN GROUPS	314.5542	3	104.8514	3.1780
WITHIN GROUPS	8875.1234	269.	32.9930	
TOTAL	9189.6777	272.		

Table 63 (contd.)

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

B

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

(11)

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	6.5895	5.9884	6.0000	5.7576
STANDARD DEVIATION	1.5402	1.5904	1.6505	2.0160

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO
BETWEEN GROUPS	26.8700	3	8.9567	3.3185
WITHIN GROUPS	726.0385	269.	2.6990	
TOTAL	752.9084	272.		

Table 63 (contd.)

Q2

12

BMDØ1V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

PROBLEM CODE AØ11
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	9.7684	9.6395	9.4746	9.3030
STANDARD DEVIATION	2.8376	2.8114	3.0870	2.3115

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO
BETWEEN GROUPS	6.6499	3	2.2166	.2770
WITHIN GROUPS	2152.4124	269.	8.0015	
TOTAL	2159.0623	272.		

Table 63 (contd.)

Q3

13

BMD01V - ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN - VERSION OF MAY 4, 1965
HEALTH SCIENCES COMPUTING FACILITY, UCLA

PROBLEM CODE A011
NUMBER OF TREATMENT GROUPS 4
NUMBER OF VARIABLE FORMAT CARDS 1
DATA INPUT TAPE 5

TREATMENT GROUP	1	2	3	4
SAMPLE SIZE	95	86	59	33
MEAN	9.9895	10.2791	9.3390	9.7879
STANDARD DEVIATION	3.2860	2.7382	2.8624	2.8805

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO
BETWEEN GROUPS	32.0350	3	10.6783	1.2003
WITHIN GROUPS	2393.0273	269.	8.8960	
TOTAL	2425.0623	272.		

APPENDIX D

SUMMARY OF RELEVANT ASPECTS OF PREVIOUS RESEARCH PROJECT

UNIVERSITY OF LANCASTER 1969

'An Experimental study of representational modes of thinking and their relationship to:

(1) performance in standardised tests of ability

(2) performance in special problems, presented visually and verbally. Applied to children aged fourteen'.

Following a review of the literature available up until 1969, which has now been updated and incorporated into Chapter Two, a research project was designed in two sections. The results from section one are relevant to the current research and briefly reported in this appendix.

SECTION ONE:

An investigation of the relationships between reported incidence of representational strategies used by children of fourteen years of age, and their abilities as measured by standardised tests.

The research theory for Section One predicted that:

(1) Children who reported high powers of 'pure' imagery, would perform significantly better on the tests of ability than children who reported a low utilisation of 'pure' imagery.

(2) Children who reported high incidence of use of both 'applied' imagery and covert verbalising during problem-solving, would perform significantly better on the tests of ability than children who reported a low utilisation of both of these representational processes.

The following null hypotheses were established:-

1. MAIN NULL HYPOTHESIS (from Betts Questionnaire Data)
The High Imagery Group will not score significantly higher than Low Imagery Group on the tests of ability.

2. MAIN NULL HYPOTHESIS (from P/W Visual/Verbal Rating Data)
The High Visual/Verbal Group will not perform significantly better than the Low Visual/Verbal Group on the following standardised tests:

   a. Morrisby Verbal Abilities Test
   b. Morrisby Shapes Test
   c. Raven's Progressive Matrices (Junior Edition)

Children were categorised into representational strategy groups from the following tests:-

'Pure' Imagery as measured by a modified shortform of the Betts questionnaire (Sheehan 1967) (Appendix B).

'Applied' Imagery as measured by a rating scale devised for the purpose (P/W Visual rating scale) (Appendix B).

Covert 'Applied' Verbalisation as measured by a rating scale devised for the purpose (P/W Verbal rating scale) (Appendix B).

The standardised tests and the following imagery and verbalising tests were administered to the whole population:

P/W Spatial/Visualisation Test (described as follows).
P/W Visual/Verbal Rating Scales (described as follows).
An adaptation of the Shortform of Betts Imagery Questionnaire developed by Sheehan (1967).

These three tests are included in appendix B, and the rationale for them is here described in detail, since the same tests are used in the main research.

P/W Spatial Visualisation Test (Appendix B)

This test was devised on the basis of items suggested by Guilford (1968). The purpose of the test was to provide appropriate problems against which subjects could establish introspective ratings of visual and verbal strategies used during the problem solution.

The problems devised are of a similar type but of increasing difficulty, to enable subjects to become conversant with the strategies they used during the process of solution (Bloom and Broder, 1958 p.8). Since it was the experimenter's intention that the subjects should use the P/W rating scales relative to the last problem in the test, it was considered necessary to employ only five items. Consequently, no attempt has been made to establish test reliability.

P/W Visual/Verbal Rating Scales (Appendix B)

Two five-point rating scales were devised; one referent to visual strategies and one referent to verbal strategies employed by subjects in solution of problem five on the P/W Spatial Visualisation Test. Taking each subject's visual and verbal ratings together produces the possibility of twenty-five categories (five x five).

After completion of the P/W Spatial Visualisation Test, the P/W Rating Scale was issued to the subjects, who were then instructed to refer to problem five of the test and complete the visual rating scale. They were then asked to complete the verbal rating scale.

Although criticism can be levelled at introspective methods of enquiry as lacking objectivity, recent psychological investigators have suggested that it is admissable where other methods of investigation are not available. Wallace (1965), for instance, has referred to:

'the recent rehabilitation of introspection, as a method of enquiry'.

Criticism might also be levelled at this method of obtaining information on the grounds that each rating scale is a one-item scale. However, at this time, no method of increasing the number of items in the scales could be envisaged that would not have a contaminating effect on the subject's introspection. That is, for example, once a subject has attempted a rating of the extent to which he has used a visual or verbal strategy in solving a problem, he will become aware of the extent of his usage of covert strategies, and it is argued that this awareness would probably, almost certainly, influence ratings he would allocate to himself, to describe the subsequent strategies used.

In this context, therefore, it is argued that one-item rating scales applied to one problem are a justifiable instrument; and <u>possibly</u> the only way of achieving the desired data.

For this reason no internal reliability of the rating scale can be achieved but a measure of test-retest reliability was attempted in order to check the constancy with which subjects rate themselves.

Seventy-eight fourth-year subjects from a similar secondary school were given the P/W Spatial Visualisation Test and Rating Scales twice, with an interval of three months. Summarised, the test-retest rating results show:

1. <u>On both scales</u>

   <u>Of the sample of 78</u>:

   22% rated themselves without change on either scale on both occasions.

2. <u>The Visual Rating scale</u>

   <u>Of the total sample of 78</u>:

   44% rated themselves without change.

   94% rated themselves either without change or within one point of their first rating.

3. <u>The Verbal Rating scale</u>

   <u>Of the total sample of 78</u>:

   49% rated themselves without change.

   79% rated themselves either without change or within one point of their first rating.

<u>Adaptation of Shortform of Betts Imagery Questionnaire (Appendix B)</u>

Sheehan (1967) reported obtaining satisfactory reliabilities from a shortform of the Betts Imagery Scale, using thirty-five items. The Questionnaire used in Sheehan's research, and in this research, was based on similar criteria to those used by Betts (1909).

1. Personal bias of item was avoided.
2. Answers require minimum of interpretation.
3. Items to cover a reasonably wide range of experience.
4. The only evidence received should be that of immediate introspection.
5. The same standard of measurement as to degree of clarity

/vividness of images experienced to be employed for each item.

6. An endeavour should be made to select items which fall readily within the experience of every subject, in order to promote rapid recall.

Sheehan's Shortform of test contained a selection of thirty-five items from the original one-hundred-and-fifty items used by Betts.

It was considered that some of these thirty-five would not prove suitable for the population under study.

Items such as the following were, therefore, replaced by items considered culturally and historically more acceptable; bearing in mind the age of the population.

Examples of omissions with reasons

A fur muff .. .. anachronistic

Whistle of a locomotive .. .. anachronistic

Swish of a silk dress .. .. cultural

Linen .. .. cultural

Your hand on another person's hair .. .. maturational

The answer sheet was constructed to contain:

1. Five answers per page, to minimise halo effects from a subject's observation of previous ratings.

2. A seven point rating scale matched to imagery criteria that were visible all the time, to be constantly referred to during rating (see example in Appendix B).

3. An initial practice page to ensure familiarity with rating procedure.

TESTING PROCEDURES USED

1. Printed procedures for standardised tests.

2. P/W Spatial Visualisation Test. (Group administered) Page 1: familiarisation and practice, until all subjects claim understanding of procedure. Pages 2 and 3: five test item: four minutes.

3. P/W Visual/Verbal Rating Scales (Group administered) No time limit. Instructions read aloud, questions arising answered simply.

4. Betts Shortform Imagery Questionnaire (Group administered) Criteria and rating method read aloud. Time given for familiarisation with rating procedures until all subjects claimed understanding. Five practice items at twenty second intervals administered orally, after which an oral check was made to ensure familiarity with the rating procedure. Thirty-five test items administered at twenty second intervals, with subjects rating each item for imagery according to given criteria.

POPULATION

Fourth year pupils were chosen as subjects for this research partly for administrative reasons since, relieved of examination pressures, fourth year children are reasonably accessible for extended testing of the type selected. The main reason for choice of this age-group, however, was to attempt to maximise hypothetical differences between children who use predominantly visual representational strategies and children who use predominantly verbal representational strategies. If the hypothesis stands, that verbal representational strategies are a later development than visual representational strategies, then it was considered that an age-group of 14+ might include children who differ considerably in this respect, developmentally. Two-hundred and thirty-four fourth year children took part.

From the total population 'High' and 'Low' groups were established according to pre-set criteria of:

(a) numerical equality of groups for comparison.

(b) equality of proportions of total population (not more than 25% for each group but as near to 25% as possible).

Absolute numerical equality could not be established.

The main hypotheses were tested by significant difference of means, producing the following conclusions.

The Main Null Hypotheses 1a, b, c stating that the High Imagery Group (Betts) would not perform significantly better than the Low Imagery Group (Betts) on the three standardised tests used, were rejected.

The Main Null Hypotheses 2a, b, stating that the High Visual/ Verbal Group (P.W. ratings) would not perform significantly better than the Low Visual/Verbal group on Morrisby Verbal Ability Test and Morrisby Shapes Test were rejected, but Null Hypothesis 2c, making the same prediction for performance on Raven's Matrices was not rejected,

2. Correlation (r, tet = .65) between number of subjects coincident in High groups and Low groups on P.W. Visual/Verbal ratings and Betts Imagery ratings.

3. A set of histograms (not included in this report) was also compiled to show the distribution of the population using different combinations of representational strategies as they relate to scores on the P.W. Spatial Visualisation Test. Although no statistical generalisation can be made about the scores obtained on the test, since internal test reliability cannot be established, it is interesting to note that highly comparable patterns of results appear for the two schools (Histograms 1 and 2 in Potter and Walsh 1969).

   It was noted that in each school similar proportions of children appear to be using the same categories of strategies. It was also noted that whereas few children claim to be using poor visual strategies (categories 4 and 5), considerably more children (approximately 40%) claim to be using poor verbal strategies.

Discussion of the Results of Section One

The three standardised tests used in the research are measures of ability which may be summarised as follows:

<u>Morrisby Verbal Abilities Test</u>: recognition, relationships and extrapolation involving words.

<u>Morrisby Shapes Test</u>: manipulation of shapes.

<u>Raven's Matrices</u>: recognition, relationships and extrapolation involving shapes.

Results indicated that there are significant relationships between ability to recall images, that is 'pure imagery', and ability to utilize covert visual processes, that is 'applied imagery', on the one hand, and performance in the standardised tests on the other hand. This finding opposes the early assertions of Thorndike (1907) and Betts (1909), at the beginning of the century, that a lack of relationship exists between imagery and comprehension.

The ability tests used by Betts and Thorndike, however, were quite different from the two Morrisby Tests and Raven's Matrices. Thorndike, (in Betts 1909, p.74), for instance, based his conclusion on the interaction of imagery with the development of arithmetical ability, saying that reported decrease in visual imagery during arithmetical practice resulted in an increase in performance. Bruner's (1967, p.68) study, using mathematical processes, is also in disagreement with Thorndike.

Results such as these can be taken to underline the necessity for researchers to remain aware that the application of current tests to problems considered resolved by older means, may produce new information.

Of the results that were accepted as significant, the difference appeared to arise from trends that show that:

(1) The High Imagery Group (Betts) are under-represented in the Low ability group (standardised tests), rather than over-represented in the High ability group (standardised tests).

whereas

(2) The Low Imagery Group (Betts) are under-represented in the High ability group (standardised tests), rather than over-represented in the Low ability group (standardised tests).

(3) The High Visual/Verbal Group (P.W. ratings) are under-represented in the Low ability group (standardised tests) and over-represented in the High ability group (standardised tests),

(4) The Low Visual/Verbal Group (P.W. ratings) are over-represented in the Low ability group (standardised tests) and under-represented in the High ability group (standardised tests).

This might be interpreted as saying that the children who score low on ability tests do so because of lack of use of representational strategies. On the other hand, children who demonstrate high use of representational strategies, while not always registering in the High ability groups, very rarely fall into the Low ability group. Omission of use of representational strategies, therefore, may be a significant occurrence in the low-scoring ability groups.

In summary, the research results indicated that the extent to which children use the representational strategies of visualising and verbalising may be a key factor in determining their performance in measures of ability. The results therefore appear to support those of Bruner (1967, p.68) who concluded that in relation to mathematics problems, children found enriched imagery useful to them in dealing with new problems, and of Dienes (1959) whose theoretical view of concept formation is of a

> 'conceptual modality space, mapped out by the weights given to it on each of the modality dimensions', and that the 'Flexibility of an individual's conceptual system depends on the extent to which his concepts and the modes that govern them, overlap'.