THE EFFECT OF IMAGERY ABILITY ON

IMITATION

OF A CLOSED-MOTOR TASK

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بسم الله الرحمن الرحيم

قال الله تعالى

عَلَّمَ الْإِنسَانَ مَا لَمْ يَعْلَمْ

العلق (٥)

صدق الله العظيم

DEDICATION

This work is dedicated to my mother, Aishah, to the memory of my late father, Salah Omar Abdulgabbar, and my wife, Noha N Alfawaz.

Table of Contents

TABLES

FIGURES

ABBREVIATIONS

Acc1-Acc5	_	Accuracy score for each numbered trial.
Anova	_	Analysis of variance.
Ar	_	Arbitrary.
BL	_	Bottom left.
BR	_	Bottom right.
C	_	Centre.
CRT	_	Cathode-ray-tube.
DF	_	Degree of freedom.
Er	_	End results.
F	_	F-Ratio.
Fd	_	Fold.
HIGH	_	High imagers.
KR	_	Knowledge of results.
LH	_	Left half.
LOW	_	Low imagers.
LStip	_	Left side tip.
LTMM	_	Long-term motor memory.
LTVM	_	Long-term verbal memory.
M	_	Meaningful.
M-acc	_	Motor recall accuracy score.
MIQ	_	Movement imagery questionnaire.
MS	_	Mean square.
N	_	Number of subjects.
NM	_	Non-meaningful.
OL	_	Observational learning.
P	_	Level of significance.
P-time	_	Performance time.

QMI	–	The shortened form of Bett's questionnaires upon mental imagery
r	–	Pearson correlation coefficients.
RH	–	Right half.
RS	–	Right side.
Sd	–	Standard deviation.
SS	–	Sum of squares.
T1-T5	–	Performance time for each numbered trial.
TL	–	Top left.
TPtip	–	Top part tip.
TR	–	Top right.
V-acc	–	Verbal recall accuracy score.
VI	–	Verbal instruction.
VVIQ	–	Vividness of visual imagery questionnaire.
W-time	–	Writing time.

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It must, however, be pointed out that much of this work is the result of the author's efforts and he solely bears responsibility for any errors.

ABSTRACT

This thesis sets out to explore the process of motor skill acquisition and presents a thorough investigation of the role played by imagery ability in the recall and reproduction of a motor task. The importance of cognitive processes, such as imaging, in motor learning is becoming increasingly obvious and needs to be understood. Having described the three phases involved in motor learning - cognitive, associative and autonomous- and discussed certain relevant learning theories- the closed-loop theory and the schema theory- the thesis moves on to examine traditional instructional methods and the contrast between observational learning and verbal instruction techniques, analysing in detail the concept of mental imagery in context of the recall of motor task.

The latter half of the thesis presents a series of experiments designed to quantify the role of imagery ability in reproduction of an origami (paper-folding) task using the different instructional methods and a variety of modelled demonstrations and comparing accuracy and performance time.

The thesis concludes that observers who transform modelled actions into either symbolic or visual images achieve a higher level of learning and a higher standard of reproduction than non-imagers, and looks forward to an expansion of research into imaging in a variety of contexts.

The results of this study have implications for those working in selecting new trainees for most industrial firms, and their concern with the assessment of selecting individuals on their learning ability and the factors contributing to this as well as the possible instructional methods to be carefully considered with respect to the cost/benefit of such an exercise .

Chapter 1
Motor learning

1.1 Motor learning & the cognitive processes:

For many years psychologists have been formulating models and theories that are specific to motor skill acquisition and important as aids to definition.. Fitts (1964) recognized that both cognitive and non-cognitive processes occur in motor learning and that although skill learning is primarily a continuous process,it involves three different phases.

The "*early phase*"; covers only the time required to understand instructions, to complete a few preliminary trials, and to establish the proper cognitive set for the task. In learning how to drive a car, one attends to kinesthetic and visual information about the hands and feet, information which is later acted upon automatically. At this phase instructions and demonstrations are the most effectivemeans of communicating the initial set of short, fixed, sequences necessary to perform the task. This collection of units is called a cognitive set.

The "*intermediate phase*", involves learning to make certain associations and to respond to specific cues, while at the same time mastering the cognitive sets. At this phase the errors become less and less gross in nature. The learners are now concentrating on refining the skill. They have developed an ability to detect some of their errors in performing the task but this ability to locate their errors is not perfect. Thus an inexperienced driver may be able to get the car moving, but often he, or she, still makes some mistake in pressing the clutch instead of the brakes. However, the learner is able to notice that he or she did not transfer their feet properly, grip the steering wheel correctly, and so on. Such types of detection are of a rather elementary nature but represent a definite step forward in the learning process. At this phase variability of performance from one attempt to another also begins to decrease.

The third and "***final phase***" is that in which the cognitive processes, such as verbal mediation, are no longer in evidence, but in which repeated practice of the skill makes it become progressively more automatic. The individual no longer has to attend to every phase of the skill, but has learned to perform most of the skill automatically. Highly skilled drivers concentrate on the road, and some of the specific adjustments that they must make in their everyday driving to make a particular journey. They do not think about each individual move of the driving routine, for these have become automatic. Instead, they have learned to concentrate on those of the more critical aspects of the skill, that are particularly difficult.

In this phase, skilled performers are now able, not only to detect their own errors, but also to make the proper adjustments to correct them. The autonomous phase is the result of a tremendous amount of practice; it allows performers to produce a response without having to concentrate on the entire skill movement. The classic study in this field is Crossman's (1959) study of cigar rollers. The time to operate a cigar-rolling machine decreased over a period of four years, by which time a person reached the maximum degree of skill required to reach the mechanical operating limit of the machine.

Fitts & Posner (1967) label Fitts' three-stage-model in order to describe the activity in each of the stages:

Stage (1): Cognitive.

Stage (2): Associative.

Stage (3): Autonomous.

1.1.1. Brief introduction to learning theories

Two important learning theories appeared in the early seventies. The first was proposed by Adams (1971) as the Closed-loop Theory, and the second was Schmidt's (1975) Schema Theory.

1.1.2. Adams' Theory

The basis for any closed-loop theory is a reference mechanism for error assessment, which can be used to compare a movement being made with performance in the past. In Adams' theory, this reference mechanism is called the *perceptual trace*. It involves the memory of past movements and is responsible for determining the quality of a movement in progress. This trace must be developed by appropriate practice of the movement being learned. Information is fed back by means of sensory pathways from the muscles, joints, eyes, ears, and so on. Adams' concept of the perceptual trace depends on the availability of knowledge of results (KR). As a part of practice, the individual combines this KR information with the feedback information received through his or her own sensory system. Eventually, the perceptual trace becomes strong enough for the individual to be able to detect and correct his or her own error when making the movements. When this occurs, Adams indicates that the individual has moved from the verbal-motor stage of learning into the motor stage of learning, where the movement can be made "automatically".

Adams considered the perceptual trace as the reference mechanism used to establish how far a limb movement should go. He needed to specify a mechanism for getting the limb moving in the first place, and in the proper direction. To accommodate this need, Adams proposed *memory trace*, as a mechanism by which to "select and initiate a response, preceding the use of the perceptual trace". The memory trace is also developed as a result of practice, but, in contrast to the perceptual trace, was described by Adams as a "modest motor program". That is, this trace does not operate as a closed-loop system, but an open-loop that sends out all the necessary information to initiate the movement. No feedback information is needed to accomplish this task.

Adams saw KR as information to be used in conjunction with the perceptual trace in order to make the next response different from the last one by having fewer errors. A number of reviews include the empirical work on KR, which showed how it is undeniably a strong variable component in motor learning (Adams, 1971; Annett, 1969; Newell, 1976; Salmoni, Schmidt & Walter, 1984).

The crucial assumption of Adam's closed-loop theory is that feedback has a strong role to play. Comparison of performance in skill-acquisition trials with KR, and in trials without KR, should reveal just how strong. Furthermore, the greater the experience with feedback over trials, the more stable subsequent performance should be in trials with KR withdrawn. In short, Adams considered as feedback essential to the error detection and correction which is basic to of a closed-loop system. Finally the memory trace starts the movement independent of feedback, and the perceptual trace regulates the movement after it has started. Adams supported his theory with evidence from the studies that follow.

To investigate the importance of feedback in regulating movement, Adams, Gopher & Lintern (1977) examined the effects of visual and proprioceptive feedback on motor learning. There were fourteen groups. The subjects learned a self-paced displacement of the arm by moving a slide along a linear track. The conditions of feedback were either augmented or minimal. Specifically, there was (a) augmented visual feedback, where a subject could see the apparatus and his movement, or minimal visual feedback, where visual cues were absent, (b) augmented proprioceptive feedback, where spring tension was on the slide, or minimal proprioceptive feedback, where the spring tension was removed from the slide, or (c) combinations of these four conditions. Seven groups had 15 and the other seven had 150 acquisition trials with KR before being given 50 test trials without KR. The results showed that when proprioceptive and visual feedback are varied, the greater the feedback the better the performance on trials both with and without KR.

Newell (1974) investigated the effect of withdrawing KR on motor learning. The task was to move a slide along a horizontal linear trackway. Subjects were randomly assigned to one of seven independent experimental conditions, with 20 subjects per group. The groups were as follows:- group one had KR withdrawn after Trial 2, group two had KR withdrawn after Trial 7, group three had KR withdrawn after Trial 17, group four had KR withdrawn after Trial 32, group five had KR withdrawn after Trial 52, group six was given KR after every trial, and group seven had no KR after any trial. The results showed that the greater the number of acquisition trials with KR, the greater the performance stability when KR is withdrawn. Furthermore, the greater the number of acquisition trials with KR, the greater the subject's capability for estimating the accuracy of response (Adams, Gopher & Lintern,1977; Newell & Chew, 1974). Thus, the most common finding is, that the more trials there are with KR, the more steady the performance is (Adams, Gopher & Lintern, 1977; Newell, 1974; Newell & Chew, 1974).

Newell (1976b) had different results in his study to investigate the ability of a response recognition mechanism. Newell reasoned that if observational learning techniques were used to give perceptual experience with feedback stimuli, the subject should develop a strong perceptual trace, even though no movement had been made. When given practice on the motor task, without KR, the subject should learn, because the perceptual trace is the basis for error perception, corresponding to KR from an external source. The task was to learn to move a slide over a 10.16cm. distance, in 100ms. The subject first listened to a tape-recording of instructions for the movement, and observed a demonstration by the experimenter of how the slide moved. The subject then attempted the task without KR. The results showed that there was a positive transfer from the auditory pre-training as well as some improvement with repetition.

Feedback and the amount of practice were related to error detection and correction (Adams & Goetz, 1973), which are essential for a closed-loop system, but are feedback and the perceptual trace independent of each other? Newell & Chew (1974) used a fast ballistic movement, and argued that after practice the elimination of auditory and visual feedback should affect error estimation based on the perceptual trace, but not response initiation, based on the memory trace. Their results were positive.

Schmidt (1975) argued that because of delays in processing feedback, the subject needs to become less and less dependent upon feedback for performance. During learning the emphasis shifts from the feedback-controlled jerky performance to the smooth execution of almost completely open-loop movement. Thus, the problem for the subject in learning motor skills, is to develop these open-loop programs, and free himself from feedback involvement. Schmidt accommodated his criticisms of Adams' Closed-loop theory on motor learning , in what he called the Schema Theory.

1.1.3. Schmidt's Schema Theory

In 1975 Richard Schmidt presented an alternative theory of motor learning. Rather than considering the memory and perceptual traces as the control mechanisms of a movement, the theory presented schemas. A schema is an outline of a set of rules that serves to provide the basis for a decision.

Schmidt stated that we learn on the basis of abstracting different pieces of information about each movement, and throughout these experiences, we construct a schema, or an outline, which will enable us successfully to carry out the movement. He proposed that four items of information are involved in the abstraction for each movement, thus:-

> 1) The Initial Condition, which involves such things as the position of limbs and body in relation to the response before it is made.

2) The Response Specifications, which involve the stored information, by the performer, on the specific , such as direction, speed, force, etc............, for carrying out the movement.

3) The Sensory Consequences of the Movement, which are determinedfrom sensory feedback received through the various sensory systems during, and after the movement is actually made.

4) The Response Outcome, where the information needed to compare the actual outcome with the intended outcome is abstracted from the response outcome.

The schema of the motor response is actually made of two schemas. First is the *recall schema* , which is involved in the production of a desired movement. It acts together with the generalized motor program, which Schmidt views as an abstract memory structure, to initiate a desired movement in accordance with the demands of the situation. The recall schema sets the specific parameters, or rules, that the program must follow in order to produce the required response. The recall schema is developed on the basis of abstracting and storing information about responses that have been made in the past. Three sources of information are necessary to develop the recall schema. 1) Information obtained about the initial conditions of the response situation. 2) Information indicating the response specifications from past responses requiring similar movements which has been stored. 3) Information about the outcome of the previous responses.

To continue and terminate the movement, Schmidt proposed the recognition schema. This schema is the reference mechanism used to compare sensory feedback with a particular movement. It is developed in the same way as the recall schema, by abstracting information from past experiences. In particular, the information abstracted and stored is comprised of the initial conditions of each response, past response outcomes, and actual sensory feedback, related to those past responses. Schmidt finds support for his theory in the results of a number of studies.

One of the main assumptions of the schema theory, is that the subject develops a recognition schema over the course of practice with KR, and that he uses the comparison of the actual feedback and the expected sensory consequences generated on each trial as the mechanism by which he arrives at the correct response. The evidence was evaluated by Schmidt from the results of a study by Bilodeau, Bilodeau & Schumsky (1959) on the effects of introducing and withdrawing KR early and late in practice. These results showed that no learning can occur without KR. The theory also predicts that error detection will increase with KR practice. Newell (1974) and Newell & Chew (1974) have shown this quite clearly (see explanation of Adams theory).

Schmidt's theory then, emphasizes the abstract, or general nature of what is stored in the control centre, as opposed to Adams' more specific view of what is represented.

1.1.4 Similarities between Adams' & Schmidt's Theories

The motor learning theories of Adams (1971) and Schmidt (1975) have some important similarities. Both are based on the important role of feedback information from the senses, and both incorporate a role for motor programs. Both theories suggest memory related constructs in which information is stored and which are directly involved in the initiation and carrying out of a response. The two theories assign an important role to KR information during the learning of motor skills. Both indicate that as a result of the appropriate amount and type of practice, learners can produce correct responses with the aid of KR, and each theory establishes a means for the performer to detect an error either while the movement is being performed or before another movement is made.

1.1.5. Cognitive processes

In spite of what the Fitts (1964) and Fitts & Posner (1967) models show about the existence of the cognitive processes in the early stages of skill learning, we still know little more about the actual role of cognitive processes in the development of skill learning (Newell, 1981).

What does Cognitive imply?

1) Cognitive processes are conscious and dependable, e.g. a chess player is aware of every piece he/she moves when playing, and can also rely on his skill knowledge in making each move correctly.

2) Cognitive processes are variable and adaptable, e.g a chess player can change his/her playing strategy in each different chess game, and can use this strategy in any other game that would require similar moves as in chess.

3) Cognitive processes involve access to, and from, a knowledge base e.g. the chess player can get access to a cognitive map and use it in any way he/she chooses to achieve the goal. Tolman (1948) was the first to use the term 'cognitive map' in his description of the spatial knowledge that seemed to be acquired by rats in a maze. In a typical experiment, a group of rats was trained to go down a particular path to reach food in a goal box. When the original path was blocked, many of the rats selected another path that also led in the direction of the goal. They had learned more than just a sequence of responses that would lead to the goal.

An example of the cognitive aspects of motor acts is the memory and recall of movement. Brewer & Pani (1985) argued that, even if there is agreement that conscious processes occur during the early stages of the acquisition of a motor skill, it is not clear exactly what types of processes these are. For example, they may involve motor images, imageless thoughts, or other types of memory representation used in "effort after production".

If it is the case that memory representation of motor acts is by nature unclear and difficult to investigate, then this deserves greater attention, since it is the purpose of science to explain, not to ignore.

The correlation between memory representation and reproduction of that movements, forms the cognitive basis of motor learning. Learning a new skill is based on the acquisition of knowledge which is stored in memory and can be saved up, or retrieved. Memory representation can be thought of as involving both symbolic and imaginal (non-symbolic) codes.

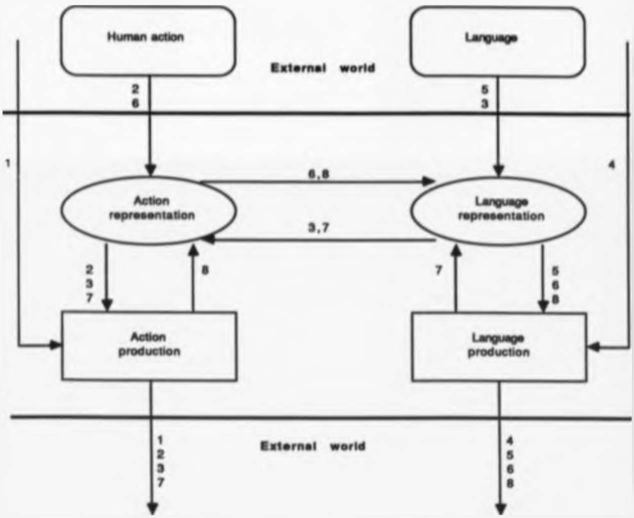
In the case of observational learning, Gerst (1971), Bandura & Jeffery (1973), Bandura, Jeffery & Bachicha (1974) and Jeffery (1976) have shown that symbolic coding plays an important role in representational development, whilst Carroll & Bandura, (1982, 1985, 1987;) Bandura & Jeffery, (1973;) and Martens, Burwitz & Zuckerman, (1976) have also shown the importance of imaginal coding in the cognitive process. Moreover, some of these studies have shown that a combined coding strategy would lead to more accurate recall of the motor task (Bandura & Jeffery, 1973; Jeffery, 1976).

Because the main effects of coding strategies occur within memory, it is impossible to distinguish the effects of coding processes without identifying memory representations. A full explanation of imaginal coding of motor movement must include an understanding of how these movements are represented in memory.

1.1.6. Annett's proposed theory:

One way to investigate the cognitive processes, presumed to be involved in the acquisition of motor skills was proposed by Annett (1982) in his "Action, Language and Imagination" paper. He was particularly interested in the relationship between verbal (symbolic) and motor (non-symbolic) processes. Annetts proposed model (Figure 1.1) shows two important subsets of entities: the top part of the figure represents input of two kinds - visually perceived human action and language input, such as verbal instructions; the middle part of the diagram represents the internal processes which can lead to two kinds of overt response (as shown in the figure).

Figure 1.1. Action, language and imagination



(Adapted from Annett, 1982)

He also stated that there are eight possible ways in which output can be accrued, which he thought of as routes through the model. The model describes six basic experiments as routes from the external world of objects and events, three of which produce the actions shown on the left side of the diagram and three of which produce the verbalizations shown on the right of the diagram.

> Route(1):- Refers to any experiment in which an object or event (excluding human action or language) evokes a non-verbal response, e.g. a tracking task.
>
> Route(2):- Refers to any experiment in which the input and output are non-verbal actions, e.g. a task of imitating human movements.
>
> Route(3):- Refers to any experiment in which the input is verbal and the output is non-verbal e.g. a task involving verbal instructions in order to produce motor movement.
>
> Route(4):- Refers to any experiment in which an object or event evokes a verbal response, e.g. a task of naming or describing something.

Routes (1) & (4) are of no particular interest in the context of this thesis, they were merely mentioned here to give a complete description of Annett's diagram.

Route(5):- Refers to any experiment in which a verbal input and verbal output represent the task of reading, with a time interval between input and output.

Route(6):- Refers to any experiment in which the input is non-verbal and the output is verbal, e.g. a task of describing the actions of other individuals.

Annett suggested that in Routes (3) & (6) both tasks described are symmetrical, and involve transactions across the hypothetical action/language bridge.

The central part of the diagram is also divided horizontally into representation and production processes, which are theoretically separable, depending on how one views the nature of the internal processes depicted in Figure 1.1. Annett in fact defined two routes, which both involve memory.

Route(7):- Refers to any experiment in which the individual could give, from the stored representation of an action, or sequence of actions, a verbal account, e.g. a task of asking subjects how they would perform a given action, such as swimming the breaststroke, tying a knot, getting from A to B, and so on (Annett, Kiss & Perera, 1978; Annett, 1986). Subjects are thus required to produce a verbal account based on some form of memorized or imagined representation of the action.

Route(8):- Refers to any experiment in which the individual refers to the verbal representation of an action or sequence of actions, to produce the corresponding action, e.g. a task of following a route through a strange city on the basis of a remembered set of instructions.

Routes (3), (6), (7) & (8) all imply a translation between verbal and non-verbal coding, that is the hypothetical action/language bridge.

Having briefly outlined Annetts (1982) model, and the kinds of experiments thought to be relevant to all routes in the diagram, we now turn to the central theoretical assumptions underlying the model

1) There are largely independent systems concerned with the perception and production of actions, and with the perception and production of language.
2) The perceptual, or representational aspect, of each of these systems is intimately linked with the relevant action, or utterance, production mechanisms.
3) There is an action/language bridge which can carry traffic in either direction.
4) The transactions across the bridge must be conducted in a common currency.

The key issues concern how actions are represented, what kind of coding enables us to perceive and comprehend the actions of other people to produce similar actions ourselves, and how to translate relatively easily between actions and the appropriate descriptive vocabulary and to follow instructions.

Moreover, Annett (1985), in his review of the cognitive processes in motor learning, accepted the distinction between cognitive and non-cognitive processes in motor learning in the proposed model of Fitts (1964) and Fitts & Posner (1967). Annett reviewed some of the previous studies of the two important kinds of cognitive processes, those which involve imaginal (non-verbal) and those which involve symbolic representations. He concluded that all actions seem to benefit from a kind of dual coding, in which some aspects are capable of being represented in images, principally visual in nature, and which represent important spatial characteristics of the task. He also stated that at the same time some of these motor codes might be "pure", that is, not accessible to consciousness but manifested in the ability to produce actions. In that connection Annett's works (1982, 1985) will be discussed more fully in the following chapters of this thesis because of his recognition of the important role of the cognitive processes in skill acquisition.

It can be concluded from all three theories of motor learning that we have just presented that there is a growing appreciation in motor skill learning of the cognitive approach.

Cognitive learning theories stress the importance of higher mental processes, such as attitudes, beliefs, and perceptions. Cognitive theorists are interested in intellectual processes, and they investigate the ways subjects develop and use rules of logic, problem solving, and language. Obviously, the subjects of their studies are almost exclusively human beings.

1.1.7. Automatic and controlled processing

By contrast, Schneider & Shiffrin (1977) presented a motor learning theory called Automatic and Controlled Processing Theory. This claimed that motor learning can occur without the involvement of any cognitive processes, assuming that automatic processing is generally a fast, parallel, fairly effortless process that is not limited by short-term memory capacity, is not under direct subject control, and performs well-developed skilled behaviours. It typically develops when subjects process stimuli in consistent fashion over many trials; it is difficult to suppress, modify, or ignore, once learned. Controlled processing is often slow, generally serial, takes much energy, is capacity limited, and subject regulated, and is used to deal with novel or inconsistent information. It is needed in situations where the required response varies from one trial, or situation, to the next, and is easily modified, suppressed, or ignored at the desire of the subject. Finally, all tasks are carried out by complex mixtures of controlled and automatic processes used in combination. Shiffrin & Schneider used the results of roughly 14 experiments, reported in Schneider & Shiffrin (1977), and Shiffrin & Schneider (1977) to support their theory.

Spelke, Hirst & Neisser (1976) have studied the development of skills for attending to, and acting on, two simultaneous messages. Two subjects participated in the study. The tasks involved the subjects reading short stories to themselves while dictating a list of words at the same time. The results of the experiment showed that, as the subjects had more practice, they were able to copy words, detect relationship between words, and categorize words for meaning, while reading as effectively and as rapidly as when reading was the only task, to be performed. From this it was suggested that learning to perform the two tasks at the same time was developed by automatic and controlled processing.

Although the research in this thesis is primarily concerned with cognitive learning, it was essential to present an outline of this theory in order to understand how we learn and control movements.

Having discussed Adams', Schmidt's, Schneider & Shiffrin's theories, it seems that the three theories have certain limitations, e.g. Adams' and Schmidt's theories were based on the important role of feedback information from the senses while Schneider & Shiffrin's theory was based on the important role of overt practice. However, in the case of observational learning, if the spatial and temporal feature of modelled behavior can be easily determined, encoded, and cognitively rehearsed, accurate reproduction can be achieved with little or no overt practice or response feedback (Bandura, Jeffery, 1973; Gerst, 1971).

The three theories were limited to either slow limb-positioning movements, rapid ballistic movements, or item recognition tasks. They didn't give an explanation of what type of coding strategies the learner used in order to understand how to execute the movements of the task, or if the task involved long sequential movements, what were the crucial aspects of the movements that the learner coded into memory, in order to recall the motor task.

At this point in time, it is essential for us to investigate and determine advantages of the cognitive processes and appropriate learning strategies for learning a sequential motor task, and the effect of individual ability upon learning the task.

The most popular methods for conveying information about the goal and appropriate action sequences are verbal instructions and observational learning, but to introduce to the learner the goal of the act together with the actions that will accomplish the desired outcome, instructors automatically resort to observational learning methods to supplement verbal instructions. Adams (1987) emphasized that observational learning was underdeveloped for a long time until the 1970s, when Bandura presented his social learning theory. However, because both instructional methods involve cognitive processes, one might use both techniques to look more closely at Annett's (1982) model, and one can examine how these cognitive processes are being represented in their analogue (non-symbolic) form, and what type of human characteristics could have some affect on these kinds of cognitive processes.

The following chapter will discuss theories and studies on observational learning.

Chapter (2)

Observational Learning

In order to investigate how actions are reproduced and what kind of coding enables us to perceive and comprehend the action of other people, it was essential to explore in detail the middle part of the diagram in figure 1.1 by conducting a few experiments to establish what internal processes lead to of overt performance. Two instructional methods were used, observational learning and verbal instruction, to bring about overt performance and make it possible to detect mismatches between performance and coded images.

In this thesis we are considering imitation as the given instruction to the learner, who has observed a modelled demonstration of a motor task.

2.1. Observational Learning and Imitation

The study of imitation has a history dating back to the early work of Tarde (1903) and Mcdougall (1908). These researchers suggested that the idea of model imitation was basic to the philosophical nature of the field at that time. Later imitation was reinterpreted as a function of associative or instrumental conditioning (Allport,1924; Holt, 1931; Humphry, 1921; Miller & Dollard, 1941). However, the process of learning by example has been interpreted by psychologists in a number of different ways, but most frequently emphasized is the observational aspect. Observational learning has been the main concern of some cognitive psychologists since the introduction of Sheffield's Symbolic Representational Theory (1961).

2.1.1. Sheffield's Symbolic Representational Theory

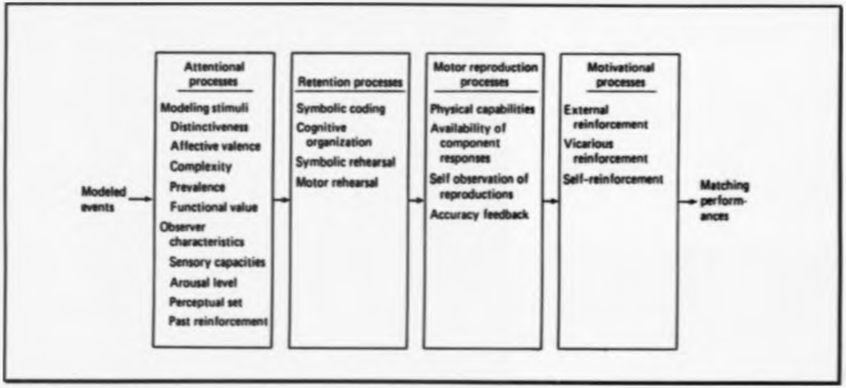
Sheffield (1961) based his Symbolic Representational Theory upon research concerned with the effectiveness of using filmed demonstrations in communicating motor skills. He found that when an individual observes a demonstration of a motor skill, he or she formulates a cognitive symbolic representation of that skill, which subsequently acts as a blueprint to guide him or her inthe overt reproduction of the skill. This perceptual blueprint enables the individual to recall the modelled act symbolically, and translate this sequence of symbols into overt performance.

Despite this important early work by Sheffield and his associates, many important questions relating to observational learning for effective reproduction remain unanswered. Bandura (1971, 1977, 1986), with his Social Cognitive Learning Theory, advanced our knowledge of the processes involved and stimulated a great deal of research on observational learning.

2.1.2. Bandura's Social Cognitive Learning Theory

Bandura's *Social Cognitive Learning Theory* is the most influential theory on observational learning referred to today. Bandura emphasizes four interrelated sub-processes. The processes and some of the variables affecting them are shown in Figure 2.1.

Figure 2.1 Component subprocesses in the social learning analysis of observational learning. (Adapted from Bandura, 1971).



The first process is the attentional process, which determines what is selectively observed and what information is extracted from on-going modelled events. Minas (1980) and Yussen (1974) have shown that observational learning is enhanced by factors that channel attention to critical features of modelled performance.

The second major subfunction in observational learning concerns the retention process. If modelling influences are to have enduring effects, the modelled information must be transformed and restructured into appropriate symbolic representations which function as internal models for action (Bandura & Jeffery, 1973; Bandura, Jeffery & Bachicha, 1974; Gerst, 1971; Jeffery, 1976; Scully & Newell, 1985).

The third subfunction of modelling is the production process which involves translating the cognitive processes of the modelled activities into appropriate actions. The behaviour is modified by the process of comparison to achieve close correspondence between the internal processes and action. With representational development and internal transformation of conception to corresponding action, reliance on performance feedback should decrease (Carroll & Bandura, 1982).

The fourth subfunction is the motivational process, which is concerned with incentive factors that govern observational learning and performance. Incentive factors facilitate acquisition through their impact on attentional and retentional processes, and affect performance by motivating observers to execute what they have learned observationally. The motivators may be extrinsic, vicarious or self-generated by means of internal standards (Bandura, 1984).

Here my primary concern is with the retention process, which is the second subfunction in *Bandura's Cognitive Learning Theory*. Observational learning in humans involves two representational systems imaginal and verbal. During exposure to modelling stimuli, sequences of corresponding sensory experiences (images) occur and appear to become associated, or integrated, by mere contiguity (Sheffield, 1961). Both Bandura and Sheffield described this response acquisition phase of observational learning.

2.1.3. Cognitive processes in observational learning

Two cognitive processes symbolic/verbal and imaginal/non-verbal seem to be involved in retaining information in observational learning and studies have shown the importance of both.

2.1.4. Symbolic/verbal codes in cognitive representation

Researchers have shown that there are certain cognitive activities that aid representational development, such as symbolic coding, for both children (Bandura, Grusec, & Menlove, 1966; Coates & Hartup, 1969) and adults (Bandura & Jeffery, 1973; Bandura, Jeffery & Bachicha, 1974; Gerst, 1971; Jeffery, 1976; Scully & Newell, 1985).

Bandura, Grusec, & Menlove (1966) have investigated the effects of symbolization on delayed reproduction of modelling stimuli. A group of children between the ages of 6 and 8 years were tested in three different conditions concurrent verbalization, passive learning and competing verbalization. Half of the children in each of the treatment conditions observed the models under a positive incentive set. The remaining subjects were provided with an incentive to learn the model's responses. The stimuli task consisted of watching a 4-minute colour film in which an adult male model exhibited a series of relatively novel patterns of behaviour. The results provided evidence for the facilitative role of symbolization in observational learning, and that observational learning was not influenced by incentive sets.

Furthermore, Coates & Hartup (1969) also examined the effects of verbalization in observational learning. Children between the age of 7 and 8 years were tested in demonstrating the matching responses of the model under one of the three conditions, induced verbalization, free verbalization, and passive observation. A 7-minute colour film depicting the behaviour of a male model was used. The model displayed 20 critical characteristics. The results demonstrated developmental changes in the role of verbalization in observational learning.

Other studies have examined the role of symbolic coding in the development of cognitive representation in adults undergoing observational learning.

Gerst (1971) investigated several procedures by which individuals could commit to memory a demonstration of a motor task. Subjects were assigned to three experimental conditions and one control condition. Each group was instructed to use a mental image, a verbal description or a concise label of a modelled act. The control group was instructed not to use any coding strategy. The modelling stimuli that the subjects observed and later reproduced were motoric responses from the language of the deaf. The results demonstrated the enhancement of the imaginal coding on observational learning. They also provided evidence that symbolic coding operation play an important role in observational learning.

Furthermore, Bandura & Jeffery (1973) examined the effects of symbolic coding and different types of rehearsal on retention of modelled performance. The task was a six component action that appeared in varying combinations in the more complex modelled performance. The results showed that most subjects in the non-coders immediate response reproduction condition, created their own coding strategy using direction and length of movements as a means of representing the models action. This also provided further evidence to support Grest's work on the importance of symbolic processes in determining both the level of observational learning and the retention of modelled responses over time.

Further evidence was provided by the work of Bandura, Jeffery, & Bachicha (1974) when they examined the influence of memory codes and cumulative rehearsal on observational learning. The modelling stimuli were identical to those used in the experiment of Bandura & Jeffery (1973). Their results lend further support to the finding that symbolic codes enhance observational learning and retention of modelled behaviour.

The work of Jeffery (1976) on the influence of symbolic and motor rehearsal in observational learning, was concerned with the effects of mode and patterning of rehearsal on the acquisition and retention of modelled activities varying in organizational complexity. Subjects observed a model performing manual construction tasks, having either high or low organizational requirements. Immediately after exposure to the model, subjects rehearsed the task either symbolically, motorically, symbolically and then motorically, or motorically and then symbolically.

A control group engaged in a distraction task to prevent any opportunities for rehearsal. The results from the subjects performance reflected the influential role that symbolic codes play in the acquisition and retention of modelled acts.

These studies demonstrated that observers who transform modelled actions into either descriptive words, linguistic constructions resembling familiar activities, or visual imagery achieve a higher level of observational learning

2.1.5. Imaginal/non-verbal coding in the cognitive representation

Cognitive representation may differ in a variety of dimensions, depending on whether the modality is primarily symbolic/verbal or imaginal/nonverbal. A number of studies were carried out on observational learning in order to investigate how information was being coded in the cognitive representational form. The results revealed that coding is not strictly symbolic/verbal form but also involves an imaginal/nonverbal form (Bandura & Jeffery, 1973; Martens, Burwitz, & Zuckerman. 1976; Carroll & Bandura, 1982, 1985, 1987).

Martens, Burwitz, & Zuckerman (1976) have investigated modelling effects on motor performance. Four experiments have been carried out to examine the influence of observing a correct model, a learning sequence model, and an incorrect model, on the performance of two motor skills. The findings from the fourth experiment suggested that information is coded and conveyed through observation in order to function in the development of the cognitive components of a motor task.

Likewise, Carroll & Bandura (1982) demonstrated the importance of making observable those parts of the model's movements that are normally out of view. A complex arm movement was modelled, and a television system was used to make the unobservable sides of the movements observable. The task was to perform a modelled response of a sequence of nine different response components which varied as to the spatial attributes of the paddle, arm, and wrist. The results from the experiment were consistent with the proposition that actions are first organized cognitively before being successfully enacted. Furthermore, Carroll & Bandura (1985, 1987), using the same modelled action pattern that was used in their prior experiment (Carroll & Bandura, 1982), studied the role of timing visual monitoring and translating cognition into action in observational learning. The results from the two studies lend more support to the assumption that subjects achieved some cognitive representation of the modelled activity before reproducing the movement pattern.

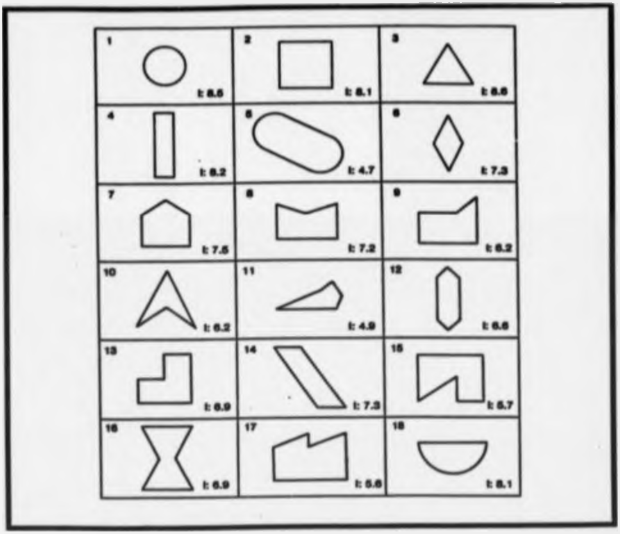
2.1.6. Meaningfulness of the cognitive representation

The ease with which a stimulus evokes an image is assumed to be related to the performance of a remembered task. The more meaningful and available the image, the better the performance. The importance of meaningfulness to the cognitive processes in observational learning has been shown by Bandura & Jeffery, (1973) Bandura, Jeffery, & Bachich, (1974).

Moreover, the memory of movements is influenced by their meaningfulness. A movement can be considered meaningful to an individual if that person can readily relate the movement to something already known. For example, a movement that forms the shape of a triangle is considered more meaningful than one that makes an unfamiliar, abstract pattern.

Hall (1980) has provided evidence on how movement meaningfulness influences remembering the movement pattern. Subjects were presented with closed multidimensional movements (as shown in Figure 2.2) by means of a pantograph, a movement device that allows the subject to make the exact same arm movement as the experimenter. The recognition test was to ask subjects to indicate whether or not each pattern was the one just practised, after moving them through a series of patterns.

Figure 2.2. The 18 series of patterns Hall used in his study. (Adapted from Hall, 1980)



Hall's experiment, among others, suggests that movements have some inherent meaningfulness to people. The more meaningful a movement is to a person, the easier it is to remember that movement. This point is an important one to be considered when providing instructions to students to help them remember how to perform a skill. We will come back to it later (in experiment 3), when we consider strategies that influence coding or the memory of a sequential motor task.

2.2. Verbal instruction

It is clear that observation provides useful information about appropriate behaviour. A model can quickly and efficiently convey what to do, or give a precise image of a task's demands. Verbal instruction can do this also, more efficiently for some skills but usually less efficiently for motor skills.

Annett (1989) has pointed out the action/language bridge, Figure (1.1), required the assumption of an internal representation of action which is somehow accessible to, and modifiable by, both the perceived actions of others and verbal instruction. This representational system must be able to access output mechanisms so that perceived action can be imitated and verbal instruction can be obeyed.

Verbal instruction presents us with both, a translation problem and a control problem how words are expressed in actions and how actions are expressed in words, and how some instructions, once lodged in verbal memory, come to control the on-going actions of the learner, but other instructions used to control initial actions, drop out of consciousness after practice and play no further part.

Learning a complex motor task under verbal instruction depends in part on how many individual action instructions there are, and in part on how translatable they are, how easily words evoke action, and how well actions are described.

Hinsley, Hayes & Simon (1977) have defined " understanding a set of instructions " as the individual ability to recognize problem categories, to programme oneself to attempt the task, and to employ this program or action plan to deal with it. It is not a requirement that the plan should be immediately successful since it may take many moves to solve the problem.

2.2.1. Understanding & coding verbal instructions

In order to understand a verbal instruction, one has to create an appropriate plan of action in order to execute the task. The plan may appear relatively easy or difficult depending on the way in which the information is presented to the subject. Carpenter & Just (1976) have shown the importance of grammatical structure and choice of words: for instance, a direct inference sentence like " The millionaire died " takes less time to be understood (processed) than " The Millionaire was murdered ", because of the implications of the word "murdered".

Another important aspect of instruction is that it often contain two elements, a condition and an action. Dixon (1982) has carried out three experiments to examine plans and written directions for complex tasks. The task of sentence reading was used. The subject was shown a video display and control panel, and told that they represented an imaginary

The task of sentence reading was used. The subject was shown a video display and control panel, and told that they represented an imaginary electronic device that he/she would have to operate. In order to perform the task, the subject had to follow the directions presented on each trial. Each time the subject pressed a foot pedal, a single sentence describing one of the steps appeared at the bottom of the video display. For instance, the display might read " **The left knob should be turned in order to set the alpha meter to 20** " this sentence would then remain in view until the subject pressed the foot pedal to see the next sentence. The results of the experiments led Dixon to suggest that when the individual is reading instructions he/she may prefer to create plans in a form which places actions first and conditions second.

Wright & Hull (1986, 1988) have investigated the process of encoding instructions, using reaction time (RT) techniques, and a question-answering task, with such words as "unless" in the question sentence "Unless the light comes on, check the fuse", seems to be associated with a strong presupposition that the action mentioned will be carried out, whereas " if not " seems to suggest that when the conditional event is relatively unexpected. They found that differences in degrees of expectation of conditional events arose from the recoding operations readers applied, not necessarily consciously, to "unless". They also suggested that "unless" might be recoded as "Do not............ if..........." with the negative element being transferred from the condition to the action information.

Verbal instructions apparently can guide performance of a motor task. Some cognitive process seems to be involved when verbal instructions are administered to a novice. Coding information from verbal instructions should fulfil the same role as coding information from observational learning techniques, in developing some label or image that represents several units of information.

2.3. <u>Memory</u>

Memory is an important component in our processing of information in order to produce the desired response. Many situations require the use of memory, e.g. conversation with someone, working out a mathematical problem, or just playing tennis and so on ....

We often think of memory as being synonymous with retention or rememberance. Howe (1970) stated that the word memory " is used to denote a capacity to remember; it is not an explanation of remembering " (p.4). The study of human memory involves a variety of topics but one need not discuss them all, because we are mainly concerned with memory for movement and for verbal information.

'Retention' is a key word in the understanding of human memory. Adams (1983) has suggested that investigators of memory for movement should concern themselves with memory for variables which are seen as important for movement, such as, knowledge of results, practice repetitions, cognitive processes, and verbal encoding of movement, whatever is judged to be determinant of movement and the retention process.

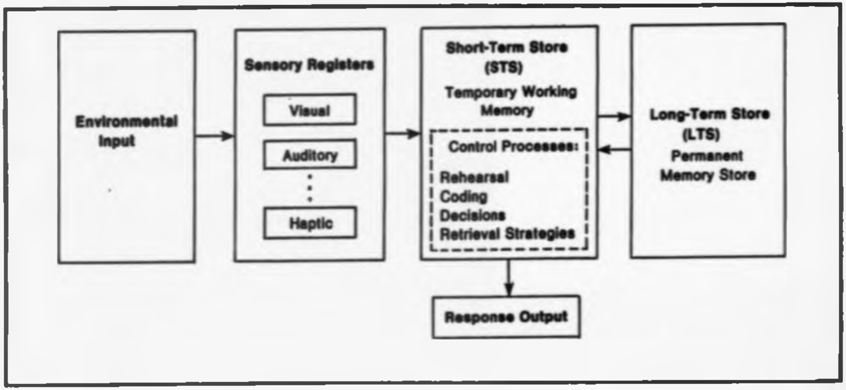
2.3.1. Functional components of memory

There have been many attempts to provide theoretical explanations of memory. These hypothetical clarifications have come primarily from two perspectives. One of these is proposed by the experimental, or cognitive psychologist, the other by the neuropsychologist, who is interested in explaining the structure of memory in term of what is occurring in the nervous system during behavioural changes that are related to memory.

I will limit my consideration of the structure of memory, to the approaches that have been developed bythe cognitive psychologist, who infers the structure of memory from its function as observed in the behaviour of individuals in memory situations.

Atkinson & Shiffrin (1968) have presented their model and theory of memory structures. The structures are best visualized as lying along a continuum (Figure 2.3), with each store representing a phase or stage of memory. However, the model has placed too much emphasis on where information resides rather than on what a person actively does with the information. According to the stage model (Figure 2.3), information is lost or forgotten in the memory store in which it happens to be.

Figure 2.3 The memory structures of Atkinson & Shiffrin. (Adapted from Atkinson & Shiffrin, 1968).



In this respect, Baddeley & Hitch (1974) & Baddeley (1981) suggested a component called working memory. In many ways working memory is similar to the sensory and short-term memory. For example, information seems to have a relatively short life in working memory. However, the important difference is that this short life is not due to the information being in working memory, but to the information not having been adequately processed by the individual to make it more resistant to being lost from memory.

2.3.2. Short-term memory (STM) & Long-term memory (LTM)

A recall test requires the person to produce a required response with few, if any, available cues or aids. In the verbal domain, recall tests typically takes the form of an essay. In motor tasks, a recall test asks the subject to respond to a certain instruction, such as " **move your arm to produce the correct distance** ", or asks the subject to reproduce a certain movement that has been observed from a demonstration.

Much of what we know about the characteristics of the information, duration, and capacity, of working memory comes from research that is typically labeled short-term memory research. Peterson & Peterson (1959) were two of the earliest psychologists to report research on this problem. They examined short-term retention of individual verbal items. Two experiments were carried out. The task was to recall 48 consonant syllables and 48 three-digit numbers. Their finding were simple and straightforward. They showed that subjects tend to lose information from short-term memory after only about 20 to 30 seconds. Other research followed shortly, supporting the notion of brief duration of information in short-term memory.

In that connection Adams & Dijkstra (1966) investigated short-term memory for motor response. The concept of their experiments was quite simple. Basically, the idea was that verbal information and motor information in short-term memory should have the same duration. Subjects were blindfolded and seated in front of a linear positioning task, which was simply a free moving handle that slid along a metal rod. The results of those experiments generally supported the notion that the duration of kinesthetic information in short-term memory is about 20-30 seconds.

In short, these studies suggested that verbal or motor information in the short-term storage stage of memory remains there for a rather brief time, approximately 20-30 seconds, before it begins to be lost from memory.

The question now is how much information we can accommodate in short-term storage. Posner (1963) stated that the capacity of short-term memory becomes the limiting factor for the reproduction of sequential, verbal, or visual information when " nearly complete representation of the stimulus (input) was required in the response " (p.333).

George Miller (1956) in his classic article on memory, provided evidence to indicate that we have the capacity to hold about seven items (plus or minus two items), such as words or digits, in short-term storage. He also suggested that if the item is too large we may require some kind of processing of information beyond the short-term storage stage. Thus it would appear that in an immediate recall situation we can handle five to nine items with relative ease. Beyond that amount, errors in recall increase.

To understand the capacity notion of 7, plus or minus two items, in motor terms, Wilberg & Salmela (1973) considered this problem by requiring subjects to recall a sequence of 2, 4, 6, or 8 movements, using a two-dimensional joystick. Their results indicated that 8 movements seemed to represent the immediate memory span for motor short-term memory.

A more permanent component of the structure of memory is long-term storage. It is generally accepted that information resides in a relatively permanent state in long-term memory (Ryan, 1965). It is also generally agreed that there is a relatively unlimited capacity for information in long-term memory (Chase & Ericsson, 1982).

2.3.3. The processes involved in recalling movement information

An important point that must be discussed in regard to remembering or learning a motor task is how the practice and test contexts are related (Bransford, Franks, Morris, & Stein, 1979). In some situations, the test goal is essentially the same as the practice goal. This is especially so for closed motor tasks. e.g., to throw a bowling ball you must stand in usually the same place and throw the ball to hit the pins that are the same distance from you when you practiced the action. In such closed motor task situations, what is known as the encoding specificity principle applies.

The encoding specificity principle was introduced by Tulving & Thomson (1973). They carried out three experiments to examine encoding specificity and retrieval processes in episodic memory. Every subject was shown and tested on three successive lists. The sole purpose of the first two lists was to induce subjects to encode each target word with respect to, or in the context of, another word. The target words, were each paired with their cue words, and were shown visually, one at a time, at the rate of three seconds a pair. The third list in each experiment was the critical list, providing the data of interest. This list, too, consisted of 24 cue-target pairs, with the material presented exactly as in the first two lists. Retrieving the words was the requirement of all subjects. From the results Tulving & Thomson suggested the formulation for the encoding specificity principle. According to this principle, the more the test context resembles the practice context, the better the retention performance will be.

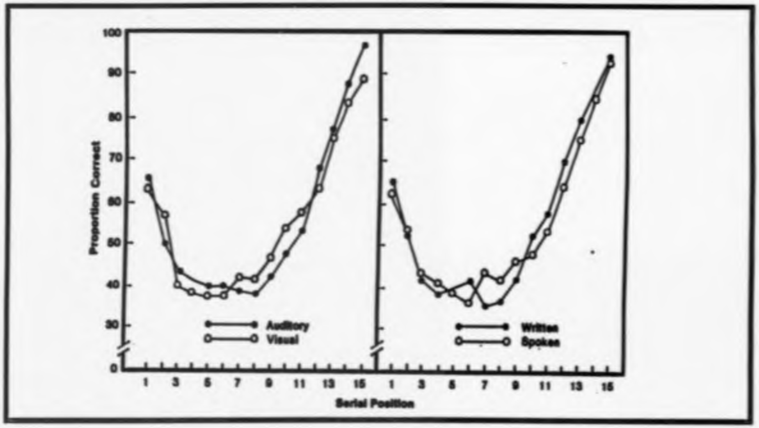
Some supportive evidence for this principle in the motor domain has been provided by the work of Lee & Hirota (1980). They investigated the encoding specificity principle in motor short-term memory for movement extent. The task was limb-positioning movements. Subjects were divided into four groups of six subjects each. The four groups represented the four presentation conditions (active preselected, active constrained, passive preselected & passive constrained). The results showed that the recall accuracy of the movements was greater when the recall test was performed under the same active or passive movement mode as was the presentation condition. Recall error increased when subjects were required to perform the recall test in the opposite movement mode. Thus, having the same movement context available at recall was beneficial for remembering the criterion movements.

2.3.4. The recall of motor or verbal serial information

In the verbal memory literature there has been a rather consistent tendency towards showing a primacy and recency effect for serial recall. That is, first and last items of a list are recalled best, while middle items are recalled poorest.

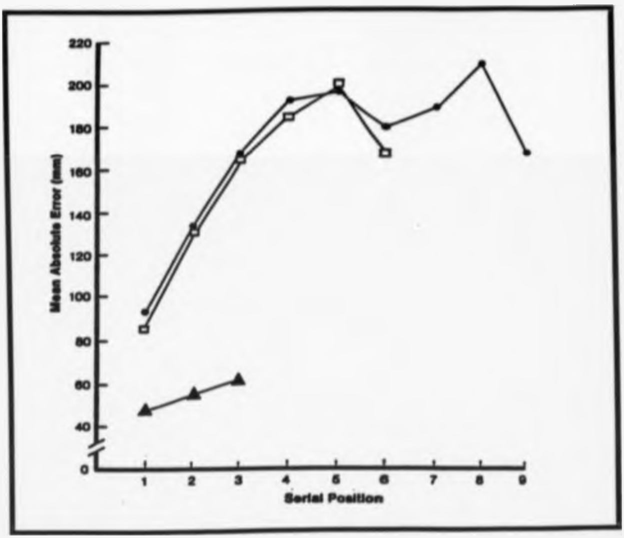
This effect can be clearly seen in the graph in Figure 2.4. These results represent an experiment by Craik (1970). In this experiment, subjects were presented lists of 15 two-syllable nouns. The presentation was either spoken (auditory) or visual, and the recall was either spoken or written. Regardless of the method of presentation or the recall, the characteristic primacy-recency U-shaped curves resulted. These results demonstrated quite clearly the primacy-recency effect.

Figure 2.4 Results from the experiment by Craik showing the serial position curves for the recall of 15 words in a list, Craik (1970).



In the motor domain concerned with the recall of a series of movements, Magill & Dowell (1977) have examined the effect of the length of a series of movements on the recall of those movements. The subjects, while blindfolded, were asked to move a handle on a linear slide to a series of stops along a steel rod. The movement series consisted of either three, six or nine movements. The recall of these movements was indicated in the same order in which they had been presented to the subjects. The results can be seen in the graph in Figure 2.5.

Figure 2.5 Results from the experiment by Magill & Dowell showing the serial position curves for the recall of a series of three, six or nine movements on a linear positioning task. Magill & Dowell (1977).



The study revealed that this linear pattern was only evident for the three-movement series. For both the six and nine movement series, a bowed serial position curve indicating the classic primacy-recency effect began to appear.

We have to remember that the curves in Figure 2.4 are inverted compared to the curves in Figure 2.5. This is because of error in the dependent measures: Thus, the better recall scores are lower in Figure 2.5.

It appears from the results of Magill & Dowell's study that serial position effects, for short-term memory, are the same as for short-term verbal memory.

Moreover, Wilberg & Girard (1977) showed the bow-shaped curve with free recall. They demonstrated that the length of the movement series was beyond "memory span", i.e. greater than five to nine movements, and the primacy-recency effect is readily noted.

From all these studies on memory recall, one might think that there is an ability within each one of us that differentiates us from others, and that this characteristic ability can take different forms, such as motor ability, imagery ability, and so on ....

2.4 Individual differences

The term ability is heard in many conversations in an educational or an athletic context. I will be considering this term more precisely when individual differences are discussed. Fleishman (1972, 1978) has been responsible for developing much of the present understanding of the relationship between human abilities and the performance of motor skills. He distinguished between skill and ability as follows: skill is a level of proficiency in a particular task, as one might speak of skill in riding a bicycle or flying an airplane; ability is the capacity of the individual that is related to the performance of a variety of tasks.

The fact that basic abilities are themselves fairly stable permits the making of useful predictions about subsequent performance in specific tasks (Fleishman, 1967). For example, knowledge about a person's numerical ability helps one to predict his probable success later on in engineering training. Knowledge about the relevant physical fitness components should help predict performance in complex athletic skills.

2.4.1. Motor ability

In 1972, Fleishman carried out research concerned with the developing of a "taxonomy of human perceptual-motor ability". He administered an extensive battery of perceptual-motor tests to a number of people. The results of this testing led him to propose that there seem to be 11 identifiable and measurable perceptual-motor abilities. He identified these abilities as follows:-

1) Multilimb coordination.
2) Control precision.
3) Response orientation.
4) Reaction time.
5) Speed of arm.
6) Rate control.
7) Manual dexterity.
8) Finger dexterity.

9) Arm-hand steadiness.

10) Wrist, finger speed.

11) Aiming.

However, these lists cannot be considered as complete inventories of all the abilities related to motor skill performance. People differ in the number and variety of abilities they possess. One might consider that an ability to form an image is also related to motor skill performance.

The following chapter will discuss in more detail imagery ability and mental imagery, and its effects on different types of memory tasks.

Chapter 3
Mental Imagery

3.1. Mental imagery

The study of mental imagery was for a long time avoided by mainstream experimental psychologists. Nevertheless, the concept has not gone away and is currently enjoying striking acceptance both as a phenomenon to be studied and as an explanatory concept in cognitive psychology.

Richardson (1969) in his book Mental Imagery has attempted to definmental imagery so that all subclasses of imagery are encompassed. Each major subclass of imagery is discussed in a separate chapter:

1) After imagery and related phenomena.
2) Eidetic imagery.
3) Memory imagery.
4) Imagination imagery.

In this research we are only interested in the third type, memory-imagery ability, defined by Richardson (1969) as

> " A process which involves the ability to reconstruct a quasi perceptual experience of which the individual is consciously aware, and which exists for him or her in the absence of presented stimuli that are known to produce their genuine perception counterpart, and which may be expected to have different effects from his or her perceptual counterparts" (p. 2).

This ability involves the reconstruction of a past percept and is, to this extent, a more centrally initiated event. For example, as human beings, we are able to form images corresponding to many different sense modalities. We can imagine the sight of our father's face, the sound of a train, the feel of rough sandpaper, the taste of a lemon, etc. All these are examples of images we are able to envision without the physical presence of the imaged objects, using the knowledge which has been stored in memory. Since, for most people, vision is the richest of the senses, most of the research that I will discuss will address the matter of visual imagery.

3.1.1. Imagery ability

Much psychological research on imagery processes began with the study of individual differences. Probably the most important factor influencing how effective imagery will be in motor skills is the imagery ability of the performer.

In this thesis I will consider one of the oldest methods of comparison that of comparing individual subjects in terms of their reports concerning the vividness or manipulability of their experienced mental imagery. This method has been used by many psychologists for studying individual differences in mental imagery.

3.1.2. Introspective questionnaires

The most interesting questions for cognitive psychology concern the possibility of correlations between the phenomenal experience of mental imagery and performance in cognitive tasks, and the identification of the physiological structures which are responsible for the two sorts of empirical phenomena. As Marks (1977) has pointed out.

> "Self-reports of imagery obtained from conscious inspection of on-going processing provides systematic data, lawfully and reliably linked to performance data of an entirely objective nature. While correlation is not causation, it is a useful technique in the development of new theories."

The most detailed technique for evaluating the subjective vividness of a person's experienced mental imagery is possibly the Questionnaire upon Mental Imagery (QMI), which was developed by Betts (1909) from Galton's Original Procedure. This included 150 items, referring to seven major modalities: visual, auditory, cutaneous, kinesthetic, gustatory, olfactory and organic. For example, subjects were asked to think of the sun sinking below the horizon, the mewing of a cat, the prick of a pin, running upstairs, the taste of salt, the smell of fresh paint and the sensation of fatigue. They judged the vividness of the evoked images on a seven-point scale, from "perfectly clear and vivid as the actual experience" to "no image present at all". Sheehan (1967a) developed a shortened form of Betts' original QMI, containing five questions from each of the seven modalities, and it is this version that I will be using in this research.

As in the case of any technique for evaluating individual differences, it is important to determine the reliability and validity of the QMI. Juhasz (1972) has shown that measures of the internal consistency of the scale are very good. Reliability of both the Betts' and Gordon measures assessed by Cronbach's alpha in Cronbach & Furby (1970) (an estimate of internal reliability) were obtained from 67 undergraduates, 34 subjects in group one and 33 in group 2, in two sections of introductory psychology, and 12 professors at Bucknell University. The estimates of odd-even reliability for the Betts test were, for undergraduates, 0.95, and for professors, 0.99. The estimates for the Gordon test were , for undergraduates, 0.88, and for the professors, 0.95. These results as we mentioned earlier suggested that for these subjects both measures have satisfactory internal reliabilities.

The question of the test's validity is more difficult to answer. As Durndell & Wetherick (1976) put it " It is difficult to obtain an external criterion for this subjective phenomenon." In general, most discussions of the validity of the QMI coherent internal structure, or to show that it correlates with other, similar tests (White, Sheehan & Ashton, 1977).

Sheehan (1966b, 1967b) had some success in relating the reported vividness of experienced mental imagery to the accuracy of visual memory. This was the result from his initial investigations of the predictive capacity of the shortened form of the QMI. However, these results failed to get more support in a more careful replication (Neisser, 1972; Sheehan & Neisser, 1969). Further investigations have produced negative findings of the usefulness of subjective judgements in predicting performance in learning and memory tasks (Danaher & Thoresen, 1972; Neisser & Kerr, 1973; Richardson, 1978). Moreover, the rated vividness of experienced imagery does not affect the effect of stimulus imageability upon recall (Sheehan, 1972). However, Sheehan & Neisser (1969) did find that scores on the QMI related to the incidental recall of block designs, so much so that vivid imagers were superior to non-vivid imagers. A similar relationship between vividness and incidental recall has been found in at least two other studies (Janssen, 1976; Morris & Gale, 1974).

In this respect, Marks (1972, 1973) has suggested that it would be more appropriate to select subjects according to their scores in the imagery modality who are most likely to function in the experimental task to be performed. Therefore, Marks devised the Vividness of Visual Imagery Questionnaires (VVIQ), containing sixteen items to be rated in terms of evoked visual imagery along five-point rating scales. The internal consistency of this test is good, the test-retest reliability is high, and factor analysis yields a single underlying dimension (White, Ashton & Law, 1974; Marks, 1972, 1973).

The QMI and the VVIQ correlate moderately well both with each other and with other subjective questionnaires on the vividness of experienced imagery (White, Ashton, Brown, 1977), and also in an investigation by using factor analysis (Lorenz & Neisser, 1985) with event recall. Subjects completed nine mental imagery measures (Mark's VVIQ, Gordon's Vividness Scale Forms 1&2, Space Relations Form of the Differential Aptitude Test, Barratt's Visualization Form A and B, Bett's QMI, Cut the Cube task, and Richardson's VVQ). The results showed, as usual, that collectively such tests define a single underlying dimension of factor analysis.

Another imagery test, the Movement Imagery Questionnaire (MIQ), has been developed in recent years at the University of Western Ontario by Hall & Pongrac (1983). The test is designed to assess individual differences in visual and kinesthetic movements imagery. The questionnaire was designed to ensure that all participants answering the questionnaire were imaging exactly the same movements. The approach taken was to consider each movement to be imaged as a separate item. Each item consisted of three parts. First, the starting position for a given movement was described and the participant was requested to assume this position, second, the movement was described and the participant was asked to produce this movement, finally, the participant was asked to resume the starting position, imagine producing the movement without actually performing it, and then rate the ease/difficulty with which the movement was imaged. The response format was a seven-point rating scale. The test-retest reliability of the MIQ is satisfactory. Reliability coefficients for each of the two sub-scales were r(32)=0.83 (Hall, Pongrac & Buckholz, 1985).

Variations in imagery ability have been shown to have important consequences on various cognitive tasks from the input of information, perception, the storage of information, verbal learning and memory, and mental manipulation of information, thinking, creativity and mental operations (Ernest, 1977).

Recent investigations have attempted to make clear which processes in visual information processing are related to the abilities in visualization or manipulation of visual imagery specifically, using cognitive tasks whose internal processes are relatively well documented (Hatakeyama, 1984; Kosslyn, Brunn, Cave, & Wallach, 1984). They found that not only is imagery not a simple, unitary ability, but it is a part of a larger, more general undifferentiated system.

3.1.3 Imagery & motor performance

We must now turn to the relationship between imagery and motor performance, a relationship which might, at first glance, seem tenuous in the extreme. Denis (1985) stated that imagery is a psychological activity that is mostly inward, belonging to the class of "private events", whereas motor performance is more external and "public" in nature. Furthermore, imagery evokes the physical characteristics of an absent object or event that has been perceived in the past or will take place in the future. Motor activity typically is more associated with the present, as individuals perform they can be viewed and objectively measured by others.

Despite these differences , researchers who believe that motor learning is controlled at the cognitive level have been investigating the relationship between imagery and the learning and performance of motor skills for the last 30 years (Richardson, 1967a, 1967b; Paivio,1971, 1985; Finke, 1979; Chevalier-Girard & Wilberg,1980; Hall, 1980, 1985; Feltz & Landers, 1983; Suinn, 1983; Denis, 1985; Goss, Hall, Buckholz & Fishburne, 1986; Fishburne & Hall, 1988). ...etc...

Shea & Zimny (1986) suggest that motor learning is essentially influenced by people's goals, what knowledge they possess and the incorporation of new knowledge with old. They believe that this knowledge is combined in a mental representation of the motor task and is acted upon by strategic trial and error processes. One might conclude from this approach to motor learning that there are arguments for a functional relationship between imagery and action.

In the last few years the term imagery has become popular within the motor skills literature, especially in physical education. The term that is usually used in the past was mental practice or mental rehearsal. One might ask the question, Are imagery and mental practice the same? Singer (1980) employed both terms to refer to "task rehearsal in which there are no observable movements" (p.426). However, many psychologists have suggested that mental practice involves more than imagery. Marteniuk (1976) has defined mental practice as "improvement in performance that results from an individual's either thinking about a skill or watching someone else perform it" (p.224).

The main purpose of this research is to investigate the effects of imagery on motor performance. There would seem to be advantages in understanding the type of coded information in the retention processes in any motor learning theory. This research will be restricted to simple laboratory motor tasks and the effect of differences in individual imagery ability.

3.1.4. Imagery as a mediational process

The imagery approach states that both imaginal and verbal mediation procedures can influence learning and memory. It also suggests that the availability of imaginal, but not verbal, mediators is related directly to the strength of the stimuli. Paivio (1969) in his paper concerning the functional significance of non-verbal imagery and verbal processes in associative meaning, mediation, and memory, did provide some theoretical basis for expecting one kind of mediator to be more effective than another when they are equally available.

Many studies have involved imagery instructions, and the use of pictures as mediators has shown that they can be as good as memory aids. Gupton & Frink (1970) have investigated the effects of instruction to employ imagery as an aid to memory, as well as the noun-verb and the verb-noun pairs in which either high or low imagery value nouns were presented . Subjects assigned an imagery value to each noun on a 7-point visual rating scale. A rating of 7 indicated nouns for which there was either no image evoked or it was very unclear, while 1 indicated a very clear image. There were two instruction conditions, the first involved thinking of a 'picture" that goes with the pair, and the second condition had no instructions noun-verb, verb-noun pair ordering. In each condition, subjects were shown 12 noun and verb pairs at a 2 per sec. rate for five trials. During a 30-sec. interval after each trial , subjects were occupied by writing random three digit numbers dictated at a 1 per sec. rate. After the fifth trial, subjects were asked to write down as many of the pairs as they could recall, in any order they wished. The results supported the notion that imagery instruction can be as powerful as memory aids.

Imagery has been considered as a mediational process for movement information in some studies. Housner & Hoffman (1978) examined the role of imagery in the reproduction of criterion locations and distance using subjects of different imagery abilities. A curvilinear positioning task was employed and the subjects were tested on their ability to reproduce six locations and six distances immediately following presentation, after a 30 seconds' rest, following a 30 seconds' imaginal rehearsal condition, and after an imaginal distraction condition. As the dual coding approach predicts, imagery as a mediator improved reproduction performance. Scores of subjects who indicated the use of an imaginal coding strategy were compared with those who did not use an imaginal code, the differences in the two groups were significant for location for the conditions of immediate reproduction and 30 seconds of imaginal rehearsal, but not either of the conditions entailing a 30 second rest or imaginal distraction. These findings also support the availability hypothesis if we assume movement locations are relatively concrete while the concept of distance is more abstract.

Housner & Hoffman (1981) showed the role of visual imagery in short-term retention of distance and location information by comparing performance of two groups of subjects and defining them as high and low imagers. Their findings suggested that when subjects employ an imaginal coding strategy, visual imagery ability may be an important factor in the retention of location information, but has little functional significance in the recall of distance. The data replicated their findings of the previous investigation concerning the role of images in motor memory (Housner & Hoffman, 1978).

In another study, Chevalier-Girard & Wilberg (1980) presented lists of ten movements in a control condition, imagery condition, and imagery plus labelling condition. Labelling entailed giving subjects verbal labels for the movement patterns formed and was congruent with techniques used in verbal studies (Paivio, 1971). The subjects were required to recall the movements in any order both immediately following their presentation and 24 hours later. Recall was better for the imagery condition than the control condition, but best for the imagery plus labelling condition. These findings are consistent with the view that images and labels can both serve as effective memory aids for item information, and are related to the dual coding assumptions of independence and interconnectedeness. The non-verbal and verbal processing systems must be at least partially independent, so encoding can be in terms of one form of representation(code) or the other, or both. If it is both, one code could be forgotten and the appropriate response could still be retrieved from the other.

Thus the two codes are considered to have additive effects on recall probability, and presumably recall performance of a motor task.

Most of these imagery studies have emphasized, or assumed, the use of visual imagery by subjects. However, Hall, Pongrac & Buckholz (1985) have suggested that in motor skills it is possible that imagery instruction to use kinesthetic imagery, might be more effective than visual imagery, because kinesthetic imagery is concerned with the feel of a movement. Based on that, they have asked subjects to use kinesthetic imagery in a number of studies, and most subjects reported that they were able to do so. However, a small percentage have indicated that they have experienced some difficulty separating kinesthetic imagery from visual imagery. Their conclusion was that consideration must be given to the performance tasks employed to validate these tests and individual differences can only predict performance if the task is imagery dependent or performed best with imaginal strategy.

Ryan & Simons (1982) studied improvements following mental or physical practice in learning to balance on a stabilometer. At the completion of the learning phase, subjects in the mental imagery conditions answered a questionnaire concerning the amount and quality of any visual or kinesthetic imagery they had experienced. It was found that physical practice produced larger improvements than did mental rehearsal, and both were better than no practice. Performance of subjects who were asked to use imagery in mental rehearsal was superior to that of subjects asked not to. Also, subjects reporting strong visual images showed more improvement than those with weak visual images, and those reporting strong kinesthetic images were better than those with weak kinesthetic images.

Goss, Hall, Buckolz & Fishburne (1986) have carried out an experiment where the subjects were required to learn a selection of movement pattern to a criterion performance level. Subjects were divided into high and low imagers based on both their visual and kinesthetic imagery rating scores on the Movement Imagery Questionnaire (MIQ) (Hall & Pongrac, 1983). The subjects were given instructions that emphasized only kinesthetic imagery. They claim that all subjects reported being able to comply with the instructions and that kinesthetic imagery was beneficial in acquiring the movement patterns. Their findings supported the position that high imagery ability facilitates the acquisition, but not the short-term retention, for movements. The reason might be, that in order to form a kinesthetic imagery, one has to cognitively process the movements information and then form the required images.

3.1.5. The characteristic of the task

When learning a motor task, consideration should be given to how easy the skill is to image. Hall (1980) has demonstrated that different movement patterns have different imagery values (see chapter 2, page 30). Therefore, the extent to which a movement pattern is remembered depends on its imagery value, the higher the imagery value, the easier the movement is to image, and the more clearly it is remembered.

Feltz & Landers (1983) have carried out a review which shows that not all motor tasks benefit equally from imagery. Comprehensive research using the meta-analytic strategy proposed by G. V. Glass (1977) suggested that mentally practising a motor skill renders performance only marginally better than no practice at all. The 60 studies yielded 146 effect sizes and the overall average size was 48. Effect size was also compared on a number of variables thought to moderate the effects of the effects produced by mental practice was larger for cognitive tasks, such as finger-maze learning, than for tasks such as dart throwing. The latter, in turn, exceeded the effects in tasks in which strength was the major component. From these findings Feltz & Landers were led to propose that mental practice effects are related to the cognitive components rather than the motor components of the task being learned.

Paivio (1985) discussed the importance of task analysis in the use of imagery. The suggestion that he made is that one usually overlooks the issue of whether or not the task involves a perceptual target. What is the performer doing in relation to the target? Is the performer moving or stationary? These questions raised by Paivio seem to be related to whether the task is "closed" or "open".

Poulton (1957) presented a classification system for motor skills as related to the industrial setting. The basis for this classification was the stability of the environment in which the skill was performed. If the environment was stable, that is predictable, then Poulton classified the skill as "closed". If on the other hand, the skill involved an ever changing, unpredictable environment, the skill was classified as "open". Moreover, Gentile (1972) expanded this classification system to make it applicable to sport. Rather than considering open and closed skills as two parts, Gentile suggested these terms were anchor points of a continuum. One end of the continuum includes skills that take place under fixed, unchanging, environmental conditions, or closed skills, (some examples would be bowling, golf, and weight-lifting). The stimulus in each of these situation waits to be acted upon by the performer. Open skills, at the other end of the continuum, involve such skills as tennis, and football. The performer must act upon the stimulus according to the action of the stimulus.

Paivio's (1985) argument was that such task differences must have implications for how imagery can be employed most effectively. He raises the question of whether a target oriented component of a skill can be effectively rehearsed using imagery, and how would it be possible to do this with an imagined target, in the way that eye-hand coordination is improved?

Most industrial tasks involve a stationary object, which make it possible mentally to rehearse or imagine a successful performance of the task. Instructional books on sports, often written by former sportsmen, typically suggest visualizing in your mind a successful performance, and this includes the target (e.g., getting a strike in bowling).

3.2. Mental imagery theories

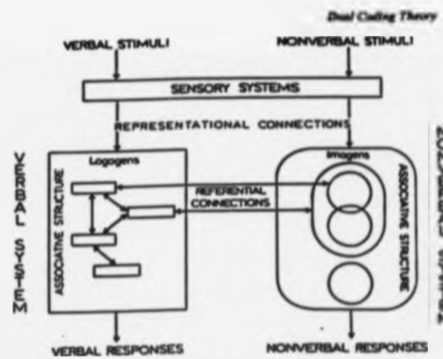
A number of theories have dominated the literature of mental imagery for the last 40 years, and some are still interesting to the cognitive psychologists of today. In the following section of this chapter a review of the major theories of mental imagery will be presented, along with some of the variables that have an effect on the use of imagery.

3.2.1. Paivio's Dual Coding Theory

One of the first, and still very influential, accounts is Paivio's Dual Coding Theory (Paivio, 1971, 1986). According to Paivio's theory, people remember and think about things they have experienced with the aid of words and images. Images, Paivio claims, are better than words for representing the way things look or appear.

This theory is based on the general view that cognition consists of the activity of symbolic representational systems that are specialized for dealing with environmental information, in a manner that serves functional and adaptive behavioural goals. This view implies that representational systems must incorporate perceptual, effective and behavioural knowledge. Paivio stated that human cognition is unique in that it has become specialized for dealing simultaneously with language, and with non-verbal objects and events. Moreover, the language system is peculiar in that it deals directly with linguistic input (in the form of speech or writing) while at the same time serving a symbolic function with respect to non-verbal objects, events and behaviours. Figure 3.1 shows the structural features of the dual coding theory that are most relevant here.

Figure 3.1 Schematic diagram of the structure of verbal and non-verbal symbolic symstems. (Adapted from Paivio, 1986)



The central assumption in the theory is that experiences are represented in concrete, modality specific ways that reflect the original events on which mental representations are based. A verbal cognitive system represents and processes linguistic information, whereas a non-verbal system handles perceptual-motor information concerning environmental objects and events. The two representational systems are functionally independent, but appropriate experiences produce referential connections between the verbal and non-verbal systems, as well as associative collections among representations within each system, as shown in Figure 3.1.

According to the theory, collections of mental representations are activated directly by external stimuli, and indirectly by referential and associative connections. In the case of words or statements, cognitive activity starts at particular verbal representations and spreads throughout the system, as in spreading-activation models of cognitive processing (e.g. Collins & Loftus, 1975).

The ability of the verbal and image systems to translate inputs into the opposite system suggests a common code exists between the two systems. The existence of an underlying common code makes further specific coding systems inessential. Anderson (1978) claims, as does Pylyshyn (1979, 1980, 1981) that any arguments made for specific coding systems can also be accommodated by a common coding system. If there is an interpretation mechanism which can deal with information from multiple codes, then information represented in a common code is more easily grasped. In this respect, Richardson (1980) has suggested that imagery is a distinct process, acting on model representations. That is to say, imagery functions as a method of recall and rehearsal which permits memory representations to be actively integrated and adapted, because common coding systems do not necessarily diminish the functionality of an image system.

3.2.2. Kosslyn's CRT Theory

Paivio has accounted for the distinction between verbal coding and images, but does not tell us much about the mechanics of the image itself. In a series of publications in the late seventies and early eighties, Kosslyn and his colleagues described a model of the imagery system which is far more detailed than any comparable imagery theory (Kosslyn, 1975, 1978, 1980, 1981; Kosslyn & Pomerantz, 1977).

In 1980 Kosslyn proposed his theory of imagery that assumes two distinct types of representations, namely, "deep" images and "surface" images. The deep images are long-term memory structures, presumed to be propositional in format, containing information about the appearance of objects and scenes. The deep images are used to generate the surface images, the analogue "quasi-pictorial" representation that we consciously experience as visual mental imagery. According to his theory, the surface image consists of the pattern of activation in a "visual buffer" which can be activated either by internally generated imagery or an externally encoded percept. Therefore visual imagery shares a common process with visual perception. The theory was shaped largely by three classes of empirical findings.

First, Beech & Allport (1978), Kosslyn, Reiser, Farah, and Fliegel (1983), and Paivio (1975) found that people require more time to form images of acts for each additional object included in the acts. In addition, the complexity of a single imaged object affects image generation time. In short, multipart images are not retrieved all at once, but are built up on the basis of separately stored codings.

Second, the results of other experiments indicated that people can construct images by making use of descriptions of how parts are to be arranged. For example, subjects in one experiment could imagine a frying pan floating 6ft. above a bicycle which is 6ft. to the right of a rabbit (Kosslyn, Reiser, Farah & Fliegel, 1983).

Third, Bundesen & Larson (1975), Farah & Kosslyn (1981), Hayes (1973) and Kosslyn (1975) showed that people can form images of different " subjective sizes" (i.e., so they seem to view from different visual angles). In general , less time is required to imagine objects of smaller size than larger size, presumably because parts of objects are omitted in images of smaller size because of "grain" constraints (Kosslyn, 1980).

Given these empirical findings, it places additional constraints on the theory. That is, as a test for formulating a theory of information processing it is useful to consider what one would need to do to program a computer to imitate the effects observed with humans. For example, the model assumes that something resembling a "cathode-ray-tube (CRT) display screen" exists within the cognitive processing system. However, Marr (1976) suggested that perceptual processing utilizes a visual buffer to construct a " primal sketch" of objects, but this is supposed not to have any "screen-like" properties and to be inaccessible to conscious processing. While computer simulation is a useful aid to theorizing, a simulation is purely a description of a system, and not a test of the system. Consequently, any procedures which function within the simulation need not to be present in actual behaviour.

As it is, Kosslyn's CRT theory did not undertake to show how imagery might function in a cognitive system, he was mainly concerned with how an image system itself might function. He claimed that images are distinct forms of representation, with separate propositional and image representational systems. In that case the two systems interact to produce images and classify objects.

Therefore, in this respect Kosslyn's CRT theory seems to be an extension of Paivio's dual coding theory of mental imagery.

3.2.3. Neisser's theory of mental imagery

Neisser (1976, 1978) proposed a model of mental imagery which accounts for image function within a "schema" theory of cognition. To understand Neisser's approach, it is important to realize that it is part of a more general account of perception and cognition. Neisser's aim has been to exploit the notions of information-processing put forward by himself in his earlier book Neisser, (1967).

First, worldwide information sources afford classes of data which may be used by a particular organization. The usable data are picked up by cognitive structures known as schemata, provided that these are in a state of expectation or readiness. A schema's anticipation amounts to a set of hypotheses about the world. The cognitive system gains knowledge by noting whether or not its schemata expectations are realized. A second function of the schemata is to control the output or the exploration system. The final element in Neisser's model which further samples the first element is worldwide information.

Neisser accounts for the phenomena of imagery in a way which is both sophisticated and simple, and at the same time emphasizes its link with perception. He argues that having an image is equivalent to imagining or pretending to see. It is an anticipation or readiness to perceive, not the retrieval of a mental picture or a perceptual description, and it occurs when the schemata normally used for perceiving are used out of the context of their normal cycles. These "disconnected" schemata are used purely in their anticipatory mode and in this way the cognitive system acts as if it were perceiving without actually doing it.

The interesting aspect of the theory , is that it clarifies the problem of the link between imagery and perception and puts aside the argument about the nature of representation, because imagery is an anticipation of perception.

3.2.4. Concluding remarks

It seems that theories on motor learning , which involve current perception of the world as a determinant of motor behaviour, are much more easily understood than theories that involve the internal cognitive representations. However, observational learning of movement, which is cognitive learning and which I have already reviewed in Chapter 2, can be a valuable testing base line for investigating the cognitive representation and how it regulates movements

Furthermore, verbal instructions are another testing ground for investigating cognitive representations. Investigators of the verbal mediations are restricting their research to the disconnected verbal response (Carpenter & Just,1976; Dixon, 1982; Wright & Hull, 1986, 1988); however, as we all know utterance is capable of more complex organization for the control of movements. Annett (1983, 1985) has shown that there is little systematic knowledge of the relationship between language and action (Figure 1.1).

Because the internal processes occur within memory, it was essential to review some of the studies that investigated the control processes of human memory. Control processes are those aspects of memory that are under the direct control of the individual. These processes include the storage, rehearsal and retrieval of information. Storage and retrieval are easier when the information to be remembered or learned is meaningful to the individual, also the study of memory to determine the characteristics of motor or verbal serial information, indicates that the function relating recall to serial position is a bow-shaped curve. Information at the beginning and the end of a series is recalled better than information in the middle of the sequence.

The link between memory and imagery has been shown by a number of psychologists. Paivio (1971) has shown some evidence that imagery helps memory. To be more precise, the rule is that increases in imaginal processing are associated with improvements in memory tasks for which imagery is useful. Mental imagery has been shown to have limited success in the learning and retention of verbal and pictorial materials but exceptional success in motor learning (Gopher, 1984). However, imagery might have played the key role in studies of mental practice, but was not identified as doing so. One might examine more closely precisely how observational learning (imitation) occurs and whether or not the cognitive process of forming a mental image is related to the recall of movements.

3.3 The paper folding (origami) task

A central feature of the research presented in this thesis is the paper folding task (origami). This closed motor task requires subjects to learn how to perform certain movements by folding a piece of paper in order to form some kind of three-dimensional object. The word 'closed' was used here in accordance with the classification of Gentile (1972), that is, a closed motor task is one where the stimulus waits to be acted upon by the performer; in this case the piece of paper is the stimulus. The task requires a great deal of imagery and an extensive sequence of movements. Also to perform this task the subject will be requiring to refer to the representational image of the task when asked to recall it.

3.4 An outline of the empirical work

The following four chapters present a series of experiments which investigates the role of imagery ability in observational learning on recalling the movement of a motor task. By using different instructional methods and a variety of modelled demonstrations with one imagery ability measurement, the underlying effects of imagery ability are investigated.

An origami task, which consists of learning to perform certain folds on a square piece of paper in order to form a three-dimensional object, was the main experimental task. Imagery ability was measured based on the individual self-rating in the shortened form of Betts questionnaire (QMI) (see Appendix (1.3)). The experiments which follow make use of the rating results from Betts' subjective questionnaire to distinguishes the individual differences between subjects and compare the accuracy and performance speed of recalling the origami task. Certain groups of subjects are instructed to rate themselves on Betts' (QMI) questionnaire. One group of subjects is instructed to learn the task by reading the verbal description of the origami task while the other is instructed to learn the task by observing a model demonstration of the task and then recalling the task. By comparing high and low imagers on accuracy and performance speed, it is possible to investigate the effect of imagery ability on the recall of task movements learned by the two instructional methods.

It was hypothesized that imagery ability affects the recall of the motor task, and evidence is presented in Chapter 4 which shows that the ability to form images has a profound effect on movement recall of the motor task learned by the method of observational learning in the early stage of learning, and that high imagers tend to recall the motor task with more accuracy than low imagers.

A new type of demonstration was introduced. This used selected still photographs chosen from a large number in various ways. Further investigations of imagery ability and different type of demonstrations were made possible by using an additional non-meaningful origami task to suppress the effects of the ability to form an image in recalling the movement of the task. This, of course, assumes that there is some relationship between the cognitive processes of forming an image and the meaningfulness of the coded images.

Moreover, in Chapter 7 we continue to investigate the effect of imagery ability on different type of observational learning techniques using demonstrations containing maximum and minimum information. This, of course, assumes that there is some relationship between the cognitive process of forming an image and the type and amount of demonstration used to learn the task.

The final chapter draws together the intricate relationship between imagery ability, imitation, demonstration and the recall of a closed motor task. Suggestions are made for the application of imagery ability in motor learning situations and about future research in applied and theoretical settings.

Chapter 4

THE EFFECT OF IMAGERY ABILITY ON OBSERVATIONAL LEARNING (IMITATION) & VERBAL INSTRUCTION

Review of the observational learning literature revealed that subjects usually rely on the internal process which occurs within memory in order to recall and perform the learned task. It was found that demonstration or modelling is one of the most widely advocated instructional techniques for conveying information to learners in connection with the temporal/spatial organization of movement patterns (Gentile, 1972; Martens, 1975). Given the widespread use of demonstration, it is interesting that motor behaviour theorists have neglected the issue of how movement sequences are acquired through observation (Carroll & Bandura, 1982).

Research on the observational learning motor tasks has employed experimental tasks in which the goal or outcome of simple movements is emphasized rather than the acquisition of complex sequences of movement (Adams, 1978). Experimental tasks such as the Bachman Ladder (Feltz, 1982; Feltz & Landers, 1978; Landers, 1975; Landers & Landers, 1973) and shoot-the moon (Martens, Burwitz & Zuckerman, 1976) and the ski-simulator (Whiting, Bijlard & Brinker, 1987) are frequently used for investigations of observational learning, each of which emphasizes outcome over the acquisition of movement patterns.

Researchers on modelling have been faced with another problem, that of how to describe describe the symbolic coding processes employed by learners as they attempt to acquire modelled movement information. Presumably, learners are capable of representing modelled movements in memory, organizing and rehearsing the motor act centrally and using the stored representation as a plan of action or images to guide and evaluate reproduction attempts. However, little is known about the nature of the representations used to code movement sequences in memory. The purpose of this research is to investigate the symbolic coding processes that regulate learning complex sequences of movements from observation.

According to the cognitive social learning theory of Bandura (1971, 1977, 1986), acquisition of movement patterns is governed by a conception-matching process. The initial step in this process, referred to as coding, is employed to represent the modelled stimuli in memory. It is assumed that two representational systems are available to transform brief sensory data into centrally organized, symbolic memory codes - a verbal system and visual images. Rehearsal processes must be initiated to maintain the symbolic codes in memory, particularly if a delay interval occurs between exposure to the model and reproduction. As Bandura, Jeffery & Bachicha (1974) put it, "if modelled responses are coded but not symbolically rehearsed immediately after exposure, they are rapidly lost from memory" (p.303).

Although verbal and visual symbolic codes play a central role in the conception-matching process put forth by social learning theorists, only a few studies have examined the function of these representational systems in the acquisition of movement sequences. With regard to verbal codes, Gerst (1971) and Berger, Carli, Hammersla, Karshmer & Sanchez (1979) had subjects view and produce movements obtained from the manual language for the deaf. In both studies it was found that verbal coding strategies can vary recall of modelled movement sequences. Studies by Bandura, Jeffery & Bachucha (1974) have shown that assigning alpha/numeric labels to discrete arm movements supplies subjects with concrete verbal codes that facilitate recall of complex combinations of movements.

Taken together, the available research provides initial support for the efficacy of verbal symbolic coding processes in observational learning of movement patterns. Very few findings have been reported in support of the effectiveness of visual (imaginal) coding strategies. In Gerst (1971) a study mentioned earlier, it was found that subjects instructed to employ imaginal coding strategies recalled more movements than subjects who formulated verbal descriptions. Furthermore, highly vivid memory images of the stimuli corresponded to more accurate recall of responses difficult to code verbally. Housner (1984) compared subjects classified as high and low in visual imagery ability in recall of complex sequences of movement comprised of discrete arm, leg, trunk and head movements. His findings showed that high imagery ability subjects recalled movement patterns with slightly greater accuracy than subjects low in imagery ability, but only for free recall of the stimuli. When subjects were assessed on their ability to reproduce movements in correct chronological order, no differences between imagery ability groups were found. Furthermore, providing subjects with instructions to employ imaginal coding strategies did not influence reproduction accuracy. The findings provided only modest support for the hypothesized role of imagery ability in the retention of support for the hypothesized role of imagery ability in the retention of modelled sequences of movement.

The purpose of the present study was to explore further the role of imagery ability in acquisition of motor movement from observation. It was reasoned that if visual imagery can be employed to store movement in memory, individuals classified as possessing high imagery ability would reproduce modelled movements with significantly greater accuracy than individuals low in imagery ability. Thus, an individual differences paradigm was used to explore the possible role of imagery ability in recall of modelled movement response.

There have been considerable reservations concerning the measurement of imagery ability, particularly when subjective self-report measures are employed. However, as we mentioned in Chapter 3, the most detailed techniques for evaluating the subjective vividness of a person's experienced mental imagery is possibly the questionnaire upon mental imagery (QMI), which was developed by Betts (1909) from Galton's original procedure, and later on was shortened by Sheehan (1967a) to contain only 35 items instead of 150 items and has been successfully used in predicting individual differences in imagery ability that correspond to performance in a variety of memory tasks (Sheehan, 1967b; Walsh, Russell & Imanaka, 1980; Hatakeyama,1984). Therefore, scores in the QMI were used to divide subjects into highs and lows.

In addition to imagery ability, one other variable was thought to influence recall of a modelled response, as Annett (1982) described it in his Action-Language Bridge: that is, using verbal instructions of the same motor task to learn and reproduce the task. Koen (1971) has argued that as stimulus complexity increases, difficulty in verbal labelling also increases and this results in a greater reliance on visual imagery. Therefore, it was hypothesized that an observational learning technique is more effective than verbal instruction in learning a motor task.

4.1 Experiment (I) part (1)

To support our hypothesis an experiment was carried out, to test a group of subjects and examine the effect of their imagery ability on the recall of a closed motor task, using two different techniques of learning. The shortened form of Betts questionnaire upon mental imagery (QMI) was used for the measurement of general imagery ability, in order to distinguish subjects into high and low imagers. Betts QMI consists of 35 items designed specifically to investigate imagery in seven major sensory modalities: visual, auditory, cutaneous, kinesthetic, gustatory, olfactory and organic. Each modality consists of five items; for example, in the visual modality, subjects were asked to think of seeing "the sun sinking below the horizon ", and to consider carefully the first image which sprang to mind. Instructions were adapted to suit different modalities. Stimulus items suggested in other modalities were "running upstairs "(kinesthetic); "the sound of escaping steam "(auditory); "touching the sand "(cutaneous); "the taste of an orange "(gustatory); "the smell of cooked cabbage "(olfactory); "the sensation of hunger " (organic). Subjects evoked images of objects suggested by the items and rated the vividness of their imagery on the Betts seven-point rating scale which ranged from "no image present at all" (7) to "perfectly clear and vivid" (1). Low scores meant high imagery ability and vice-versa, the score points ranged from 35 to 245 on the QMI (See appendix 1.1).

The experimental hypotheses were 1) Imagery ability could enhance observational learning in the accuracy of recall of a closed motor task. 2) Observational learning techniques increase accuracy and performance in the recall of a motor task more than verbal instruction techniques do.

4.1.1. Method

Experimental Design

A three-factor mixed design was used, with between observational learning and verbal instructions techniques, between high & low imagers and within repeated measured trials. The dependent variables were 1) Accuracy score in points - that is, 2 points for each step currently recalled in the correct sequence, 1 point for each step recalled out of the correct sequence, and 0 points for steps not recalled. This scoring gives equal weight to content and order of recall. In the event pure sequence errors were infrequent. 2) Performance time in seconds.

Subjects

Subjects were asked to complete Betts QMI and forty were selected from a pool of 80 subjects based on their scores. The 20 subjects who scored the lowest rating were chosen to be the high imagers, and the 20 subjects who scored the highest rating were chosen to be the low imagers. The majority of the subjects were students drawn from across a range of departments in the University of Warwick. The remainder were members of the secretarial and technical staff of the University. Their ages ranged from 17 to 46 years old with a mean age of 25.6. They were divided into two groups of 20 subjects in each learning technique, observational learning (OL) or verbal instruction (VI). Ten subjects of each sex were assigned to each of the two groups.

Subjects within each group were divided according to their rating on the shortened form of Betts' questionnaire upon mental imagery (QMI). A two-way (B.B) analysis of variance was carried out between OL vs VI and between high and low imagers on their QMI rating scores, and the results showed that there was a significant difference between the rating score for the imagery groups [$F(1,36)=73.78$, $p<0.01$]. The high imagers rating scores showed that they have clearer and more vivid images than the low imagers. Also the results showed that there was a significant difference between the two techniques in the subjects' QMI rating scores [$F(1,36)=10.73$, $P<0.01$] the subjects in the VI technique showed themselves to have clearer and more vivid images than the subjects in the OL technique. Table 4.a shows the mean; for more information, see Appendix 1.2. This means that imagery ability and learning technique are confounded in this experiment.

Table 4.a. Mean on Betts' (QMI) rating scores for high and low imagers.

Imagery	Learning technique OL (N=20)	VI (N=20)
High (N=20)	84.1	68.6
Low (N=20)	121.3	107.7

Modelling Stimuli and Apparatus

1) A paper folding task (origami) was used, which consisted of 13 consecutive movements to make a shape like a star with a 21 x 21 cm. sheet of plain white paper (see Appendix 1.3).

2) Thirteen verbal instruction cards, each describing one of the crucial movement involved in the task mentioned above (see Appendix 1.4).

3) A wooden rack to hold the cards.

4) An electronic stop watch.

5) Three pictures (1) a square (2) a triangle and (3) a quadrilateral (with two 90^0 angles at the bottom of the shape and two unequal angles at the top of the shape).

6) Video camera.

7) Video-tape recorder.

8) Colour television.

9) Instruction sheet.

4.1.2. General procedures

The subjects were divided into two groups of 20, with 10 high and 10 low imagers in each group. Each group was assigned a different learning technique from observational learning to one, verbal instruction to the other. Each subject was tested individually by the experimenter. There were four phases in this experiment - learning phase, pre-test phase, relearning phase and performance phase. For each learning technique there was a different procedure:

Observational learning

The procedure for the learning phase for the observational learning group was to ask each subject to sit in front of a colour television screen (as shown in Figure 4.1a) and observe a demonstration of the task performed by a model on a video-tape cassette five times. Each demonstration lasted for about 90 seconds and there was a five second rest between each demonstration during which the video-tape cassette was rewound. When all the five demonstrations were finished the subject was asked to imitate the movements of the task once, as quickly and accurately as possible, and this was called the pre-test phase; the number of correctly imitated movements of the task was recorded as the accuracy score, along with the performance time. The relearning phase followed in which , each subject was asked to observe once again the demonstration of the task in order to note any error they may have made. By now the subject had had six demonstrations and one performance trial. In the performance phase none of the subjects had any problem in performing the task correctly, so each of them was asked to imitate the movements of the task five more times, as quickly and accurately as possible (as shown in Figure 4.1b). By this time all the subjects had learned the task and therefore had perfect accuracy scores; only performance time in seconds was recorded using an electronic stop watch for each of the five recall trials. Subjects were videotaped throughout the performance trials to ensure accuracy in recording data.

Verbal instructions

The procedure for the learning phase for the verbal instruction group was to ask each subject to sit facing the experimenter and to place in front of him or her a wooden rack holding the verbal instruction cards,upon which the steps of the task were described in the right order (see Figure 4.2a). Each subject was asked to read all 13 instructions aloud five times. Reading time was not to exceed 90 seconds, and there was a rest interval of 5 seconds between each trial during which the cards were sorted back into the right order. When all the five reading trials were finished, each subject in the pre-test phase was asked to execute the movements of the task once as quickly and accurately as possible. The relearning phase followed in which each subject was asked to read aloud once again the 13 verbal instructions. By now the subject had had six reading learning trials one performance trial. Therefore, in the performance phase none of the subjects had any problem in performing the task correctly, so each of them was asked to execute the movement of the task five more times, as quickly and accurately as possible (see Figure 4.2b). By this time all the subjects have learned the task and had almost perfect accuracy scores; only performance time in seconds was recorded using an electronic stop watch for each of the five recall trials. Subjects were also videotaped throughout performance trials to ensure accuracy in recording data.

Figures 4.1a, 4.1b, 4.2a & 4.2b.

Figure 4.1a. Observational leaning technique.

Figure 4.2a. Verbal instruction technique.

Figures 4.1b & 4.2b both refer to the same photo (above), which shows the experimenter seated in front of the subject while he is performing the task

Subjects were instructed as follows:

Instructions for observational learning group

Learning phase

"I want you to observe the full demonstration of a paper folding task five times .Try to memorize the movements because you will be asked to imitate all the movements that you have observed when all the five demonstrations are finished. OK?"

Pre-test phase

"I want you to imitate the movements of the origami task you have observed as fast and accurately as possible just once".

"GO."

Relearning phase

"I want you to observe once again a full demonstration of the origami task. Observe carefully and note any error you may have made. OK?"

Performance phase

"I want you to imitate all the movements that you have been observing for five more trials, as fast and accurately as possible with 5 seconds rest between each trial."

"GO."

Instructions for verbal instruction group

Learning phase

"I want you to read the instructions aloud from these cards. After reading each card turn it over and read the next one, you have 1.5 minutes to read all 13 cards. I want you to go through these instructions 5 times, trying to memorize the steps, because you will be asked to execute all the movements described on the cards after you have finished. OK?"

Pre-test phase

"I want you to execute all the 13 movements described on each card for the origami task that you have been reading about, as fast and accurately as

"GO."

Relearning phase

"I want you to read all the 13 instructions aloud again one more time. Read carefully and note any error you may have made. OK?"

Performance phase

"I want you to execute all the 13 movements described on the cards that you have been reading for five more trials, as fast and accurately as possible, with 5 seconds rest between each trial".

"GO".

4.1.5. Results

Using the Minitab program available on the Daisy computer, two anova were carried out between the observational learning vs verbal instruction, between imagery on the available sets of data, first a two-way anova (B.B) (2X2) on accuracy scores for the pre-test trial, second a three-way anova (B.B.W) (2X2X6) on performance time for the pre-test trial and each of the five performance trials.

Accuracy score

As stated earlier, an accuracy score was only recorded for the pre-test trial. The results showed that there were significant main effects between observational learning and verbal instruction [$F(1,36)=6.11$, $p<0.05$] and between high and low imagers[$F(1,36)=9.39$, $P<0.01$]. the main finding was that subjects in the observational learning group performed the task with more accuracy than subjects in the verbal instruction group and this lent partial support to our second hypothesis that the observational learning technique makes for greater accuracy in the recall of a motor task than verbal instruction. Inspection of the mean as shown in Table 4.b indicated that the high imagers recalled the movements more correctly than the low imagers.

Table 4.b. Mean & standard deviation accuracy scores for all subjects

		High		Low		
Group	N	Mean	Sd.	Mean	Sd	Total
OL	20	25.2	1.48	21.5	1.58	23.35
VI	20	21.8	1.99	22.4	1.27	22.1

A significant interaction was shown between observational learning and verbal instruction and high and low imagers[$F(1,36)=18.7$, $p<0.01$]. This showed that the high imagers in the observational learning group performed the task with more correct movements than all the other imagers in the pre-test trial. This supported our first hypothesis, that imagery ability enhances observational learning in the accuracy of recall of a closed motor task. The graphs in figures 4.3 & 4.4 show the differences clearly. (See also Appendix 1.5 for summary table of the two-way anova.)

Figure 4.3

Differences in accuracy score between high & low imagers

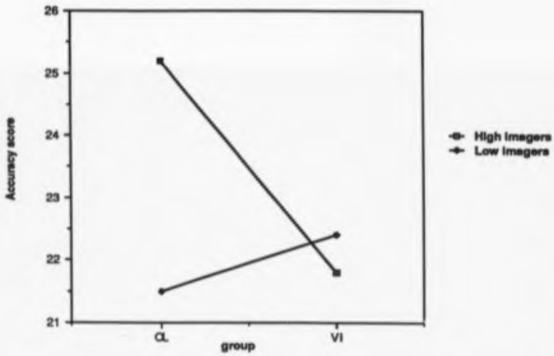
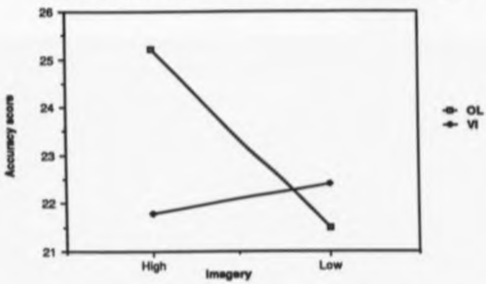


Figure 4.4

Interaction in accuracy score between OL vs VI & Imagery groups



Performance time

A three-way analysis of variance (B.B.W) (2X2X6) was carried out between observational learning vs verbal instruction, between imagery and within six trials on performance time in seconds. The results showed that there were a significant main effects between trials [$F(5,180)=118.7$, $P<0.01$], between observational learning group and verbal instruction [$F(1,36)=39.76$, $P<0.01$] and between high and low imagers [$F(1,36)=4.15$, $P<0.05$]. The trials main effect indicated that subjects' performance time decreases from one trial to the next, overall. Inspection of the means as shown in Table 4.c indicated that the observational learning group performed the task faster than subjects in the verbal instruction group, and that high imagers performed the task faster than low imagers. The graphs in figures 4.5 & 4.6 shows these differences clearly. (See also appendix 1.6 for summary table of the three-way anova.)

Table 4.c. Mean performance time in seconds for all subjects

		Pre-test trial	T1	T2	T3	T4	T5
	High(N=10)	69.13	63.88	54.67	51.77	51.63	47.74
OL						Mean T_1-T_5 = 58.96	
	Low(N=10)	79.56	66.58	57.21	57.95	54.58	52.84
	High(N=10)	123.19	77.01	64.15	58.70	52.83	52.23
VI						Mean T_1-T_5 = 73.59	
	Low(N=10)	120.69	81.03	70.60	65.11	62.91	54.60

N=20 subjects in each learning technique

N=20 subjects in each imagery group.

Figure 4.5

Differences in performance time between OL vs VI techniques & trials

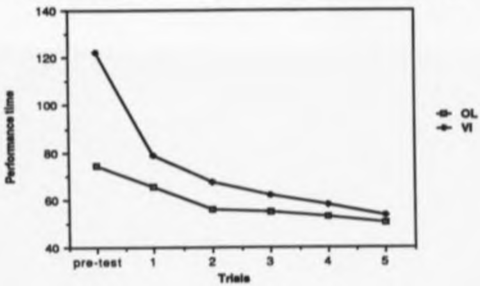
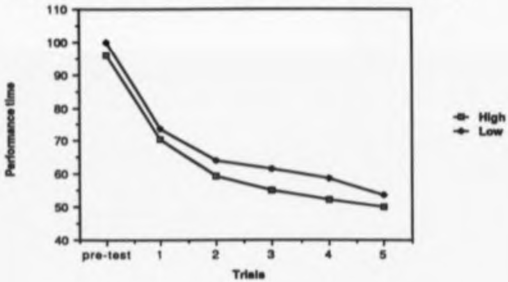


Figure 4.6

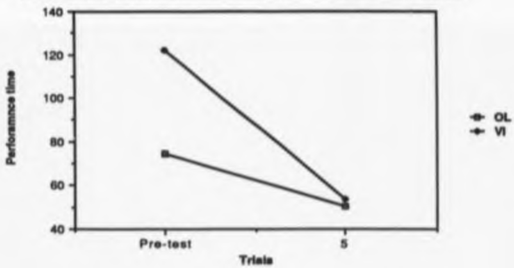
Differences in performance time between high vs low imagers & trials



The only significant interaction was between observational learning and verbal instruction techniques and the six trials [$F(5,180)=28.2$, $P<0.01$]. There was a greater improvement in the verbal instruction group through trials in performance time than the observational learning instruction group. Indeed the verbal instruction group improved by 23.84%. The interaction is shown on the graph in Figure 4.7 and in Appendix 1.6.

Figure 4.7

Interaction in performance time between learning techniques & trials



4.1.4. Discussion

Results showed that subjects in the observational learning technique group performed the task with better accuracy than subjects in the verbal instruction group in the pre-test trial. It might be that the information gained through visual stimuli is more detailed than that gained through verbal coding. Evidence for the effectiveness of the OL technique was indicated by the significant difference in accuracy scores shown in the graph

Moreover, the first hypothesis, that imagery ability could enhance OL in the recall of a closed motor task, was supported by the significant difference in accuracy between high and low imagers in the pre-test trial and performance time through the six performance trials. In the pre-test trial, as shown Figure 4.3, high imagers performed the task with more accuracy than low imagers. The accuracy interaction in the pre-test trial, between learning techniques and imagery group showed that high imagers in the OL technique performed the task significantly better than any other imagery group as shown in the Figure 4.4. From this result we might be able to assume that one of the factors that channel attention to the critical feature of a modelled performance is the ability to form an image.

Furthermore, in the case of performance time, the results indicated some support for the second hypothesis. Evidence for the effectiveness of the OL technique was indicated in the significant differences between subjects performance time in the OL & VI techniques. The subjects in the VI technique took longer time through all trials to perform the task than the subjects in the OL technique, as shown in the graph in Figure 4.5. More specifically the subjects may have experienced difficulty in transforming the detailed verbal codes into visual images in order to execute the movement and from this we might deduce support for Martens argument (1975) that "visual presentation is preferred over verbal instruction because language is unable to specify with precision, critical aspects of human movement." Moreover, from the difference in performance time, we could make the assumption that the subjects in the OL technique recalled and recognized the visual images of the movement of the motor task, then transformed these coded images into action, whereas subjects in the VI technique had first to recall and recognize the verbal codes of the task, then transform these codes into visual images and then into action production (Annett, 1982). In addition to that, the subjects in the OL technique gained task-relevant information from the modelled performance in the relearning phase which facilitated their performance of the task (Martens, Burwitz & Zuckerman, 1976).

The significant interaction in performance time between learning techniques and trials shows that subjects in the VI technique group became more expert through all trials than subjects in the OL technique group. As we assumed earlier that verbal codes are transformed into visual/spatial images which take over after learning has been established , so it appears that subjects improved the speed of their performance using the transformed visual/spatial images though trials, as shown in the graph in Figure 4.7.

An improvement through trials was clearly visible for all the different techniques and imagery groups as shown in all the graphs. This corresponds with Crossman's (1959) study in which he noted that performance time decreases as the log linear function of the log trials. This evidence has been reviewed by Mazur & Hastie (1978) and Newell & Rosenbloom (1981).

It was observed that all subjects in OL & VI had difficulty in recalling the movements of the task, specially in the pre-test trial. The explanation for the lack of recorded information for short-term storage acquired by the subjects in the VI technique group might be that steps 12 & 13 were not clearly explained thereby making it difficult for the subjects to encode and interpret them. More specifically the subjects may have experienced difficulty in transforming the presented verbal instructions into the visual/spatial images needed in order to recall the correct movements of the task, although that was clearly not the case here, because even the low imagers in the OL technique group experienced the same difficulty in recalling the movements of the task in the pre-test trial. Apparently an action consisting of more than 10 moves is too far beyond the boundary of short-term memory. This is consistent with the findings of Miller (1956), who showed that the capacity of short-term memory is seven plus or minus two bits of information.

4.1.5. Conclusion

In summary, the findings of the present study suggest that it would be correct to say that imagery ability enhances observational learning in a closed motor task in the early stages of learning. Furthermore, observational learning gives shorter performance time through performance trials than verbal instruction techniques within short-term memory. However, long-term improvements in performance of a motor task learned by the verbal instruction technique tend to be more marked than in the case of a task learned by the observational learning technique. These results appear to support the notion that there is a relation between the verbal and motor processing systems, in that they communicate with each other using imagery as a mediator to convey information from one system to the other.

Chapter 5

MOTOR RECALL & VERBAL RECALL UNDER LONG-TERM MEMORY (LTM)

In 1982 Annett suggested that there is a dissociation between verbal and perceptual motor competencies but that translation between the two is nevertheless possible via the action-language bridge described in Chapter 1. Not only is it possible for subjects to follow verbal instructions in carrying out a task but, conversely, it is possible for subjects to provide explanations of how they have carried out actions with which they are familiar. In 1985 Annett carried out a series of experiments by giving subjects instructions such as "tell me in as much detail as you can how you mount and ride away on a bicycle", "take two ends of string and tie them together to make a bow", and "perform a forward roll", and in their reactions he found unmistakable signs of imaging behaviour. For instance, the subjects' immediate response to such requests, was either to close their eyes or to look away from the experimenter's face, and there was a tendency for them to make tentative movements, as in grasping handle bars or pieces of string. Annett concluded that overt performance is not critical to the production of an explanation, but when overt performance is inhibited imagery is absolutely essential to the production of a verbal explanation.

Assuming that all subjects in part 1 of this Experiment 1 have learned the origami task well and become familiar with how to perform it especially after all those performance practice trials, we arrive at the hypothesis that internal representations, or images, of actions are capable of activating their linguistic counterparts in explanations of how to perform a motor task, bearing in mind that individual differences in imagery ability have some kind of effect on both verbal and motor recall of the same motor task under long-term recall.

5.1. Experiment I Part 2

The goal here was parallel to that of part 1, with the same motor task (origami) and the same two groups of subjects who had previously learned the task by the OL and VI techniques, except that in this part of the experiment we tested the effect of long-term verbal memory along with long-term motor memory. The aim was to observe the accuracy of recall and to note the number of errors that the subject made on recalling all the 13 movements of the task, either verbally or motorically. The experimental hypotheses were: 1) high imagers would recall the motor task better than low imagers under long-term recall. 2) subjects who had learned the motor task by the OL technique would be able to recall the motor movements of the task better than those who had learned the task by the VI technique under long-term recall; 3) subjects who had learned the task by the VI technique would recall the verbal description of the motor task better than those who had learned the task by the OL technique.

5.1.1. Method

Experimental design

A three-factor mixed design was used, with between (observational learning and verbal instruction) techniques, between (high & low) imagers and within repeated measured trials. The dependent variables were: 1) accuracy scores in points, that is the same method of scoring was used on as in the first part of the experiment - 2 points for a correct movement recalled or a verbal step listed in the correct sequence, 1 point for a correct movement recalled or a verbal step listed not in the correct sequence, 0 point for any movement not recalled or step not listed, with a maximum scoring points of 26. 2) writing and performance time in seconds.

Subjects

The same group of subjects in part 1 of the experiment were tested on long-term memory 2 months later; only 26 of the original 40 subjects agreed to participate in the second part of the experiment. 14 of these subjects were from the VI and the remaining 12 subjects were from the OL group. The subjects within each group were divided according to their rating score on the shortened form of Betts' questionnaire upon mental imagery (QMI). All the original subjects were allocated to their original high or low imaging groups. A two-way (B.B.) analysis of variance was carried out between observational learning and verbal instruction and between high and low imagers on their QMI rating scores, and the results showed that there was a significant difference between the rating scores for the imagery groups [$F(1,22)=42.88$, $P<0.01$]. The high imagers rating scores showed that they have clearer and more vivid images than the low imagers. However, no significant difference was shown between the two groups in each of the learning techniques. Table 5.a shows the mean and the standard deviation, (for more information see Appendix 2.1)

Table 5.a. The mean & standard deviation on Betts (QMI) rating scores for high and low imagers

	Learning technique					
	OL			VI		
Imagery groups	N	Mean	Sd.	N	Mean	Sd.
High	6	72	15.56	7	63.67	7.45
Low	6	104.57	17.44	7	102.14	14.79

Apparatus

1) An electronic stop watch.

2) Video camera.

3) Video-tape recorder.

4) Colour television.

5) Instruction sheet.

6) A sheet of plain white paper upon which to record the verbal steps.

7) A diagram as in Figure 5.1 was drawn of the star folding task showing the hierarchical structure of routes expressed in corresponding verbal statements written down,. This figure was used to analyse the accuracy of the steps of the origami task recalled verbally by all subjects.

5.1.2. Procedures

The subjects in the OL and VI groups were divided at random into two sub-groups once again, regardless of their imagery ability. There were six subjects in each sub-group in the OL group and 7 subjects in each sub-group in the VI group. The first sub-group of each group was tested on long-term verbal memory (LTVM), followed by long-term motor memory (LTMM), whilst subjects in the second sub-group were tested on long-term motor memory (LTMM), followed by long-term verbal memory (LTVM). Each subject was asked to sit at a desk, and try to recall the movements of the origami task that they had learned two months ago on a sheet of plain white paper measuring 21 x 21 cm. An electronic stop watch was placed by the right-hand of the experimenter and so that its face could only be seen by him. All the subjects' movements were video-taped by the experimenter. Instructions for the OL and the VI groups were the same but the two sub-groups received different instruction thus:

Subjects were instructed as follows:

Instruction for LTVM + LTMM

Long-term verbal memory (LTVM)

"I want you to recall how you fold the paper in front of you to make a star You are not required to touch it but just write down the steps in the correct order on the second piece of paper. Take your time, and tell me when you have finished." (If the subject answers "NO I cannot remember", the reply will be "Go ahead and write as much as you can remember").

"GO"

(The time the subjects took to write down the steps was measured in seconds by the experimenter)

Long-term motor memory (LTMM)

"Now I want you to take the piece of paper and fold it into a star, as fast and accurately as possible. If you cannot remember just do the best you can and tell me when you have finished."

"GO"

(The movements of each subject were video-taped and the performance time measured by the experimenter).

Subjects were instructed as follows:

Instruction for LTMM + LTVM

long-term motor memory (LTMM):

"I want you to recall how you folded the square piece of paper in front of you to make a star. Now make a star, as fast and accurately as possible, and tell me when you have finished. (If the subject answers "NO, I cannot remember", the reply will be "Go ahead and do as much as you can remember").

"GO"

(The subject's movements were video-taped by the experimenter, who also measured the performance time).

Long-term verbal memory (LTVM):

"I want you to write down all the steps you took in making a star in the correct order, take your time. If you cannot still remember just do the best you can and tell me when you have finished".

"GO"

(The time the subjects took to write down the steps was measured in seconds by the experimenter)

The movements of each subject were video-taped, then judged and analysed by the experimenter. The hierarchical structure of routes as shown in the diagram in Figure 5.1 was used to score each verbal step listed by each individual subject.

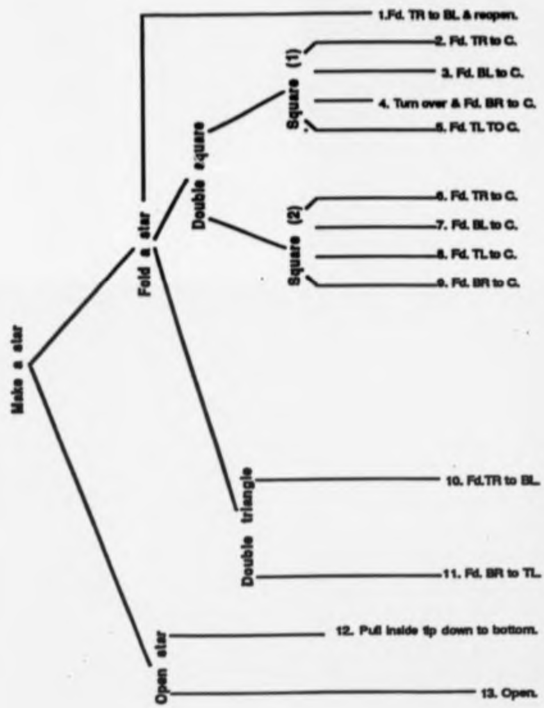


Figure 5.1 Diagram of the star folding task in the form of a structure

5.1.3. Results

Using the same minitab program available on the Daisy computer that was used previously to analyse the data in part 1, a three-way anova (B.B.W.) (2X2X2) was carried out on each of the two sets of data: 1) accuracy scores; 2) performance time in seconds for each trial.

Accuracy scores

The results showed that there was a significant main effects between trials [F(1,22)=11.92, P<0.01], this main effect indicated that subjects find it easier to recall the motor movements they have learned in performing a task than to give verbal descriptions of the movement of the same task from long-term recall. Inspection of the means in Table 5.b and the graph in Figure 5.2 shows this difference clearly. No other difference or interaction was shown to be significant. (See Appendix 2.2 for a summary table of the three-way anova.)

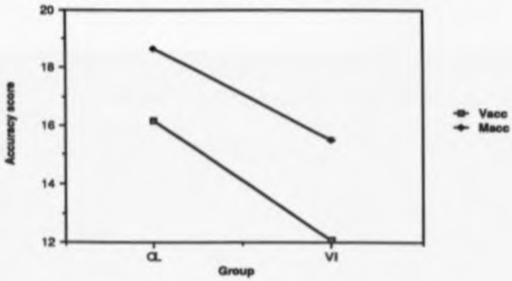
Table 5.b. Mean accuracy scores for all subjects.

	Learning technique					
	OL			VI		
Imagery groups	N	V-acc	M-acc	N	V-acc	M-acc
High	6	18.83	22.67	7	12.29	14.00
Low	6	11.00	15.33	7	14.00	16.43

N= number of subjects in each imagery group.
V-acc= Verbal recall accuracy scores.
M-acc= Motor recall accuracy scores.

Figure 5.2

Differences in accuracy scores between verbal & motor recall



Performance time

The same three-way analysis of variance (B.B.W.) (2X2X2) was carried out between observational learning vs verbal instruction, between imagery groups, within performance time for writing the verbal steps or performing the movements. The results showed that there was a significant difference between the time taken to write the verbal descriptions and the time taken to actually perform the same task [$F(1,22)=15.71$, $P<0.01$]. Inspection of the means in Table 5.c and the graph in Figure 5.3 shows this difference clearly. No other difference or interaction was shown to be significant. (See Appendix 2.3 for summary table of the three-way anova.)

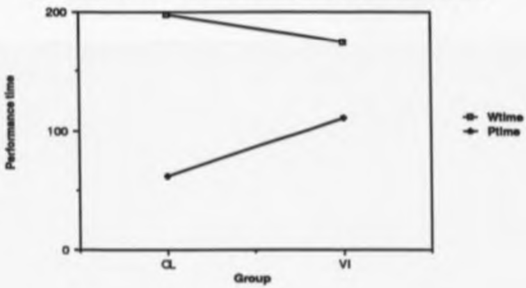
Table 5.c. Mean accuracy scores for all subjects.

	Learning strategies					
	OL			VI		
Imagery groups	N	W-time	P-time	N	W-time	P-time
High	6	168.99	70.46	7	217.88	98.41
Low	6	163.72	131.20	7	183.82	94.31

N= number of subjects in each imagery group.
W-time= Writing time
P-time= Performance time.

Figure 5.3

Differences in performance time between writing & performing the task



In verbal recall using the diagram in Figure 5.1 of the hierarchical structure of routes through the corresponding verbal statements written down, various kinds of errors were observed thus:

a) Omissions: e.g. sometimes subjects forget the second half of a step to open the sheet after folding it, for instance, or to turn it over.

b) Reversals: e.g. 'top right' for 'bottom left'.

c) Intrusions: e.g. step (1) was sometimes repeated across the other diagonal.

d) Condensation: e.g. a sequence of steps to make a square was condensed into a single statement such as 'fold the corners to the middle'.

The number and type of those errors in relation to the subjects original learning technique are shown in the Table 5.d. However OL condensation Errors are not in fact errors.

Table 5.d. The number & type of errors for all subjects.

Type of error	OL	VI
Omission	6	11
Reversals	3	5
Intrusions	4	2
Condensation	10	8

5.3.4 Discussion & Conclusion

Results have not supported any of the hypotheses in this experiment. Therefore, it seems, that the initial learning technique has no significant effect on the recollection of a motor task after a long interval. However, the significant differences between accuracy and performance time after a long interval showed that the verbal and motor information are processed from two different systems. This supports one of Annett's (1982) assumptions that there are two independent systems, one which is concerned with perception and production of actions, and another which is concerned with perception and production of language. Moreover, the results showed that imagery was no longer relevant to either accuracy or performance in recalling the origami task in long-term memory. This provides further support for the conclusion of Part 1, that imagery ability enhances observational learning in the early stage of reproduction.

Chapter 6

THE EFFECT OF DEMONSTRATION CONTENT AND IMAGERY ABILITY ON IMITATING A CLOSED MOTOR TASK

The results of the previous experiments showed that imagery ability enhances observational learning (OL) of a closed motor task (e.g. origami), in the early stage of reproduction, and further that observational learning (OL) gives shorter performance time through trials than verbal instruction (VI), within short-term memory. It is still not clear however, what type of information learners store within their short-term memory.

Bandura's social learning theory (1971, 1977, 1986) on observational learning is understood as a multi-factor theory containing (1) attentional processes (2) representational processes (3) motor reproduction processes,and (4) motivational processes (Guidelines like these provide us with a general model of the important considerations in any learning conditions). The work of Lasher (1981), on the cognitive representation of an event involving human motion, demonstrated that the coherence of an event depends upon the perceived intention of the person in motion. Her method of investigation was based on presenting some selected stills from a sequence of filmed motions performed by a ballet-dancer to a group of subjects. Subjects were shown filmed sequences of a real dancer, followed by still pictures, in a recognition memory paradigm, with reaction time and error as dependent variables. Four types of picture were generated by the dancer's performance type 1, preparatory-completing type 2, completing-preparatory type 3, reversal, completing-preparatory; type 4, reversal, preparatory-completing. She hypothesized that "when the intention is perceived as completed, that segment of motion is encoded as a coherent event". One of her interesting findings was that in the case of continuing locomotion without contour motion, such as gliding along on ice, no further energy is being expended. The gliding motion itself represents the fulfilment of an intention, and the event can be encoded as completed.

Our main concern in this research will be to continue to focus on the effect of imagery ability on the recalling of a motor task, concentrating on the first process of Bandura's social learning theory (1971, 1977, 1986) and to investigate the second aspect the importance of the information contained in the demonstration, and using a similar method of investigation as Lasher (1981), we will choose two types of still from a filmed model of a motor task, and will ask the subjects to imitate the movements of the motor task in order to arrive at some sort of coherent relationship between imagery ability and imitation.

This original new approach of Lasher's in using the still pictures of a filmed model in her experiment as a visual stimuli, gave us the idea of presenting still pictures of a modelled motor task with different configuration of positions in order to test whether the information contained in the demonstration is as important as Bandura (1971, 1977, 1986) suggested in the second part of his social learning theory. We assume that certain items are easier to encode if they reveal the demonstrator's intention.

The more meaningful and available the image, the better the performance. The importance of meaningfulness in the cognitive processes in observational learning has been shown by Bandura & Jeffery (1973) and Bandura, Jeffery & Bachich (1974). Moreover, how movements are remembered depends on the meaningfulness of the movement. A movement can be considered meaningful to an individual if that person can readily relate the movement to something already known. For example, a movement that forms the shape of a triangle is considered more meaningful than one that makes an unfamiliar, abstract pattern. Hall has investigated the influence of meaningfulness on memory in a study described in Chapter 2. His results and those of others suggest that the more meaningful a movement is to a person, the more easily he/she will be able to remember that movement. Based on that, in this study we have introduced the non-meaningful motor task.

With all this in mind, this study seeks to investigate the recall of a sequential motor task after an observed demonstration, concentrating on the reproduction of pattern but comparing pattern recall with the type of information contained in each demonstration, in order to differentiate between the use of high and low imagery ability in imitation.

6.1. Experiment II

This experiment, sets out to determine which type of code or codes the observer maintains from a demonstrated motor task, and whether immediate reproduction of these codes may be related to imagery ability. The experimental hypotheses were 1) high imagers would be influenced more by the meaningful or nonmeaningful nature of the information in recalling a motor task than low imagers. 2) high imagers would benefit more from discerning the intention in making a movement than low imagers.

6.1.1. Method

Experimental design

A four-factor mixed design was used, with between (high and low) imagers, between (arbitrary and end result) stills, within (meaningful vs non-meaningful) and within five repeated trials. The dependent variables were 1) the accuracy scores and 2) performance time in seconds. Subjects were divided into two groups each of which had a different type of demonstration thus: Group (Er) observed a demonstration containing only the stills of the end results of the thirteen crucial movements of the motor task. Group (Ar) observed a demonstration containing an arbitrary selection of stills - that is, one from the middle of each of the thirteen crucial movements of the motor task.

Subjects

The shortened form of Betts' questionnaire upon mental imagery (QMI) was administered to 84 subjects; only 62 subjects participated in the experiment by filling in the questionnaire, and on the basis of their rating scores on the (QMI), 20 subjects from among the very high imagers, and 20 subjects from among the very low imagers were selected. The majority of the subjects were students drawn from different departments at the University of Warwick and from Coventry Technical College. Their ages ranged from 17 to 42 with a mean age of 24.83. An equal number of both male and female subjects participated in the experiment.

Subjects within each of the two groups were divided according to their rating score on the shortened form of Betts' questionnaire upon mental imagery

(QMI). A two-way (B.B.) (2X2) analysis of variance was carried out between the high and low imagers on their (QMI) rating scores, and the results showed that there is a significant difference between the rating score for the imagery group [$F(1,36)=70.76$, $P<0.01$]. The high imagers rating scores showed that they have clearer and more vivid images than the low imagers. Table (6.a) shows the mean , also for more information see Appendix (3.1).

Table 6.a. The mean for high and low imagers' rating scores on Betts (QMI)

Imagery		Group (Br)		Group (Ar)
High	N=10	79.5	N = 10	81.8
Low	N=10	111.7	N = 10	107.9

<u>The experimental tasks</u>

Two origami tasks have been used. a) A meaningful origami task was set consisting of 13 consecutive movements designed to form a rabbit shape on a 21X21 cm. piece of plain yellow paper, as shown in Figures 6.1a & 6.1b. b) A non-meaningful origami task was also used consisting of the same number of consecutive movements but without having a meaningful shape as the end result, as shown in Figures 6.2a & 6.2b.

Figure 6.1a. The thirteen end result (Er) stills for the meaningful origami task

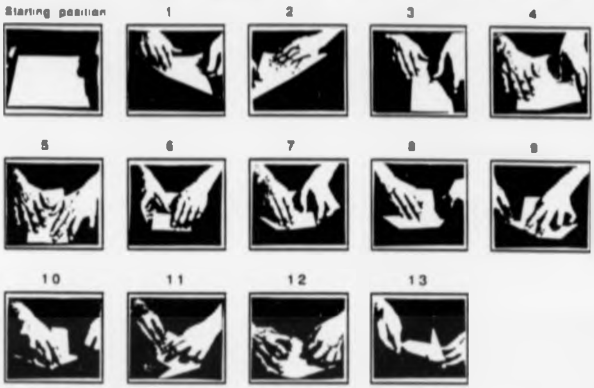
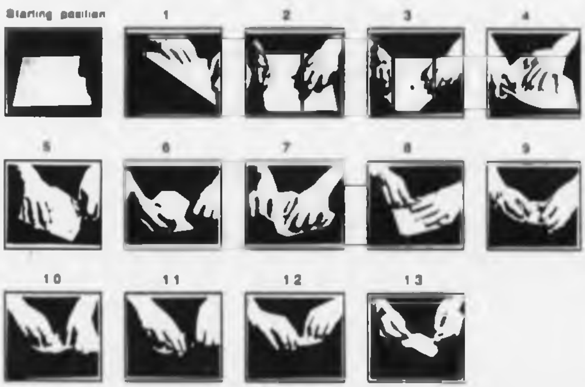


Figure 6.1b. The thirteen arbitrary (Ar) stills for the meaningful origami task

Figure 6.2a.. The thirteen end results (Er) stills for the non-meaningful origami task

Figure 6.2b.. The thirteen arbitrary (Ar) stills for the non-meaningful origami task



Materials and apparatus.

1) Camera : 35 mm. S.L.R. with power winder (approximately 2 frames/second).

2) Lens : 50 mm. macro.

3) Film : Fuji RHP 135-36

4) Light : 2X1000 w tungsten halogen with dichroic filters (one to give direct illumination, one to give diffuse fill in reflector).

5) Adm5 computer terminal.

6) RT80 lab computer and 8" disk drive.

7) Tape sync unit (Edrimatic).

8) 2"Khz Oscillator.

9) 2 Kodak SAV2000 projectors

10) 1 Cassette tape recorder.

11) 8 Kodak carousels

12) One wooden cabinet with two adjustable shelves to hold the 2 Kodak sav2000 projectors.

13) Sony video camera.

14) Video-tape recorder (VHS).

15) Colour television.

16) 21X21 cm. plain yellow pieces of paper.

17) An electronic stop watch.

18) Instructional sheets.

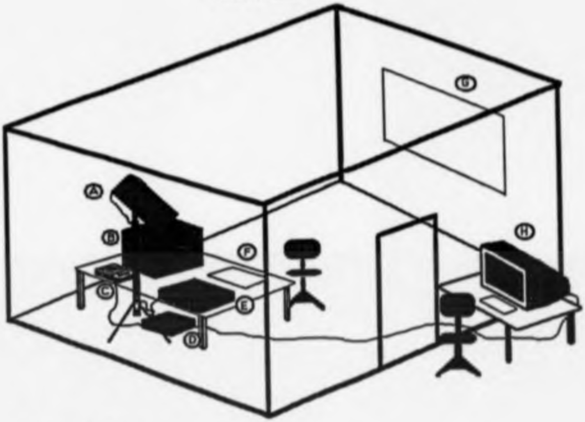
In order to insure that the two origami tasks presented the subjects with different stills positions, the movements of the two tasks as being demonstrated by the experimenter were photographed by a professional photographer using a 35 mm. camera with power winder (a rate of approximately 2 frames per second) with exposure 1/125 S f8. In order to ensure accuracy of the task performance, the experimenter himself had previously practised the two tasks. The two tasks were performed on a navy blue piece of cloth using a bright yellow piece of paper, and a 2X1000 w Tungsten halogen with daylight filter to ensure clarity of shadows and edges of the shapes.

An RT180 lab computer was used and an Adm5 terminal with two basic programs on an 8" disk drive (taking into consideration the mean average for the performance time for the two origami tasks) controlled the timing on the tape sync unit (Edrimatic) while operating two Kodak SAV2000 projectors to eliminate the dark frames that occur between each slide. To minimize the noise, the two projectors were positioned in a wooden cabinet with two adjustable shelves to line up the two projectors screens on top of each other. The experiment set up is shown in figure 6.3 a and b.

6.1.2. General procedure

The procedure for the two groups was the same. Each subject was tested individually by the experimenter. The experiment involved three different phases: a learning phase, a recall phase and a relearning phase. The subject was asked to sit facing a projector screen and to observe one demonstration of the task as shown in the diagram and photos in Figure 6.3a and 6.3b. The subject was then asked to turn the chair around, and on the piece of paper in front of him, he was asked to recall the movements of the task just shown, as fast and accurately as possible, just once. The recall of movements was video-taped by the experimenter, along with performance time. The subject was then asked to repeat the observation and reproduction of both origami tasks 5 times, even when the subject achieved the correct movement pattern on the first trial. Each group as we mentioned earlier was asked to observe a different type of demonstration.

Figure 6.3a



A) Video Camera.

B) Dual slide projectors enclosed.

C) Audio Tape Recorder.

D) Video Syncroniser unit.

E) VHS Video Cassette Recorder

F) Subject's test paper and electronic Stopwatch.

G) Slide projectors screen.

H) Video monitor and electronic stopwatch.

Figure 6.3b. The subjects were tested on imitation and recalling the two origami tasks

a) The subjects observing the meaningful origami task.

b) The subjects observing the non-meaningful origami task.

c) Experimenter's position while the subject performs the task

d) The subject performing the task

Two sets of thirteen still pictures were selected from 95 which covered the entire task. Those chosen to illustrate end results were those which showed the position of the hands and paper at the end of each of the thirteen folds. The "arbitrary" selection was made from shots roughly midway between folds. The model took 71.41 sec. to perform the task. Figure 6.3c & 6.3d shows the distribution of the selected stills pictures for the Er & Ar groups and the diagram of the Rabbit task in the form of a hierarchical struture

Group (Er)

Ten subjects observed a demonstration showing stills of the end results of the 13 crucial movements of the meaningful origami task, and then were shown stills of the ends results of the 13 crucial movements of the non-meaningful origami task. The other ten subjects observed a demonstration showing stills of the end results of the 13 crucial movements of the non-meaningful origami task followed and then were shown stills of the end results of the 13 crucial movements of the meaningful origami task

Group (Ar)

Ten subjects observed a demonstration showing 13 stills selected arbitrarily from each of the 13 movements of the meaningful origami task and then were shown 13 stills selected arbitrarily from each of the 13 movements of the non-meaningful origami task. The other ten subjects observed a demonstration showing 13 stills selected arbitrarily from each of the 13 movements of the non-meaningful origami task and then were shown13 stills selected arbitrarily from each of the 13 movements of the meaningful origami task

The length of the time for each still to be presented was controlled by one of the basic programs on the 8" disk drive; the average time for the model to perform the task was 71.41 sec, so the exposure duration time for each still was 71.41/13= 5.49 sec.

Figure 6.3c The distribution of selected still pictures and time interval in seconds for the Er & Ar groups.

A) Er selected stills.

B) Ar selected stills.

= The selected still pictures from the total of 95 stills.

5.26 = Interval time in seconds between selected still.

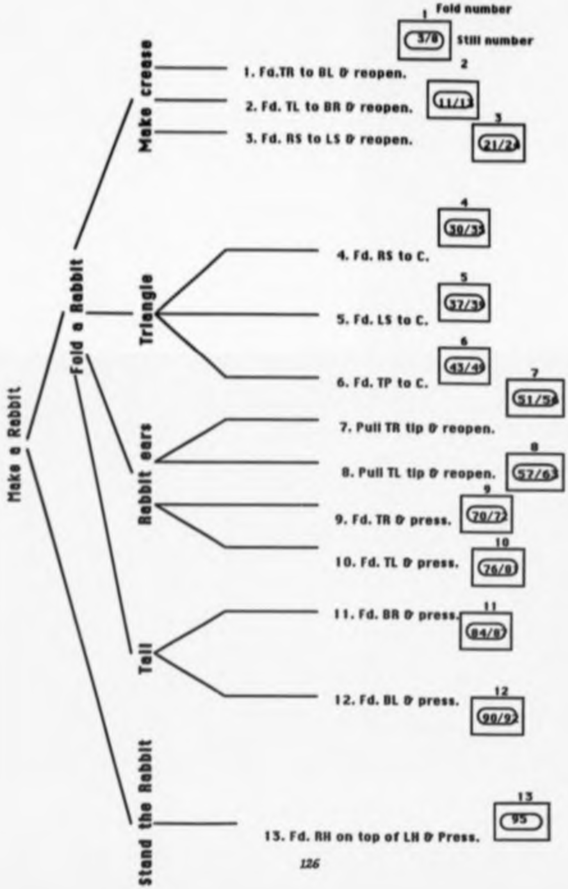


Figure 6.34 Diagram of the Rabbit folding task in the form of a hierarchical structure

All the subjects were given the same experimental instruction as follows:

Learning (phase)

"I want you to observe the full demonstration of the paper folding task. Try to memorize the movements because you will be asked to imitate all the movements that you have observed when the demonstration is finished. OK?"

Recall (phase)

"I want you to imitate the movements of the origami task that you have observed, as fast and accurately as possible, for only one trial."

"GO."

The subjects were asked to start a video timer as soon as the experimenter left the room, to ensure that the subject did not have time mentally to practice the task, and also to control the starting and ending positions for each trial.

Relearning (phase)

"I want you to observe again, one more time, a full demonstration of the origami task. Observe carefully and note any error you may have made."

"GO."

Recall (phase)

The same instruction as in the first recall, and this will continue for five trials.

6.1.3. Results

The same method of scoring was used in this experiment as in the previous experiment: 2 points for each correct step in the correct sequence, 1 point for each correct step not in the correct sequence, 0 point for any step not recalled, with a maximum accuracy score of 26.

Using the Data Management program available on the Amstrad 1512, a four-way anova (B.B.W.W) (2X2X2X5) between Er & Ar groups, between high and low imagers, within meaningful and non-meaningful tasks and within five trials, was carried out on each of the two sets of data. 1) Accuracy scores. 2) Performance time for each of the five trials.

Accuracy scores

The results showed that there was a significant main effects between trials [$F(4,144)=167.97$, $P<0.01$], between high and low imagers [$F(1,36)=6.83$, $P<0.01$] and between the meaningful and non-meaningful motor tasks [$F(1,36)=452.53$, $P<0.01$]. The trials main effect indicated that subjects improved in accuracy through trials. Inspection of the mean as shown in Table 6.b indicates that the high imagers recalled more correct movements than the low imagers, which replicates the results of the previous experiment, that imagery ability enhances the accuracy of recall of the origami task. The meaningful and non-meaningful main effect showed that the meaningful motor task is recalled better than non-meaningful task. No other differences were significant. The graphs in Figures 6.4 and 6.5 shows these differences clearly, (also see Appendix 3.2 for summary table of the four-way anova).

Table 6.b. Mean accuracy scores for all subjects

			acc1	acc2	acc3	acc4	acc5	
High	Group (Er)	M	12.9	20.2	23.6	25.4	26.0	High (Er) Mean= 15.03
		NM	5.4	7.4	8.8	10.0	10.6	
	Group (Ar)	M	11.2	19.0	22.2	26.0	26.0	High (Ar) Mean= 14.68
		NM	5.7	7.8	8.6	9.8	10.5	
Low	Group (Er)	M	10.9	19.0	20.9	23.2	26.0	Low (Er) Mean= 13.22
		NM	4.4	5.5	7.4	8.4	9.5	
	Group (Ar)	M	9.2	13.7	17.2	22.8	26.0	Low (Ar) Mean= 12.42
		NM	4.6	6.1	7.4	8.2	9.0	

M= Meaningful task.
NM= Non-meaningful task.

Figure 6.4

Differences in accuracy scores between high & low imagers

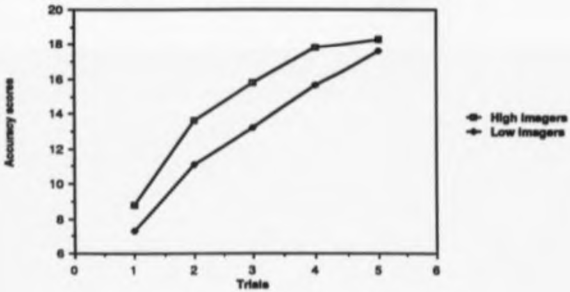
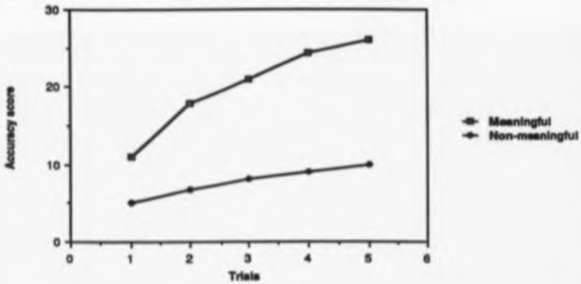


Figure 6.5

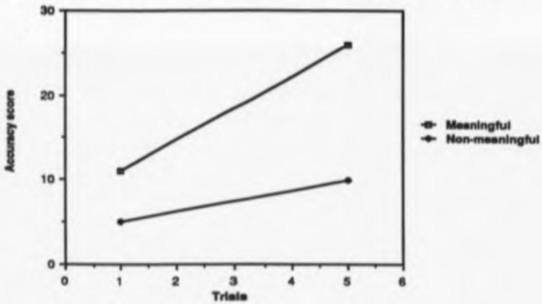
Differences in accuracy scores between meaningful & non-meaningful tasks



A significant interaction was apparent between the type of task and the repeated measured trials [F(4,144)=34.13, P<0.01], showing that the subjects improved in accuracy through the five trials while recalling the meaningful task better than the non-meaningful task. The graph in Figure 6.6 shows this improvement. No other interaction was shown to be significant. For more information, see Appendix 3.2.

Figure 6.6

Interaction in accuracy scores between meaningful & non-meaningful & trials



Performance time

The same four-way analysis of variance (B.B.W.W.) (2X2X2X5) was carried out on performance time in seconds. The results showed that there were a significant main effects between trials [$F(4,144)=12.57$, $P<0.01$] and between meaningful and non-meaningful tasks [$F(1,36)=44.44$, $P<0.01$]. The trials main effect indicated that subjects' performance time increases from one trial to the next overall. This was probably because the amount recalled was increasing, and so time is hard to interpret. Inspection of the means as shown in Table 6.c indicated that the meaningful task took longer to perform than the non-meaningful task. This difference is shown in the graph in Figure 6.7. For more information See Appendix 3.3.

Table 6.c. Mean performance time in seconds for all subjects.

			T1	T2	T3	T4	T5	
High	Group (Br)	M	71.88	89.60	91.72	90.61	83.94	High (Br) Mean= 72.54
		NM	48.74	61.75	56.81	67.05	65.18	
	Group (Ar)	M	76.23	86.34	95.84	88.46	79.48	High (Ar) Mean= 72.5
		NM	54.25	60.33	65.39	61.28	57.48	
Low	Group (Br)	M	69.38	81.15	84.83	98.08	90.96	Low (Br) Mean= 82.00
		NM	55.68	66.21	87.02	102.01	87.74	
	Group (Ar)	M	73.52	90.32	89.32	84.08	89.60	Low (Ar) Mean= 71.89
		NM	40.76	61.91	62.59	60.58	57.29	

M= Meaningful task.
NM= Non-meaningful task.

Figure 6.7

Differences in performance time between meaningful & non-meaningful tasks

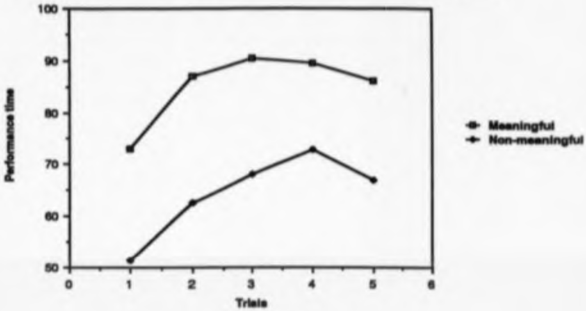
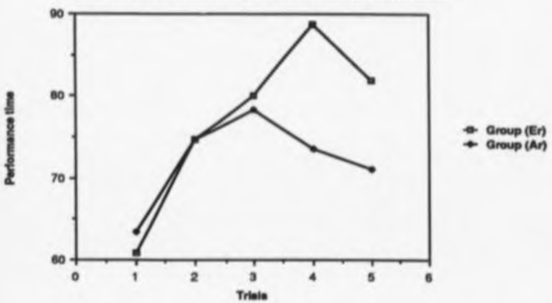


Figure 6.8

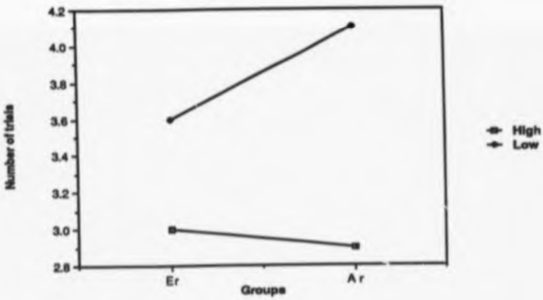
Interaction in performance time between (Er) & (Ar) & trials



The only significant interaction was between the Er & Ar groups and the five repeated trials [F(4,144)=3.25, P<0.01]. There was a greater improvement in the Ar group through trials in performance time than the Er group. Indeed the Ar group improved by 22.57%. The interaction is shown in Figure 6.8 and Appendix 3.3. No other interaction was shown to be significant in the anova.

Figure 6.9

Differences reproduction trials between high and low imagers



In addition to these results it was observed that some subjects tend to achieve their perfect performance of the meaningful task in fewer trials than others. A two-way (B.B.) (2X2) anova was carried out between high and low imagers and between Er & Ar groups on the number of trials a subject needed to perform the task correctly. The results showed that there was a significant difference between high and low imagers [$F(1,36)=6.01$, $P<0.01$] the high imagers achieved correct imitation of the task in fewer trials than the low imagers, as shown in the graph in Figure 6.9. Table 6.d shows the mean and the standard deviation for all subjects. For more information, see Appendix 3.4 for a summary of the two-way anova.

Table 6.d Mean & standard deviation of the number of trials for all subjects.

Imagery			Group (Er)			Group (Ar)	
			Mean	Sd.		Mean	Sd.
High	N=	10	3	1.05	N=10	2.9	0.88
Low	N=	10	3.6	1.43	N=10	4.1	0.88

6.1.4. Discussion

The results indicated partial support of the hypothesis that high imagers would benefit more from the meaningful and non-meaningful information in recalling of a motor task than low imagers. Evidence for the effectiveness of imagery was shown by the significant differences in accuracy of recall between high and low imagers through trials as shown in the graph in Figure 6.4. Despite this supportive result, the interactions between imagery and other variables in this study were not significant and therefore, we are still not clear what is its functional value in recalling a motor skill. It appears that the use of imagery enhances accuracy of recall of a motor task and may not interfere with the speed of performance.

Moreover, the significant differences in accuracy and performance speed of recalling between the meaningful and non-meaningful tasks indicated that the subjects were more intent upon goal achievement than trying to remember each still as presented. More support for this notion was given by the improvement in accuracy and performance through trials 1-5 (See Figure 6.6) for the meaningful task than the non-meaningful. It appears that the degree of meaningfulness of the information in a demonstration affects subsequent accuracy and performance.

The second hypothesis, that high imagers would benefit more from observing the purpose of a movement than low imagers was not supported. However, in trials 1-5, as shown in the graph in Figure 6.8, the (Ar) group improved significantly more in speed of performance than the (Er) group. It appears that what is being coded from the model demonstration is the purpose of the movement. For the second time in this study it has been shown that goal achievement was being coded.

The differences in the number of reproduction trials between high and low imagers as shown in the graph in Figure 6.9, indicated that high imagers established a perfect performance of the origami task in fewer trials than the low imagers. It appears that imagery helped the subjects to arrive at a more organized format for the motor task.

6.1.5. Conclusion

It can be concluded that accuracy of recall is related to the meaningfulness of the information encoded in memory, and that the more accurate the recall of movement the longer it takes to execute it. However the demonstration method of presenting one still at a time to the observer succeeded in showing that learning was a matter of establishing goals and not simply the remembering of each movement as presented. Images for the result of each crucial movement of the origami task appear to facilitate improvement in performance time.

Chapter 7

THE EFFECT OF IMAGERY ABILITY AND THE AMOUNT OF INFORMATION IN A DEMONSTRATION ON LEARNING A MOTOR TASK

From the previously described work it would be correct to conclude that imagery ability enhances observational learning of a closed motor task i.e origami in the early stage of reproduction. This conclusion was drawn from the first experiment Chapter 4. The improvement in accuracy scores in the pre-test phase (when the subjects were asked to imitate the same movements, after observing a full demonstration on a video-tape recorder, five times with 5 seconds rest between each demonstration) showed a significant difference between high and low imagers in the early stage of learning, with the high imagers reproducing the movements of the origami task more accurately than the low imagers.

However, the results from Part 2 of the same experiment, which was to re-tested the same group of subjects on long-term memory recall, have shown that the difference between high and low imagers was no longer discernible after an interval of 2 months and that high and low imagers recalled the motor task with no significant difference in accuracy.

The second experiment on the effects of demonstration content on imagery ability when imitating a motor task was designed to look more closely at what type of information contained in the demonstrations most readily encoded in the subject's memory, and what part is played by imagery ability in decoding it when the subject is asked to imitate the movements. The results of the second experiment have shown once again that the high imagers imitated the origami task with fewer errors than the low imagers but did not show any interaction between imagery scores and any other variables in the experiment. The experiment showed that individual differences in imagery ability affect the accuracy of imitation but does not give us any idea what type of information is being encoded and then decoded.

One might expect that from the demonstration of differences in meaningful and non-meaningful origami tasks in the second experiment the high imagers would have benefited more, but that was not the case. It seems that all the subjects imitated the task with the same accuracy. Before we start discussing the following experiment we have to mention that we carried out a pilot study for Experiment 2, where four groups of subjects were tested on imitating the origami task after observing four types of demonstrations, and the results were as follows:

1) The first group of subjects was asked to observe a demonstration of the motor task presented to them on a slide-projector. All 95 stills of the task after being photographed were shown and then the group was asked to reproduce the same movements.

2) The second group of subjects was asked to observe a full demonstration of the same task and after seeing half of the stills that had been photographed (selected on an alternate basis from the total number) to imitate the same movements.

3) The third group of subjects was asked to observe a full demonstration of the same motor task but was only shown the stills of the end results of the 13 crucial movements of the task(13.68% of the total number of the stills) before being asked to imitate the same movements of the motor task. The

stills of the end results (ER), consisted of the still (frame) of the final outcome of each fold of the origami paper.

4) The fourth group of subjects was asked to observe a full demonstration of the same motor task showing only an arbitrary selection of stills, one from the middle of each of the 13 crucial movements of the task(13.68% of the total number of the stills), and then imitate the same movements of the task. The stills were selected from the middle point of the 13 crucial folds, showing the model on the point of performing the next movement. The results of the pilot study showed a non-significant difference between the four groups, whether they observed100%, 50%, 13.68% (Er) or 13.68% (Ar) of the total number of stills [$F(3,12)=1.84$]. One might expect that if one further reduced the amount of information in a demonstration to below 13.68%, then the high imagers would benefit more from their ability to form images in recalling the task than low imagers.

Demonstration is the best known method of training a human to perform a perceptual motor task. However, one might ask which type of training would be more effective - repetitive demonstration or successive repetitions of a modelled sequence. Cook (1937) & Fouts (1970) have shown that learning is enhanced by repetitive demonstration. Previous to that McGuire (1961) had investigated the number of immediate, successive repetitions of a modelled sequence most effective in learning and found that performance can be enhanced by two or more repetitions. His conclusion was that the benefit of these repetitive demonstrations may be increased by distributing repetitions over a period of time rather than showing them in immediate succession.

Landers (1975) investigated the effect of temporal spacing of demonstrations and audience presence on learning a gymnastic skill. The motor task used in the study involved climbing the free-standing balance ladder, described by Bachman (1961). Subjects were 180 girls ranging in age from 11 to 13 years old. The observer viewed a demonstration of the task either before performing, or both before performing and midway through, the learning trial, or only midway through the learning trial. The results showed that the observers viewing the demonstration both prior to, and midway through, the learning trial performed the task better than all other groups.

Following these findings, one might expect that training using the technique of active learning (showing the observer a number of separate demonstrations of the task, each followed by a performance trial) would result in better accuracy and performance than using the technique of passive learning, (showing the observer repetitive demonstrations leading to a single performance of the motor task).

As mentioned earlier in Chapter 2 observational learning is enhanced by factors that channel attention to critical features of the modelled performance (Lumsdaine, 1962; Minas, 1980; Yussen, 1974). Additional support for this issue has emerged from the results of the pilot study of experiment II, mentioned in the beginning of this chapter. Moreover, the results from experiment II itself show that one can perform a motor task after only observing the crucial movements.

7.1. Experiment III

In this respect, one could hypothesize that the more information available in the demonstration the less will imitation be affected by imagery ability.

With minimal information from the model, subjects with high imagery ability will learn more effectively than those low on imagery ability. To support this hypothesis we need to set up an experiment to test a group of subjects on accuracy and performance of a motor task. The experimental hypotheses were 1) That active learning technique is superior to passive learning in accuracy and performance of recalling the origami task. 2) High imagers would benefit more from minimal information contained in a model demonstration than low imagers. 3) The more information available from a modelled demonstration of a motor task the better the accuracy and performance in recalling the task.

7.1.1. Method

Experimental design

A four-factor mixed design was used, with between (active and passive) learning groups, between (high & low) imagers, between (13, 8, & 4) stills presented , and within five repeated measured trials. The dependent variables were 1) the accuracy scores and 2) the performance time in seconds. There were six different conditions, the three active learning groups which had 13, 8 and 4 stills presented to them were called conditions 1, 2 & 3 respectively, and the three passive learning groups which also had 13, 8 and 4 stills presented to them were called conditions 4, 5 & 6 respectively.

Subjects

The subjects were 30 male and 30 female paid volunteers from among undergraduate and graduate students at the University of Warwick, and students from Coventry Technical College. The 60 subjects were selected from a pool of 105 who rated themselves on Betts (QMI). The selection was based on their imagery rating scores, that is, the highest thirty and the lowest thirty. Their ages ranged between 17-45 years, with a mean average of 25.5. Five subjects of each sex were randomly assigned to each of the six treatment conditions.

Subjects within each of the six treatment conditions were divided according to their rating score on the shortened form of Betts' questionnaire upon mental imagery (QMI). A two-way (B.B.) analysis of variance was carried out between active and passive groups and between the high and low imagers on their (QMI) rating scores, and the results showed that there is a significant difference between the rating scores for the imagery groups [$F (1,8) = 33.08$, $p < 0.01$]. The high imagers rating scores showed that they have clearer and more vivid images than the low imagers. Table 7.a shows the mean for all subjects. (For more information see Appendix 4.1.)

Table 7.a The mean for high and low imagers on Betts (QMI) rating scores

Imagery	N		Stills condition	
High	10	13 stills	8 stills	4 stills
	Subjects in each treatment cond.	86.40	84.30	79.10
Low	10	13 stills	8 stills	4 stills
	Subjects in each treatment cond.	146.30	137.30	122.00

<u>Modelling Stimuli and Apparatus</u>

The same photo slides of the rabbit origami task were used from Experiment II Figure 6.1, which showed the stills for the end results of the 13 crucial movements of the task. In addition the following materials were used:-

1) Tape sync unit (Edrimatic).
2) 2"Kh2 Oscillator.
3) 2 Kodak SAV2000 projectors.
4) 1 Cassette tape recorder.
5) 8 Kodak carousels.
6) One wooden cabinet with two adjustable shelves to hold the 2 Kodak sav2000 projectors.
7) Sony video camera.
8) Video-tape recorder (VHS).
9) Colour television.
10) 21X21 cm. plain yellow pieces of paper.
11) An electronic stopwatch.
12) Instructional sheets.
13) Adm5 computer terminal.
14) RT180 lab computer and "8" disk drive.

The RT180 lab computer and Adm5 terminal were used with two basic programs on an 8" disk drive (taking into consideration the length of time to perform the origami task of 72.41 sec.) to control the timing on the tape sync unit (Edrimatic) while operating two Kodak SAV2000 projectors to eliminate the dark black frames that occur between each slide. To minimize the noise the two projectors were positioned in a wooden cabinet with two adjustable shelves to line up with the two projector screens on top of each other.

7.1.2. General procedure

The subjects were divided into two groups of 30. Each group received a different method of observational learning, passive or active. Each successive set of ten subjects within each group observed a demonstration of the task with less information contained in each demonstration than the previous group. The first ten subjects observed a full demonstration containing 13 stills from the total number of the 95 stills for the task. These 13 stills showed the end results of the crucial movements needed in order to perform the origami task as shown in the diagram in Figure 7.1. This selection was based on the results from Experiment II which showed that there was no significant difference between the selected stills if they were selected from end results of the 13 crucial movements or arbitrarily chosen from the middle point of the same 13 movements.

The second ten subjects observed a demonstration containing only 8 stills which showed all the symmetric movements (symmetric in a sense that whatever movement is made on the right a similer one would be made on the left) needed in order to perform the task, as shown in in the diagram in Figure 7.2, and the third ten subjects observed a demonstration containing 4 stills which showed only half of the symmetric movements needed to perform the task as shown in the diagram in Figure 7.3. The percentages were 13.68%, 8.42%, 4.21% from the total 95 stills of the task. Presentation time for all the 95 stills was 72.41 seconds. In order to calculate the exposure duration for the stills for this experiment, and get the same presentation time, the total time was divided by the number of the stills presented thus:-

I) Subjects in conditions 1 & 2 for the respective active and passive learning techniques had 13 stills to observe with an exposure duration of 72.41/13= 5.57sec.

II) Subjects in conditions 3 & 4 for the respective active and passive learning techniques had 8 stills to observe with an exposure duration of 72.41/8= 9.05sec.

III) Subjects in conditions 5 & 6 for the respective active and passive learning techniques had 4 stills to observe with an exposure duration of 72.41/4= 18.1sec.

Figure 7.1. The diagram for the 13 Rabbit stills.

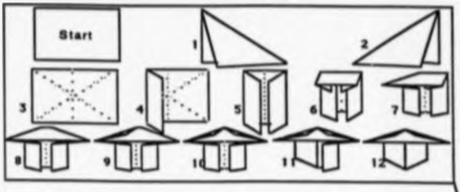


Figure 7.2. The diagram for the 8 Rabbit stills.

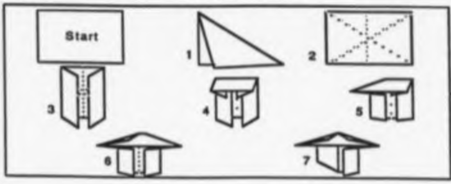
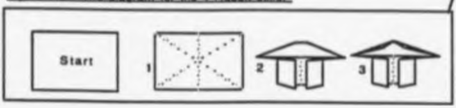


Figure 7.3. The diagram for the 4 Rabbit stills.



<u>Active learning</u>

The procedure for the active learning group of subjects was for them to observe the demonstration of the task once, and after each demonstration imitate the movements of the task as fast and accurately as possible. The procedure was repeated five times and each time an accuracy score was recorded using the same method of scoring as in the previous experiments - 2 points for each correct step in the correct sequence, 1 point for each correct step not in the correct sequence, 0 point for any step not recalled. Performance times were recorded by the experimenter using the electronic stopwatch. The subjects were also video taped to ensure accuracy in scoring.

<u>Passive learning</u>

The procedure for the passive learning group of subjects was for them to observe the full demonstration of the task five times, with 5 seconds rest between each demonstration during which the two projectors were reset. When all the five demonstrations were finished the subjects were asked to imitate the movements of the task five times, as quickly and accurately as possible. Subjects were video-taped to ensure accuracy in recording data and accuracy and performance times were measured by the experimenter using the same method as for the active learning groups.

Subjects were instructed as follows:

Active learning group

Learning phase

"I want you to observe once the full demonstration of the paper folding task. Try to memorize the movements because you will be asked to imitate all the movements that you have observed when the demonstration is finished. Ok?"

Recall phase

"I want you to imitate the same movements of the origami task that you have observed, as fast and accurately as possible, just once".

"Go."

The above procedures of learning and recalling were repeated five times and the subjects were asked to start the video timer each time, as soon as the experimenter left the room as shown in Experiment 2 Figure 6.3. This was to ensure that the subjects did not have time to rehearse the task mentally, and also to control the starting and finishing positions for each trial.

Passive learning group

Learning phase

"I want you to observe the full demonstration of a paper folding task five times. Try to memorize the movements because you will be asked to imitate all the movements that you have observed. Ok?"

Recall phase

"I want you to imitate the same movements of the origami task that you have been observing as fast and accurately as possible, just once".

"Go."

The subjects were asked to recall the task only five times and to start the timer as soon as the experimenter left the room, as shown in Figure 6.3. This was to ensure that the subjects did not have time to practice the task mentally, and also to control the starting and finishing positions for that trial.

7.1.3. Results

The same method of scoring the accuracy of recall was used as in the previous experiments, and, as before, performance time was measured in seconds for all the five trials.

Using the Faststat program available on the Macintosh plus computer, a four-way anova (B.B.B.W.) (2X2X3X5) was carried out on each of the two sets of data. 1) accuracy scores; 2) performance time/seconds for each of five trials.

Accuracy scores

The results showed that there were significant main effects between trials [$F(4,192)=58.37$, $P<0.01$], between high and low imagers [$F(1,48)=8.53$, $P<0.01$] and between the three treatment conditions [$F(2,48)=54.97$, $P<0.01$]. The trials' main effect indicated that subjects improved in accuracy through trials. Inspection of the means, as shown in Table 7.b indicated that the high imagers recalled more correct movements than the low imagers, this replicated for the third time the results of the previous two experiments, that imagery ability enhances the accuracy of recall of an origami task. The treatment conditions main effect showed that the more stills the subjects observed the better the accuracy of recall of the origami task. No other differences were significant, such as, active vs passive was not significant. The graphs in Figures 7.4 & 7.5 show these differences clearly. (See Appendix 4.2 for summary table of the four-way anova.)

Table 7.b. Mean accuracy scores for all subjects

		No.stills	Acc1	Acc2	Acc3	Acc4	Acc5		
		13	14.8	18	24.4	26	26		
	Active	8	12.4	20.4	23.2	26	26		Mean
		4	5.6	7.2	9.2	11.6	14.4	Active	17.68
High									
		13	24	24.4	25.6	26	26	Passive	16.27
	Passive	8	13.2	13.2	13.2	13.2	13.2		
		4	6.8	9.2	11.2	12	12.8		
		13	12	16.4	19.2	24	24		
	Active	8	10.4	13.6	18	18.8	19.6		Mean
		4	7.2	8	8.8	11.2	12.8	Active	14.93
Low									
		13	19.6	20.8	23.6	24	26	Passive	13.12
	Passive	8	8.4	8.8	8.8	9.2	9.2		
		4	6.8	7.2	8	8	8.4		

Figure 7.4

Differences in accuracy between high and low imagers

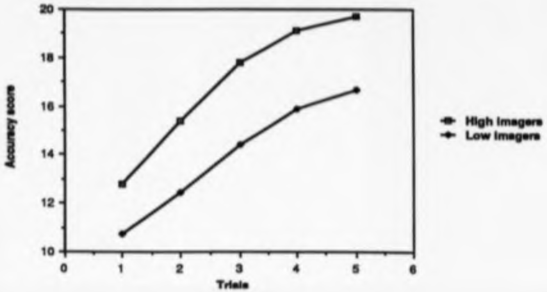
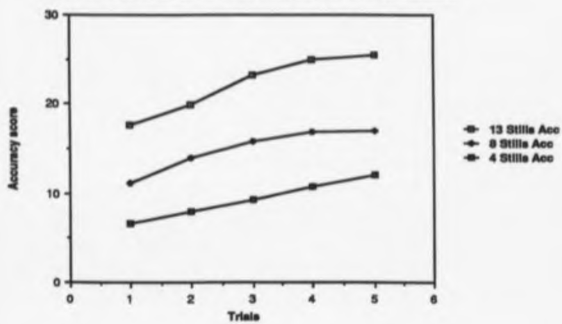


Figure 7.5

Differences in accuracy scores between 13, 8 & 4 stills conditions



A significant interaction was shown between the active and passive learning groups and the stills conditions (13, 8 & 4) presented to the subjects [$F(2,48)= 10.76$ $p < 0.01$]. A post-hoc Tukey's test was carried out between the six condition groups on the level of accuracy in recalling the motor task. The results showed that the accuracy score for the subjects in condition (5), that is, active learning with only 4 stills presented, was significantly worse than the subjects in condition (2), that is, passive learning with 13 stills presented. In addition, the accuracy score for the subjects in condition (2) was significantly better from the subjects in the other two passive conditions (4) & (6). No other differences were significant. The subjects in condition (2) recalled the motor task with more accuracy than the three other conditions just mentioned. The graph in Figure 7.6 shows this difference. (For more information about the results see Appendix 4.3.

In addition two further significant interactions were shown by the results, one between the active and passive groups and the repeated measured trials [$F(4,192)= 19.21$, $p < 0.01$] and the other between groups X stills X trials [$F(8,192)= 2.64$, $p < 0.01$]. The active vs passive and trials interaction showed that the active learning groups improvement in accuracy through the five trials was better than the passive learning groups. The groups X stills X trials interaction indicated that the more information the active learning groups assimilated the greater improvement in their accuracy through trials over that of the passive learning groups. The graphs in Figures 7.6 & 7.7 show these improvements more clearly. For more information, see Appendix 4.2.

Figure 7.6

Interactions in accuracy between active & passive groups & stills conditions

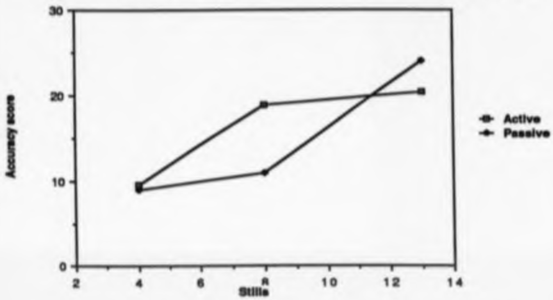
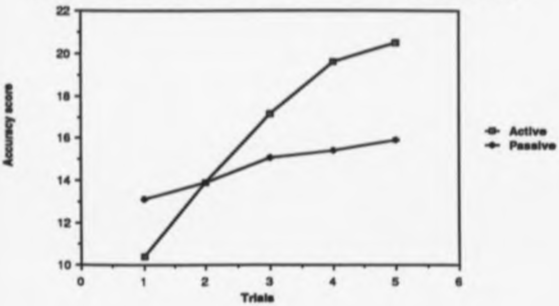


Figure 7.7

Interaction in accuracy between active vs passive learning groups & trials



Performance time

The same four-way analysis of variance (B.B.B.W.) (2X2X3X5) was carried out between active vs passive, between imagery, between stills conditions and within five trials on performance time/seconds. The results showed that there was a significant difference between trials [$F(4,192)= 3.21$, $p< 0.05$] and between the three stills conditions [$F(2,48)= 4.64$, $p < 0.05$]. The trials main effect indicated that subjects' performance time increases from one trial to the next overall. Inspection of the means as shown in Table 7.c indicated that the more stills were presented to the observer the longer the performance time. This difference is shown in the graph in Figure 7.8. For more information, see Appendix 4.4.

Table 7.c. Mean performance time in seconds for all subjects

		No. stills	T1	T2	T3	T4	T5		
High	Active	13	92.45	84.83	112.53	97.19	90.08		
		8	57.36	82.25	102.77	90.82	74.82		Mean
		4	41.07	54.9	72.01	77.07	83.73	Active	80.92
	Passive	13	109.68	84.58	80.46	71.92	70.76		
		8	82.08	82.84	76.72	70.28	67.2		Mean
		4	104.71	90.23	71.59	67.68	61.41	Passive	79.48
Low	Active	13	72.98	104.57	121.75	110.85	103.57		
		8	49.29	62.14	71.59	86.88	68.33		Mean
		4	57.77	61.63	71.49	73.98	78.36	Active	79.65
	Passive	13	96.37	89.99	80.96	74.67	69.23		
		8	92.08	68.35	78.01	68.54	64.58		Mean
		4	81.29	74.99	74.42	74.89	65.67	Passive	78.34

The only significant interaction was between the active and passive groups and the five trials [$F(4,192)= 31.44$ $p < 0.01$]. There was a greater improvement among the passive learning group through trials in performance time than among the active learning group. Indeed the passive learning group improved by 67.61%. The interaction is shown on the graph in Figure 7.9 and Appendix 4.4.

Figure 7.8

Differences in performance time between 13, 8 &4 stills conditions

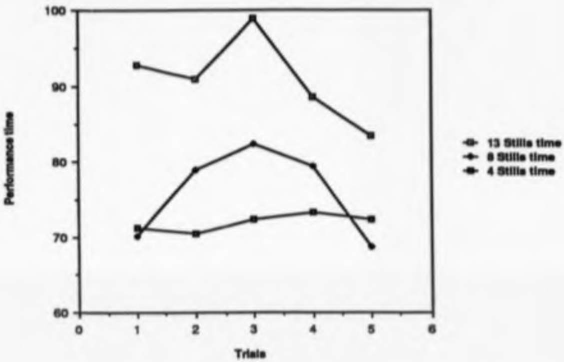
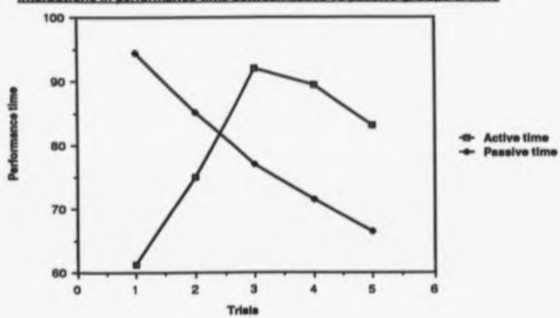


Figure 7.9

Interactions in performance time between active vs passive groups & trials



In addition to the analysis of variances, Pearson correlation coefficients were calculated between performance time and accuracy scores for active and passive learning groups on all five trials, as shown in Table 4d. The significant relationship between performance time and accuracy scores through the five trials for the active learning group showed that, while subjects in the latter learning group improve their accuracy scores from one trial to the next, performance time also increases. However, for the passive learning groups there was a non-significant relationship between performance time and accuracy scores through the five trials. These correlations are displayed in Table 7.d.

Table 7.d. Performance time and accuracy scores correlations

	Active			Passive		
	Mean T.	Mean Acc.	r	Mean T.	Mean Acc.	r
Trial 1	61.82	10.4	0.44*	94.37	13.13	0.12
Trial 2	75.08	13.93	0.49*	85.17	13.93	0.11
Trial 3	90.02	17.13	0.47*	77.08	15.07	0.23
Trial 4	80.30	19.6	0.46*	71.50	15.40	0.10
Trial 5	83.14	20.47	0.45*	66.40	15.93	0.16

* = significant at 0.05 level of confidence
N = 30 subjects in each, active & passive learning groups.

7.1.4. Discussion

Results indicated partial support for the hypothesis that active learning technique is superior to passive learning technique in accuracy and performance of recalling the origami task. Evidence for the effectiveness of the passive learning technique was indicated in the significant trials interaction as shown in Figure 7.9. Over trials 1-5, those subjects observing a number of repetitive demonstrations followed by performance of the task improved significantly in terms of time compared with the active learning group. It appears that learning by passive association (the repeated observed demonstration without any interference from any performance trials between them) is effective only on the accuracy of recall for early reproduction, previous to practice on performing the motor task. The repetitive demonstrations of the motor task enables the observer-learner to form a mental picture of the sequence of events uninterrupted by his own actions. It was observed that if a movement is incorrectly coded through the repetitive demonstrations, then errors are carried through all recall trials. Nevertheless, the learner is able to continually recall the motor task with acceptable efficiency.

Over trials 1-5 in the graph in Figure 7.7, the active learning group improved significantly better than the passive learning group on accuracy of recall. It appears that separate demonstrations of the task, each followed by a performance trial, enhance improvement of accuracy of recall in all the stills conditions. It may be that observers in the active learning group were able to strengthen and stabilize their memory images from performing the motor task, whereas by the end of the fifth repetitive demonstration for the passive learning groups subjects may have lost some information or memory images of the motor task. The active learning group either disregarded the model's demonstration after trial 2 or had used trial 2 to code the model's demonstrations with their own performance, and hence increased their accuracy of recall on subsequent trials.

Furthermore, in the case of performance time, the results indicated some support for the reverse of the latter hypothesis. Evidence for the effectiveness of the active learning technique was indicated in the significant trials interactions. On trial 1, in the graph in Figure 7.9 active learning groups performed the task in less time than the passive learning group. It appears that learning by separate demonstrations is effective in improving performance time in early reproduction, but not accuracy which only improves with practice of the motor task. In trial 8, the passive learning group performed significantly faster than the active learning group. It appears that learning by passive association enhances performance time. It may be that the observer in the passive learning group has been mentally practising the task while observing the follow up demonstrations after trial 2, but were less accurate. The observers in the active learning group were slower in performing the task, but were more accurate.

The second hypothesis, that high imagers would benefit relatively more from the impoverished demonstration than low imagers, was not supported. However, in trials 1-8, as shown in the graph in Figure 7.4, the high imagers performed the task significantly better than the low imagers. It seems that high imagers tends to use their ability to form a better image to construct a model of their own actions to refer to when asked to recall a motor task, and that individual differences in vividness of imagery can be related to recognizing observable differences in stimulus matching, or accuracy of recall of a perceptual motor task. Results such as this suggest that imagery ability is an important factor in motor skill acquisition.

The third hypothesis, that the more information observed from a model's demonstration the better the accuracy of recall and speed of performance of the task, was fully supported. Evidence for the effectiveness of the 13 stills presented was indicated in the significant differences over trials 1-8, as shown in the graphs in Figure 7.5 & 7.8. The graph shows that those treatment conditions observing 13 stills from a model demonstration performed significantly better than the 8 stills condition, and the 8 stills condition performed significantly better than the 4 stills condition. Learning by model demonstrations may contain a maximum or a minimum amount of information. A maximum amount of information would be in a life model or video-tape demonstration containing all the necessary cues that are needed to learn the task. Minimum information, would be in a static demonstration showing only the critical movements of the task. With the exception of the accuracy results of the 8 stills active learning group, it appears that in the latter condition the observer extracted more information from the symmetrical movements presented to them by the model. This might be related only to the origami task which contains folds that would be seen from previous movements.

7.1.5. Summary of findings

It can be concluded that images were once again being coded in memory for the origami task by the significant differences between high and low imagers in accuracy of reproduction. The coding of images depends on the observational learning method used for learning the task. It appear that active learning strengthens and stabilizes coded images through repeated learning trials. However, the learner in the passive learning technique appears to gain more benefit in speed of performance from passive association. Images encoded by the observational learning method for the origami task appear to contain either minimum or maximum information depending on the amount of information contained in the demonstration.

This supports the notion that the movements learned by the observational method are coded in the form of visuo-spatial coding. Furthermore, it appear that the representational aspect of the motor system is directly linked with motor reproduction.

Chapter 8

CONCLUSIONS, POSITIONS AND DIRECTIONS.

The previous chapters have dealt with the theoretical relationship between imagery ability and imitation, in the recall of a closed motor task. A series of experiments have been conducted and described and some conclusions have been drawn. This final chapter has three objectives: first to draw final conclusions from the present study; second, to attempt to position this research within a wider framework of imagery as a mediator in imitation and observational learning under different types of demonstration; and third to suggest possible directions for future research in theoretical and applied settings.

8.1. Conclusion from the present study

Observational learning involves cognitive processes which permit the learner to retain the mental image of the task. This type of learning is presumed to employ an image processing system in association with motor memory representations. In particular images function to enhance and refresh existing representation. From the analysis of the cognitive processes in observational learning in Chapter 2 it appears that observers who transform modelled actions into either symbolic or visual imagery achieve a higher level of learning. This suggests that motor imagery has a visual spatial basis. One possibility is that forming a mental image is related to the recall of movements.

Cognitive psychology has devoted some of its efforts to exploring motor learning. Existing theories of motor learning seem to centre around recognition and memory systems (Adams, 1971; Schmidt, 1975), and the internal cognitive representational issue and the function of imagery has been neglected. Indeed the ability to form an image does not just allow one to establish a distinct or specific form of representation, but endows that representation with a corresponding meditational role in a cognitive system. It appears that imagery of motor movement function as part of a cognitive process enables the learner to recall the motor movements. The present investigations of role of imagery ability, imitation and demonstration in the recall of a closed motor task, showed that the imagery ability of the individual plays an important part in enhancing the imitation and the recall of the motor task. These differences appear not to be related to the type or content of the demonstrated motor act but are confined to the reproduction of the movements.

An adequate experimental methodology with which to investigate imagery and to distinguish the individual differences in mental imagery makes research in this field possible. Since the early 1900s psychologists (e.g. Betts)have used psychometric methods of comparison i.e. have compared individual subjects according to the vividness and manipulatability of their experienced mental imagery. This method permits one to investigate those cognitive processes involved in the recall of a motor task in a more formal manner.

The first part of Experiment I in Chapter 4, showed that imagery ability enhances the early stages of observational learning of a closed motor task, in this case an origami proper-folding task. This suggests that information is encoded in the form of images, and that these coded images do indeed function in motor recall. The differences in performance time between the two instructional methods, observational learning and verbal instruction suggest that coded images need to undergo two separate transformation processes, one which represents the information as it is decoded, and one which reproduces the movement of the task. The ability to form an image might be thought to operate as a guideline for the representational system but not the motor production system. One of the ways in which coded images may function in the recall of movement under either of the two instructional methods is by consolidating the memory representation system.

Part 2 of Experiment 1 reported in Chapter 5, showed that imagery was no longer effective on accuracy of recall in long-term memory (LTM). This provides further support for the earlier conclusion, that imagery ability enhances only the early stages of observational learning. It is noteworthy that the short-term advantages gained through immediate reproduction were no longer evident in recall after a long interval.

Subsequent experiments employ demonstrations containing the type and amount of information the subjects may readily encode in their memory, to be decoded with the help of their imagery ability when they are asked to imitate the same movement of a motor task such as paper-folding.

The sixth chapter introduced a comparison between the meaningful and non-meaningful origami task to be learned by the observational technique. High and low imagers were tested on the recall of the movement involved in the two origami tasks. A significant difference was found in accuracy of recall between the high and low imagers, and therefore it was concluded that the origami task movements are coded in the form of images. Images did not interfere with the speed of performing the task. Despite these results, the interactions between imagery and all other variables in the study were not significant, therefore, we are still not clear what is the functional value and controllability of imagery employed in the recollection of a closed motor task. Separate effects were found on accuracy of recall and performance within the meaningful and non-meaningful origami tasks. The standard of imitation in the performance of the meaningful task was significantly better than in the case of the non-meaningful task. Accuracy of recall appears to be geared to the meaningfulness of the information being coded in memory, and of course the more accurate the movement recalled the longer the time to execute it. However, the type of demonstration used in this experiment based on the method of presenting one still at a time to the observer suggests that learning was a matter of establishing goals and not simply remembering each movement as presented. Images for the end results of each crucial movement of the origami task appear to facilitate improvement in performance time.

Chapter seven showed by the significant differences between high and low imagers that images were once again being coded in memory for the origami task and confirmed that the coding of images depends on the observational method used for learning the task. It appears that active learning strengthens and stabilizes coded images through the repeated learning trials. However, the passive technique appears to promote greater speed of performance from "stimulus association", that is, the repeated chunks of coded images without any interference from performance trial between them. The demonstration could contain a maximum amount of information which would be the full sequence of movements, or a minimum amount of information which would be a partial sequence of movements. Obviously the maximum amount of information may be more than sufficient for the subject to complete the task but the minimum amount of information must be just sufficient for the subject to complete the task, this amount differing from subject to subject. Thus images coded by the method of observational learning for the origami task appear to be coded corresponding to the amount of information given in the demonstration.

8.2. A position for imagery ability in imitation and observational learning

There is no doubt that movements are coded in the form of images and the ability to form these images appears to play an important role in organizing and planning the motor task movements, especially in the early stage of learning movements of a closed motor task. Imagery ability seems to act as a mediator within a cognitive model of a closed motor task. Indeed imagery might best be recognized as a cognitive process which involves other forms of representation. The relationship between imagery ability and coded images within a cognitive model of a closed motor task did not reflect the accuracy of recall in motor reproduction.

It is obvious that cognitive processes are important in the acquisition of a skill. Annett (1982, 1983, 1985, 1986, 1989) has attempted to provide a general theoretical model within which to explore these cognitive issues. The model has been described in Chapter 1 Figure 1.1 which illustrates the cognitive processes involved in acquiring a skill and some of their interconnections. Annett's Action-Language Bridge and what Prinz (1986) has called the ideo-motor hyphen require the assumption of an internal representation of action which is somehow accessible to, and modifiable by both the perceived actions of others, and verbal instruction and descriptions. This representational system must be able to access output mechanisms so that perceived action can be imitated and verbal instructions can be obeyed (Annett, 1989). This research has examined the two experimental paradigms described in Figure 8.1, notably imitation and verbal instructions.

Figure 8.1

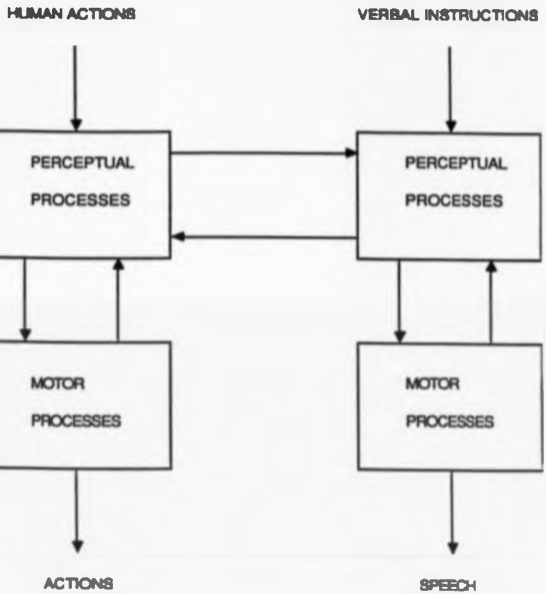


Figure 8.1, (adapted from Annett, 1986). Two important classes of events, actions and verbalizations, are analysed by specific perceptual systems. Each perceptual system is intimately linked with a corresponding output system. Imagery, motor or verbal, occurs when the perceptual and motor processes are jointly active (as represented by the vertical bi-directional arrows) in the absence of external inputs or motor output. The action and language systems communicate via the perceptual processes, the action-langu-age bridge represented by the horizontal bi-directional arrows. The figure illustrates the processes and connections believed to be active during imitation following instructions and imagery practice.

Piaget's (1951, 1953) development theory & Bandura's (1971, 1977, 1986) cognitive social learning theory gave a partial account of the processes involved in imitation. Behaviourists favoured active learning and the reinforcement of overt response (S-R) and were critical of the old industrial training method of "sitting by Nellie", that is to say, the observational method, by which workers were left to learn their jobs by watching other people doing the same job (Seymour, 1966). Annett (1989) has pointed out "that any observational learning theory, modelling and imitation, requires an internal representation of actions which is capable of being dissociated from their actual production. This internal representation must be such that it is modifiable by experience without feedback from the consequences of action on the real word" (p. 65). Thus motor reproduction may be generated from the use of internal representation and cognitive structures. However, the nature of these representations must be explained in order to provide an adequate theory of learning. Once one has a theory of the way or ways in which a task can be performed, one is in a very good position to ask about ways in which people may differ in their performance.

First, we have to consider how actions are perceived in order to understand how actions are represented. Meritzoff and Moore (1977) have shown that 12-to-21-day-old infants can imitate both facial and manual gestures, such as,tongue protrusion, mouth opening, lip protrusion and sequential finger movement. These primitive imitative responses are signs of mature imitation and tend to disappear before being replaced eventually by true walking. However, the existence of these responses in the early stage of development suggests the possibility of some connection between action perception and action production.

Bandura's (1971,1977, 1986) Social Cognitive Theory provided an explanation of the processes involved in observational learning. He suggested that four subprocesses component are involved in observational learning: 1) an attentional process; 2) a retention process; 3) a production process and 4) a motivational process. This research has focused on the first three subprocesses of Bandura's theory. Evidence of how only minimal cues are needed to perceive meaningful human action was shown by Johansson (1973), Cutting & Kozlowski (1977), Kozlowski & Cutting (1978) and Cutting & Proffit (1981, 1982). A filmed model wearing dark clothing with point-light sources mounted on major joints of the body (ankles, hips, elbows, etc...) was instantly recognized once the individual began performing a certain meaningful movement. It was difficult for the subjects to recognize the point-lights when they were moving in random fashion but as soon as the point-lights began to follow an action pattern, such as walking or armswinging performed by the model, they were instantly recognized and remembered. Also individuals can be recognized by their walk, and it is possible to predict with reasonable accuracy the sex of the model and the weight of any load they are carrying. Annett (1989) has concluded that "we are able to abstract invariants from such impoverished stimuli and these enable us to make socially significant judgements. It is important for humans to be able to infer not only the identity but the intentions of the model." Lasher (1981) has presented evidence that schematic structure, identifies some kind of end state, and goal or intention of outcome of perceived actions.

Some guide-lines as to what constitutes a good demonstration have been suggested by Sheffield (1961) who states that perception of actions is governed by some general rules of perceptual organization. These organizational factors would include "natural" units and the way in which they are organized into a meaningful act or succession of acts. Annett (1989) has carried out several studies in which subjects were asked to explain how they carried out tasks in which they were relatively skilled. Most of the statements given by the subjects actually refer to the end states which must be achieved before the next step of the task is undertaken, as when, for instance, a subject is asked to "explain how you take two ends of string and tie them together to make a bow" (See Figure 8.2). However, some evidence in this research has shown that the perceptual units relevant to perceived movement are related to movement reproduction, that is to say that the necessary conditions for subsequent movements are not just arbitrary chunks of perceived movement but meaningful wholes related to specific behavioural goals.

Demonstration is the most well known method used in training a human how to perform a motor task, and it is very frequently used in the early stage of training where it is believed to be generally more efficient than trial and error training. Landers (1975) confirms this by the results of his study on learning a gymnastic skill. A short description of the study is given at the beginning of Chapter 7. In another task used by Martens, Burwitz and Zuckerman (1976), which consisted of rolling a ball up an incline, the differences between successful and unsuccessful performance are not so clear from an external viewpoint, and the natural demonstrations were not as effective as specially filmed sequences. As Adams (1984, 1987) points out, observational learning provides only incomplete information for

Figure 8.2

<u>**Subject 6**</u>

OK/ um create a loop holding it between/ oh round my index finger hands/and tie the bow together/in double knot/creates a bow.'

<u>**Subject 8**</u>

'Er yes I would pick up the string and slide my hands along one to each end/er bring the ends up to meet one another/with my right hand I would put the string over the left ends/ and then bring it underneath/ and then the piece that I've just brought underneath I would put over/ and push it through loop/ and pull the whole thing tight. '

<u>**Subject 11**</u>

Um well I would take both pieces of string between er/the forefinger and thumb of each hand/ er being right handed I would hold the left hand still/ and take the right hand pass er/ pass the free end of the string in my right hand over the standing portion of the string in my left hand over and under to produce a a a um/ what would be a 360 degree wrap e/r that would provide the basis for a bow......'

Figure 8.2. (adapted from Annett, [illegible]) Sample protocols: subjects are asked to explain how to tie a bow. Protocols from subjects 6 and 8 are complete but only the first 10% of subject 11's response is shown.

movement. Some aspects of a movement will probably be out of sight, and all internal proprioceptive/kinesthetic sensation is missing.

Some types of demonstration seem to be more effective in learning a human skill than others. Cook (1937), Fouts (1970) and McGuire (1961) have shown that learning is enhanced by repetitive demonstration of a modelled sequence. Landeweerd, Seeger & Praagman (1981) have investigated the effect of instruction on process control performance. Subjects were divided into two groups, one of which was given type (I) information, that is information limited to the three most important aspects of the input-output relations, and one of which was given type (II) information, consisting of ample information, on the process itself in addition to the type (I) information. The results indicated a significant learning effect in the group with type (II) information. It was concluded that in such cases information about the process is apparently more effective than information about input-output relations only. This illustrates that movements are stabilized more when presented in the form of "passive associations" prior to performance. It seems that the amount of information given to the learner is very important in learning a task, and has its maximum or minimum limitations. The meaning of this information appears to be an important factor. Hall (1980) has shown the importance of meaningfulness of coded images to recall.

When subjects are requested to image a motor skill in an experiment, generally there has been little concern with how subjects might differ in their ability to comply with this request. Yet there are individual differences in imagery ability and these differences may influence the results. For example, if the subjects in an experimental condition are asked to use an imagery strategy and these subjects are all low imagers, it is likely no effect or only a small effect for the condition will be shown. It would seem desirable, therefore, that the interaction of imagery ability with recall of a motor task in an experiment, be taken into account.

There has been only a limited number of studies that have investigated imagery ability and the performance of a motor skill. Start & Richardson (1964) measured both vividness and controllability of imagery, and found no relationship between these aspects of imagery ability and the learning and performance of a gymnastic skill. There was some evidence, however, that vivid imagers who did not have control of their imagery performed less well than all other participants. Similarly, Epstein (1980) was unable to show any strong relationship between individual differences in imagery and performance accuracy in a dart-throwing task. It might be that this type of task does not require a great deal of imagery processing.

One study demonstrating more positive results was conducted by Ryan & Simmons (1982). Subjects were categorized according to the frequency with which they used imagery in everyday life and then assigned to one of six groups: imagers asked to employ imagery in mental rehearsal, imagers asked to use imagery, non-imagers asked to use imagery, non-imagers asked not to use imagery, physical practice and no practice. The focus of the study was the degree of improvement, measured on a stabilmeter (balance task), there had been at the completion of the acquisition phase. The results showed that physical practice produced larger improvement scores than mental imagery, and both were better than no practice. The groups requested to employ imagery were superior to those asked not to. In addition, subjects reporting strong visual images showed more improvement than those with weak visual images and those reporting strong kinesthetic images were superior to those with weak kinesthetic images.

Several studies have been able to demonstrate a positive relationship between imagery ability and the memory of movement information. Housner & Hoffman (1978, 1981) found that high imagers were more accurate in reproducing movement locations than low imagers in immediate reproduction and imaginal strategy. These were compared with low imagers who did not. However, this relationship between imagery ability and the reproduction of movement location has sometimes failed to emerge (Walsh, Russell, Imanaka, 1980).

The above studies suggest that imagery ability can interact with instructions to use mental imagery to influence performance. Unfortunately, the number of movement studies concerning imagery ability is small and a relationship between imagery ability and performance has not always been shown. Hall, Pongrac, Buckolz (1985) have argued that a major reason may be that the tests employed to measure imagery ability usually have not been concerned with movement. They have pointed out that these subjective questionnaires have entailed rating images of people, places and scenes (e.g. Vividness of Visual Imagery Questionnaire (VVIQ); Marks, 1973). Despite this argument the shortened form of Betts' Questionnaire (QMI) encapsulates the seven major sensory modalities of the human so it can be used as an adequate measurement of general imagery ability.

What can we say about imagery ability? It appears that it has an important role as a mediator between coded images and the reproduction of an origami task. In all the experiments in this research the subjects were not instructed to imagine the task. Despite that, subjects high in reported imagery ability were able to recall the movement of the task with greater accuracy than the low imagery subjects. Adams (1971) and Ho & Shea (1978) refer to images as being important to movement coding and control.

To sum up, I would suggest that there is enough evidence to support the notion that the internal representation which was formed during observational learning (Bandura, 1971, 1977, 1986) refers to symbolic representations which may be either imaginal (that is in analogue form) or visual , or verbal (that is coded as a verbal description of the movement to be carried out). Bandura & Jeffery (1973), Bandura, Jeffery & Bachicha (1974) and Jeffery (1976) have shown that in a number of studies verbal coding enhances retention. However, some complex skills are difficult to code verbally whilst visual imagery might be of greater value, i.e. the origami task. Gerst (1971) found verbal coding to be more effective in retention of a series of hand signals, but any instruction as to how to code the demonstration information was more effective than none.

It appears that learners are able to form internal representations of complex movements which may be visual or verbal and take the form of meaningful images relying on the minimal imperative cues that can be coded and depending on the way the information has been demonstrated

8.3. Future Directions

The importance of cognitive processes, such as imagery, in motor learning is becoming increasingly more obvious. The role of the effect of imagery ability in motor learning is still barely understood. Further investigations need to be carried out to establish an adequate measure of imagery ability, and the instrument employed in this assessment should be specifically concerned with the motor domain. The process of imaging could be further investigated to distinguishes between different types of imagery ability, for instance, the ability to form a visual image and keep it for a longer time than others, or the ability to reconstruct an image from a verbal description.

The variety of tasks on which subjects have been tested needs to be extended to take in different types of motor task and sports skill. The present investigations have merely highlighted the potential for investigating imagery ability as a mediator between coded images and reproduction. Any claims about the effect of the ability to form images in the recall of a motor act are as yet restricted to the origami task, movement location and stabilmeter (balance task).

To conclude, this thesis presents a thorough investigation of the effect of imagery ability on the recall of the origami task and describes the potentially powerful means of investigating such an effect. While the main body of the thesis is largely empirical, the theoretical considerations of imagery and motor learning are developed in the vein of cognitive psychology. The underlying process involved in imaging appears to affect the recall of the origami task in such a way that imagery acts as a mediator the subject relies on to transfer the coded images into reproduction of movements. The implications of this for theories of motor learning is that it supports the notion that internal representation is coded in the form of images. These images provide the only source of information about the motor act in relation to other environmental objects. The importance of internal representations to the recall of the movements is still arguable but this thesis suggests that cognitive processes, such as imagery, are confined to higher aspects of motor recall. The fact that imagery ability of the individual played an important role in the recall of the origami task has been firmly established. Future investigations using the techniques established here may succeed in distinguishing between the effects of imagery ability on different type of motor task.

References

Adams, J .A., Gopher, D. & Lintern, G. (1977). Effects of visual and proprioceptive feedback on motor learning. *Journal of Motor Behavior*, 9, 11-22.

Adams, J. A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior*, 3, 111-149.

Adams, J. A. (1978). Theoretical issues for knowledge of results. In G. E. Stelmach (ed.), *Information processing in motor control and learning*, New York: Academic Press.

Adams, J. A. (1983). On intergration of verbal and motor domains. In R. A. Magill (ed), *Memory and Control of Action*. (pp.3-15). Amsterdam: North-holland.

Adams, J. A. (1984). Learning of movement sequences. *Psychological Bulletin*, 96, 3-28.

Adams, J. A. (1987). Historical review and appraisal of research on the learning, retention, and transfer of human motor skills. *Psychological Bulletin*,101, 41-74.

Adams, J. A. & Dijkstra, S. J. (1966). Short-term memory for motor responses. *Journal of Experimental Psychology*, 71, 314-318.

Adams, J. A. & Goetz, E. T. (1973). Feedback and practice as variables in error detection and correction. *Journal of Motor Behavior*, 5, 217-224.

Allport, F. H. (1924). *Social Psychology*. Cambridge, MA: Riverside Press.

Anderson, J. R. (1978). Arguments concerning representations for mental imagery. *Psychological Review*, 85, 249-277.

Annett, J. (1969). *Feedback and Human Behaviour*. Baltimore, MD: Penguin.

Annett, J. (1982). In the proceedings of the Canadian Society of Psychomotor Learning: sport & motor behaviour. In L. Wankel & R. Welberg (ed), *Research Practice*. University of Alberta, Canada.

Annett, J. (1983). Motor learning: a cognitive psychological viewpoint. In H. Reider, K. Bos, H. Mechling, & K. Reischle (eds.), *Motor Learning and Movement Behaviour*: A contribution to learning in sport (pp. 220-230). Schorndoff, West Germany: Verlag Karl Hofmann.

Annett, J. (1985). Motor learning : A review. In H. Heuer, U. Kleinbeck, & K. H. Schmidt (eds.), *Motor Behaviour : Programming, Control and Acquisition* (pp. 189-212). New York: Springer-Verlag.

Annett, J. (1986). On Knowing How to Do Things. *Experimental Brain Research Series 15*. Spring-Verlag Berlin. Heidelberg.

Annett, J. (1989). Training skilled performance. In A. M. Colley & J. R. Beech (ed), *Acquisition and performance of cognitive skills* (pp.63-80). New York: John Wiley & sons.

Annett, J., Kiss, G., Perera, R. (1978). Cognitive Aspects of Skill Acquisition. Final report to S.S.R.C.

Atkinson, R. C. & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (eds.), *The Psychology of Learning and Motivation: Advances in research and theory* (vol.2, pp. 89-197). Newyork: Academic press.

Bachman, J. C. (1961). Motor learning and performance as related to age and sex in two measures of balance coordination. *Res. Quart. Amer. Ass. Hlth. Phys. Educ. Recr.*, 32, 123-137.

Baddeley, A. D. & Hitch, G. (1974). Working memory. In G. H. Bower (ed), *The Psychology of Learning and Motivation* (vol.8, pp. 47-89).

Baddeley, A. D. (1981). The concept of working memory: A view of its current state and probable future development. *Cognition*, 10, 17-23.

Bandura, A. (1971). *Psychological Modeling: Conflicting Theories*, Chicago: Aldine-Atherton.

Bandura, A. (1977). *Social Learning Theory*. Englewood cliffs, NJ: Prentic-Hall.

Bandura, A. (1984). *Social Foundations of Thought and Action*. Englewood Cliffs, NJ: Prentic-Hall, in press.

Bandura, A. (1986). *Social Foundation of Thought and Action*: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentic-Hall.

Bandura, A. & Jeffery, R. W. (1973). Role of symbolic coding and rehearsal processes in observational learning. *Journal of Personality and Social Psychology*, 26, 122-130.

Bandura, A., Grusec, J. E. & Menlove, F. L. (1966). Observational learning as a function of symbolization and incentive set. *Child Development*, 37, 499-506.

Bandura, A., Jeffery, R. & Bachicha, D. L. (1974). Analysis of memory codes and cumulative rehearsal in observational learning. *Journal of Research in Personality*, 7, 295-305.

Beech, J. R. & Allport, D. A. (1978). Visualisation of compound scenes. *Perception*, 129-138.

Berger, S. M., Carli, L. L., Hammersla, K.S., Karshmer, J. F. & Sanchez, M. E. (1979). Motoric and symbolic mediation in observational learning. *Journal of Personality and Social Psychology*, 37, 735-746.

Bernstein, N. (1967). *The Coordination and Regulation of Movements*. Oxford: Pergamon press.

Betts, G. H. (1909). *The Distribution and functions of mental imagery*. New York: Columbia University. Teachers College, contribution to education series, no, 26.

Bilodeau, E. A., Bilodeau, I. M. & Schumsky, D. A. (1959). Some effects of introducing and withdrawing knowledge of results early and late in practice. *Journal of Experimental Psychology*, 58, 142-144.

Bransford, J. D., Franks, J. J., Morris, C. D. & Stein, B. S. (1979). Some general costraints on learning and memory research. In L. S. Cermak & F. I. M. Craik (eds.), *Levels of Processing in Human Memory* (pp. 331-354). Hillsdale, NJ: Erlbaum.

Bundesen, C. & Larsen, A. (1975). Visual information of size. *Journal of Experimental Psychology: Human Perception and Performance*, 1, 214-220.

Carpenter, P. A. & Just, M. A. (1977). Reading comprehension as eyes see it. In M. A. Just & P. A. Carpenter (eds.), *Cognitive Processes in Comprehension* (pp. 109-137). Hilladal, New Jersey.

Carroll, W. R. & Bandura, A. (1982). The role of visual monitoring in observational learning of action patterns: Making the unobservable observable. *Journal of Motor Behavior*, 14, 153-167.

Carroll, W. R. & Bandura, A. (1985). Role of timing of visual monitoring and motor rehearsal in observational learning of action patterns. *Journal of Motor Behavior*, 17, 269-281.

Carroll, W. R. & Bandura, A. (1987). Translating cognition into action: The rol of visual guidance in observational laerning. *Journal of Motor Behavior*, 19, 385-398.

Chase, W. G. & Ericsson, K. A. (1982). Skill and working memory. In G. H. Bower (ed), *The psychology of learning and motivation* (vol. 16, pp. 1-58). Newyork: Academic press.

Chevalier-Girard, N. & Wilberg, R. B. (1980). The effects of image and label on the free recall of organized movement lists. In P. Klavora & J. Flowers (eds.), *Motor Learning and Biomechanical Factors in Sport*. Toronto: Canadian Society for Psychomotor Learning and Sport Psychology, publishers.

Coates, B. & Hartup, W. W. (1969). Age and verbalization in observational learning. *Developmental Psychology*, 1: 556-562.

Collins, A. M. & Loftus, E. F. (1975). A spreading-action theory of semantic processing. *Psychological Review*, 82, 407-428.

Cook, T. W. (1937). Amount of material and difficulty of the problem solving. II. The disc transfer problem. *Journal of Experimental Psychology*, 3, 1-12.

Craik, F. I. M. (1970). The fate of primary memory items in free recall. *Journal of Verbal Learning and Verbal Behavior*, 9, 143-148.

Cronbach, L. J. & Furby, L. (1970). How we should measure " changes": Or should we ? *Psychological Bulletin*, 74, 68-80.

Crossman, E. R. F. W. (1959). A theory of the acquistion of speed-skill. *Ergonomics*, 2, 153-166.

Cutting, J. E. & Kozlowski, L. T. (1977). Recognizing friends by their walk: gait perception without familiarity cues. *Bulletin of the Psychonomic Society*, 9, 353-356.

Cutting, J. E. & Proffitt, D. R. (1981). Gait perception as an example of how we may perceive events, in Walk, R. D. and Pick, H. L. (eds.), *Intersensory Perception and Sensory Integration*. New york: Plenum.

Cutting, J. E. & Proffitt, D. R. (1982). The minimum principle and the perception of absolute, common and relative motions. *Cognitive Psychology*, 14, 211-286.

Danaher, B. G. & Thoresen, C. E. (1972). Imagery assessment by self-report and behavioral measures. *Behavior Research & Therapy*, 10, 131-138.

Denis, M. (1985). Visual imagery and the use of mental practice in the development of motor skills. *Canadian Journal of Applied Sport Sciences*, 10, 4S-16S.

Dixon, P. (1982). Plans and written directions for complex tasks. *Journal of Verbal Learning and Verbal Behavior*, 21, 70-84.

Durndell, A. J. & Wetherick, N. E. (1976). The relation of reported imagery tests to cognitive performance. *British Journal of Psychology*, 67, 501-506.

Epstein, M. L. (1980). The relationship of mental imagery and mental rehearsal to performance of a motor task. *Journal of Sport Psychology*, 2, 211-220.

Ernest, C. H. (1977). Imagery ability and cognition: A critical review. *Journal of Mental Imagery*, 2, 121-216.

Farah, M. J. & Kosslyn, S. M. (1981). Structure and strategy in image generation. *Cognition Science*, 4, 371-383.

Feltz, D. L. (1982). The effects of age and number of demonstrations on modeling of form and performance. *Research Quarterly for Exercise & Sport*, 53, 291-296.

Feltz, D. L. & Landers, D. M. (1978). Informational-motivational components of a model's demonstration. *Research Quarterly*, 48, 525-533.

Feltz, D. L. & Landers, D. M. (1983). The effects of mental practice on motor skill learning and performance: A meta-analysis. *Journal of Sport Psychology*, 5, 25-57.

Finke, R. A. (1979). The functional equivalence of imagery and movements. *Quarterly Journal of Experimental Psychology*, 34A, 349-365.

Fishburne, G. J. & Hall, C. R. (1988). Visual and kinesthetic imagery ability and movement. In M. Lashuk (ed.), *Proceedings of the 1988 Alberta Teacher Educators in Physical Education Society Annual Meeting* (pp. 10-23). Calgary: University of Calgary.

Fitts, P. M. (1964). Perceptual-motor skill learning. In A. W. Melton (eds), *Categories of Human Learning* (pp. 243-285). New York: Academic press.

Fitts, P. M. & Posner, M. I. (1967). *Human performance*. Belmont, CA: Brooks/Cole.

Fleishman, E. A. (1966). Human abilities and the acquistion of skill: comments on professor Jones, paper. In E. A. Bilodeau (ed), *Acquisition of skill* (pp. 147-167). New york: Academic press.

Fleishman, E. A. (1967). Individual differences and motor learning. In R. M. Gagne (ed), *Learning and Individual Differences* (pp. 165-191). Columbus, OH: Merrill.

Fleishman, E. A. (1972). On the relationship between abilities, learning and human performance. *American psychologist*, 27, 1017-1032.

Fleishman, E. A. (1978). Relating individual differences to the dimensions of human tasks. *Ergonomics*, 21, 1007-1019.

Fouts, G. T. (1970). Imitation in children, the effects of an audience, and number of presentation (*Doctoral Dissertation, University of Iowa, 1970*). Dissertation Abstracts International, 31, 1563B.

Gentile, A. M. (1972). A working model of skill acquisition with application to teaching. *Quest*, Monograph XVII, 3-23.

Gerst, M. S. (1971). Symbolic coding processes in observational learning. *Journal of Personality and Social Psychology*, 19, 7-17.

Gerst, M. S. (1971). Symbolic coding processes in observational learning. *Journal of Personality and Social Psychology*, 19, 7-17.

Glass, G. V. (1977). Standards and criteria. *Journal of Educational Measurement*, 15, 237-261.

Gopher, D. (1984). The contribution of vision-based imagery to the acquisition and operation of a transcription skill. In W. Prinz & A. F. Sanders (eds.), *Cognition and Motor Processes* (pp. 195-208). New York: Springer-Verlag.

Goss, S., Hall, C. R., Buckolz, E. & Fishburne, G. J. (1986). Imagery ability and the acquisition and retention of movements. *Memory and Cognition*, 14, 469-477.

Gupton, T. & Frinke, G. (1970). Imagery, mediational instructions, and noun position in free recall of noun-verb pairs. *Journal of Experimental Psychology*, 86, 461-462.

Hall, C. R. (1980). Imagery for movement. *Journal of Human Movement Studies*, 6, 252-264.

Hall, C. R. (1985). Individual differences in the mental practice and imagery of motor skill performance. *Canadian Journal of Applied Sport Sciences*, 10:4.

Hall, C. R. & Pongrac, J. (1983). *Movement Imagery Questionnaire*. London, Ontario: University of Western Ontario.

Hall, C. R., Pongrac, J. & Buckholz, E. (1985). The measurement of imagery ability. *Journal of Human Movement Science*, 4, 107-118.

Hatakeyama, T. (1984). Individual differences in imagery ability and mental size comparison. *Tohoku Psychologica Folia*, 43, 112-126.

Hayes, J. R. (1973). On the function of visual imagery in elementary mathematics. In W. G. Chase (ed.) *Visual Information Processing*. New York and London: Academic press.

Hinsley, D. A., Hayes, J. R. & Simon, H. A. (1977). From words to equations: meaning and representation in algebra word problems. In M. A. Just & P. A. Carpenter (eds.), *Cognitive Processes in Comprehension* (pp. 89-104). Hillsdal, New Jersey.

Ho, L. & Shea, J. B. (1978). Effects of relative frequency of knowledge of results on retention of a motor skill. *Perceptual & Motor Skills*, 46, 859-866.

Holt, E. B. (1931). *Animal Drive and The Learning Process* (vol.1). New York: Holt, Rinehart & Winston.

Housner, L. (1984). The role of visual imagery in recall of modeled motoric stimuli. *Journal of Sport Psychology*, 6, 148-158.

Housner, L. & Hoffman, S. J. (1978). Imagery and short-term motor memory. In G. C. Roberts and K. M. Newell (eds.), *Psychology of Motor Behavior and Sport*. Champaign, Illinois: Human kinetics publishers.

Housner, L. & Hoffman, S. J. (1981). Imagery ability in recall of distance and location information. *Journal of Motor Behavior*, 13, 207-223.

Howe, M. J. A. (1970). *Intoduction to Human Memory*. New York: Harper & Row.

Humphrey, G. (1921). Imitation and the conditioned reflex. *Pedagogical Seminary*, 28, 1-21.

Janssen, W. (1976). *On the nature of the mental image*. Soesterberg: Institute for perception TNO.

Jeffery, R.W. (1976). The influence of symbolic and motor rehearsal on observational learning. *Journal of Research in Personality*, 10, 116-127.

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. *Perception and Psychophysics*, 14, 201-211.

Juhaz, J. B. (1972). On the reliability of two measures of imagery. *Perceptual & Motor Skills*, 35, 874.

Koen, F. (1971). Verbal mediators in cross-model from discrimination. *Canadian Journal of Psychology*, 25, 103-110.

Kosslyn, S. M. (1975). Information representation in visual images. *Cognitive Psychology*, 7, 341-370.

Kosslyn, S. M. (1978). Measuring the visual angle of the mind's eye. *Cognitive Psychology*, 10, 291-297.

Kosslyn, S. M. (1980). *Images and Mind*. Cambridge, Mass: Harvard University press.

Kosslyn, S. M. (1981). The medium and the message in mental imagery. *Psychological Review*, 88, 46-66.

Kosslyn, S. M. & Pomerantz, J. R. (1977). Imagery, proposition and the form of internal representations. *Cognitive Psychology*, 9, 52-76.

Kosslyn, S. M., Brunn, J., Cave, K. R. & Wallach, M. (1984). Individual differences in mental imagery ability: A computional analysis. *Cognition*, 18, 195-243.

Kosslyn, S. M., Reiser, B. J., Farah, M. J. & Fliegel, S. L. (1983). Generating visual images: Units and relations. *Journal of Experimental Psychology: General*, 112, 278-303.

Kozlowski, L. T. & Cutting, J. E. (1978). Recognizing the gender of walker from point-lights mounted on ankels: Some second thoughts. *Perception & Psychophysics*, 23, 459.

Landers, D. M. (1975). Observational learning of a motor skill: Temporal spacing of a demonstartion and audience presence. *Journal of Motor Behavior*, 7, 281-288

Landers, D. M. & Landers, D. M. (1973). Teacher versus peer models: Effects of model's presence and performance level on motor behavior. *Journal of Motor Behavior*, 5, 129-139.

Landeweerd, J. A., Seeger, H. J. J. L. & Praagman, J. (1981). Effects of instruction, visual imagery and educational background on process control performance. *Ergonomics*, 24, 133-141.

Lasher, M. D. (1981). The cognitive representation of an event involving human motion. *Cognitive Psychology*, 13, 391-406.

Lee, T. D. & Hirota, T. T. (1980). Encoding specificity principle in motor short-term memroy for movement extent. *Journal of Motor Behavior*, 12, 63-67.

Lorenz, C. & Neisser, U. (1985). Factors of imagery and event recall. *Memory & Cognition*, 13, 494-560.

Lumsdaine, A. A. (1961). *Student response in programmed instruction* (Pub. No. 943). Washington, DC: National Academy of Sciences-National Research Council.

Magill, R. A. & Dowell, M. N. (1977). Serial position effects in motor short-term memory. *Journal of Motor Behavior*, 9, 319-323.

Marks, D. F. (1972). Individual differences in the vividness of visual imagery and their effect on function. In P. W. Sheehan (ed.) *The Function and Nature of Imagery*. New York & London: Academic press.

Marks, D. F. (1973). Visual imagery differences in the recall of pictures. *British Journal of Psychology*, 64, 17-24.

Marks, D. F. (1977). Imagery and Consciousness: A theoretical review from an individual differences perspective. *Journal of Mental Imagery*, 2, 275-290.

Marr, D. (1976). Early processing of visual information. *Philosophical Transactions of the Royal Society of London Series B*, 275, 483-519.

Marteniuk, R. C. (1976). Mental imagery in associative learning and memory. *Psychological Review*, 76, 241-263.

Martens, R. G. (1975). Further considerations of "Retention characteristics of motor short-term memory cues": A reply to Laabs. *Journal of Motor Behavior*, 7, 151-152.

Martens, R., Burwitz, L. & Zuckerman, J. (1976). Modeling effects on motor performance. *Research Quarterly*, 47, 277-291.

Mazur, J. E. & Hastie, R. (1978). Learning as accumulation: A reexamination of the learning curve. *Psychological Bulletin*, 85, 1256-1274.

McDougall, W (1908). An Introduction to Social Psychology. London: Metheun & Co. Ltd.

McGuire, W. J. (1961). Some factors influencing the effectiveness of demonstrational films: Repetition of instructions, slow motion, distribution of showings, and explanatory narrations. In A. A. Lumsdaine (ed), *Student Responses in Programmed Instruction*. National Academy of Sciences-National Research Council.

Meltzoff, A. N. & Moore, M. K. (1977). Imitation of facial and menual gestures. *Science*, 198, 75-80.

Miller, G. A. (1956). The magical number seven plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63, 81-79.

Miller, N. E. & Dollard, J. (1941). *Social learning and imitation*. New Haven: Yale University press.

Minas, S. C. (1980). Acquisition of a motor skill following guided mental and physical practice. *Journal of Human Movement Studies*, 6, 127-141.

Morris, P.E. & Gale, A. (1974). A correlational study of variables related to imagery. *Perceptual and Motor Skills*, 38, 659-665.

Neisser, U. (1967). *Cognitive Psychology*. New York: Appleton-Century-Croft.

Neisser, U. (1972). Changing conceptions of imagery. In P. W. Sheehan (eds.), *The Function and Nature of Imagery*. New York and London: Academic press.

Neisser, U. (1976). *Cognition and Reality*. San Francisco: Freeman.

Neisser, U. (1978). Anticipations, images and introspection. *Cognition*, 6, 167-174.

Neisser, U. & Kerr, N. (1973). Spatial and mnemonic properties of visual images. *Cognitive Psychology*, 5, 138-150.

Newell, A. & Rosenbloom, P. S. (1981). Mechanisms of skill acquisition, and the law of practice, in J. R. Anderson (ed), *Cognitive Skills and Their Acquisition*. Hillsdale NJ: Erlbaum.

Newell, K. M. (1974). Knowledge of results and motor learning. *Journal of Motor Behavior*, 6, 235-244.

Newell, K. M. (1976a). Knowledge of results and motor learning. In J. Keogh & R. S. Hutton (eds.), *Exercise and Sport Sciences Reviews* (pp. 195-228). Santa Barbara, Ca: Journal Publishing Affiliates.

Newell, K. M. (1976b). Motor learning without knowledge of results through the development of a response recognition mechanism. *Journal of Motor Behavior*, 8, 209-217.

Newell, K. M. (1981). Skill learning. In D. H. Holding (ed). *Human Skills*. Chichester: Wiley.

Newell, K. M. & Chew, R. A. (1974). Recall and recognition in motor learning. *Journal of Motor Behavior*, 6, 245-253.

Paivio, A. (1969). Mental imagery in associative learning and memory. *Psychological Review*, 76, 241-263.

Paivio, A. (1971). *Imagery & Verbal Processes*. New York: Holt.

Paivio, A. (1985). Cognitive and motivational functions of imagery in human performance. *Canadian Journal of Applied Sport Sciences*, 10, 22S-28S.

Paivio, A. (1986). *Mental Representations: A dual coding approach*. New York: Oxford press.

Peterson, L. R. & Peterson, M. J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology*, 58, 193-198.

Piaget, J. (1951). *Paly, Dreams and Imitation in Childhood*. London: Routledge & Kegan Paul.

Piaget, J. (1953). *The Origins of Intelligence in The Child*. London: Routledge & Kegan Pual.

Poulton, E. C. (1957). On the prediction in skilled movements. *Psychological Bulletin*, 54, 467-478.

Prinz, W. (1986). Modes of linkage between perception and action, in Prinz, W. & Sanders, A. (eds.), *Cognitive and Motor Processes*. Berlin: Springer-Verlag.

Pylyshyn, Z.W. (1979). Imagery theory: Not mysterious - just wrong. Behavioral and Brain Sciences, 2, 561-563.

Pylyshyn, Z.W. (1980). Computation and Cognition: Issues in the foundations of Cognitive Science. Behavioral and Brain Sciences, 3, 111-133.

Pylyshyn, Z.W. (1981). The imagery debate: Analogue media versus tacit Knowledge. Psychological Review, 87, 16-45.

Richardson, A. (1967a). Mental Practice: a review and discussion, Part I. Research Quarterly, 38, 95-107.

Richardson, A. (1967b). Mental Practice: a review and discussion, Part II. Research Quarterly, 38, 263-273.

Richardson, A. (1969). *Mental Imagery*. London: Routledge & Kegan Paul.

Richardson, J. T. E. (1978). Spatial and mnemonic properties of visual images. *Cognitive Psychology*, 2, 101-115.

Richardson, J. T. E. (1980). *Mental Imagery and Human Memory*. London: Macmillan.

Ryan, E. D. (1965). Retention of stabilometer performance over extended periods of time. *Research Quarterly*, 36, 46-61.

Ryan, E. D. & Simons, J. (1982). Efficacy of mental imagery in enhancing mental rehearsal of motor skills. *Journal of Sport Psychology*, 4, 41-51.

Ryan, E. D. & Simons, J. (1982). Efficacy of mental imagery in enhancing mental rehearsal of motor skills. *Journal of Sport Psychology*, 4, 41-51.

Salmoni, A. W., Schmidt, R. A. & Walter, C. B. (1984). Knowledge of results and motor learning: A review and critical reappraisal. *Psychological Bulletin*, 95, 355-386.

Schmidt, R. A. (1975). A Schema theory of discrete motor skill learning. *Psychological Review*, 82, 225-260.

Schneider, W. & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review*, 84, 1-66.

Scully, D. M & Newell, K. M. (1985). Observational learning and the acquisition of motor skills: Toward a visual perception perspective. *Journal of Human Movement Studies*, 11, 169-186.

Seymour, W. D. (1966). *Industrial Skills*. London: Pitman.

Shea, J. B. & Zimny, S. T. (1986). A cognitive approach to learned movement. In O. G. Meijer & K. Roth (eds.), *Movement Behaviour: The motor-action controversy*. Amsterdam: North Holland.

Sheehan, P.W. (1966). Functional similarity of imaging to perceiving individual differences in vividness of imagery. *Perceptual and Motor Skills*, 23, 1011-1033.

Sheehan, P. W. (1967a). A shortened form of Bett's questionnaire upon mental imagery. *Journal of Clinical Psychology*, 23, 386-389.

Sheehan, P. W. (1967b). Visual imagery and the organizational properties of perceived stimuli. *British Journal of Psychology*, 58, 247-252.

Sheehan, P. W. & Neisser, U. (1969). Some variables affecting the vividness of imagery in recall. *British Journal of Psychology*, 60, 71-80.

Sheehan, P.W. (1972). A functional analysis of the role of visual imagery in unexpected recall. In P. W. Sheehan (ed), *The Function and Nature of Imagery*. New York & London: Academic press.

Sheffield, F. N. (1961). Theoretical considerations in the learning of complex sequential tasks from demonstrations and practice. In A. A Lumsdaine (ed), *Student Response in Programmed Instruction*. Washington, DC: National academy of Sciences-National Research Council.

Shiffrin, R. M. & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review*, 84 127-190.

Singer, R. N. (1980). *Motor Learning and Human Performance*. New York: Macmillan.

Spelke, E., Hirst, W. & Neisser, U. (1976). Skills of divided attention. *Cognition*, 4, 215-230.

Start, K. B. & Richardson, A. (1964). Imagery and mental practice. *British Journal of Educational Psychology*, 34, 280-284.

Suinn, R. M. (1983). Imagery & Sports. In A. A. Sheikh (ed), *Imagery, Current Theory, research, and application* (pp. 507-534). New York: Wiley & Sons.

Tarde, G. (1903). *The laws of imitation*. New York: Holt, Rinehart & Winston.

Tolman, E. C. (1948). Cognitive maps in rats and men. *Psychological Review*, 55, 189-208.

Tulving, E. & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, 80, 352-373.

Walsh, D., Russell, D. & Imanaka, K. (1980). Memory for location and distance information and imagery ability. *Acta Psychologica*, 44, 117-130.

White, K., Ashton, R. & Brown, R. M. D. (1977). The measurement of imagery vividness: normative data and their relationship to sex, age & modality differences. *British Journal of Psychology*, 68, 203-211.

White, K., Ashton, R. & Law, H. (1974). Factor analysis of the shortened form of Bett's questionnaire upon mental imagery. *Australian Journal of Psychology*, 26, 183-190.

White, K., Sheehan, P.w. & Ashton, R. (1977). Imagery assessment: A survey of self-report measures. *Journal of Mental Imagery*, 1, 145-169.

Whiting, H. A., Bijlard, M. J. & den Brinker, B. P. L. (1987). The Effect of the Availability of a dynamic Model on the Acquisition of a Complex Cyclical Action. *The Quarterly Journal of Experimental Psychology*, 39A, 43-59.

Wilberg, R. B. & Girard, N. C. (1977). A further investigation into the serial position curve for short-term motor memory. *Proceeding of the IX Canadian Psychomotor Learning and Sport Psychology Symposium* (pp. 241-247). Banff, Alberta, Canada.

Wilberg, R. B. & Salmela, J. (1973). Information load and response consistency in sequential short-term memory. *Perceptual and Motor Skill*, 23-29.

Wright, P. & Hull, A. J. (1986). Answering questions about negative conditionals. *Journal of Memory and Language*, 25, 691-709.

Wright, P. & Hull, A. J. (1988). Reading to do: creating contingent action plans. *British Journal of Psychology*, 79, 187-211.

Wright, P. & Hull, A. J. (1988). Reading to do: creating contingent action plans. *British Journal of Psychology*, 79, 187-211.

Yussen, S. R. (1974). Determinants of visual attention and recall in observational learning by preschoolers and seconds graders. *Developmental psychology*, 10, 93-100.

Appendix 1.1

The Bett's QMI vividness of imagery scale *

<u>Instruction for doing the test</u>

The aim of this test is to determine the vividness of your imagery. The items of the test will bring certain images to your mind. You are to rate the vividness of each image by reference to the accompanying rating scale, which is shown at the bottom of the page. For example if your image is 'vague and dim' you give it a rating of 5. Record your answer in the brackets provided after each item. Just write the appropriate number after each item. Before you turn to the items on the next page, familiarize yourself with the different categories on the rating scale. Throughout the test, refer to the rating scale when judging the vividness of each image. A copy of the rating scale will be printed on each page. Please do not turn to the next page until you have completed the items on the page you are doing and do not turn back to check on other items you have done. Complete each page before moving to the next page. Try to do each item separately independent of how you may have done other items.

The image aroused by an item of this test may be:

Perfectly clear and as vivid as the actual experience.	Rating 1
Very clear and comparable in vividness to the actual experience.	Rating 2
Moderately clear and vivid.	Rating 3
Not clear or vivid, but recognizable	Rating 4
Vague and dim.	Rating 5
So vague and dim as to be hardly discernible.	Rating 6
No image present at all, you only ' knowing' that you are thinking of the object.	Rating 7

*This scale was constructed as part of N. I. M. H. Project M-3950; J. P. Sutcliffe, Principal [illegible]

An example of an item on the test would be one which asked you to consider an image which comes to your mind's eye of a red apple. If your visual image was moderately clear and vivid you would check the rating scale and mark '3' in the brackets are follows:

Item	Rating
5. A red apple.	(3)

Now turn to the next page when you have understood these instructions and begin the test.

Think of some relative or friends whom you frequently see, considering carefully the picture that rises before your mind's eye. Classify the images suggested by each of the following questions as indicated by the degrees of clearness and vividness specified on the rating scale.

Item	Rating
1. The exact counter of face, head, shoulders and body	( )
2. Characteristic poses of head, attitudes of body etc.	( )
3. The precise carriage, length of step, etc. in walking.	( )
4. The different colours worn in some familiar costume	( )

Think of seeing the following, considering carefully the picture which comes before your mind's eye; and classify the image suggested by the following question as indicated by the degree of clearness and vividness specified on the rating scale.

5. The sun as it is sinking below the horizon.	( )

Rating Scale

The image aroused by an item of this test may be:

Perfectly clear and as vivid as the actual experience.	Rating 1
Very clear and comparable in vividness to the actual experience.	Rating 2
Moderately clear and vivid.	Rating 3
Not clear or vivid, but recognizable.	Rating 4
Vague and dim.	Rating 5
So vague and dim as to be hardly discernible.	Rating 6
No image present at all, you only ' knowing' that you are thinking of the object	Rating 7

Think of each of the following sounds, considering carefully the image which comes to your mind's ear, and classify the images suggested by each of the following questions as indicated by the degree of clearness and vividness specified on the rating scale.

Item	Rating
6. The whistle of a locomotive	( )
7. The honk of an automobile.	( )
8. The mewing of a cat.	( )
9. The sound of escaping steam.	( )
10. The clapping of hands in applause.	( )

Rating Scale

The image aroused by an item of this test may be:

Perfectly clear and as vivid as the actual experience	Rating 1
Very clear and comparable in vividness to the actual experience.	Rating 2
Moderately clear and vivid.	Rating 3
Not clear or vivid, but recognizable.	Rating 4
Vague and dim.	Rating 5
So vague and dim as to be hardly discernible.	Rating 6
No image present at all, you only ' knowing' that you are thinking of the object.	Rating 7

Think of 'feeling' or touching each of the following , considering carefully the image which comes to your mind's touch, and classify the images suggested by each of the following questions as indicated by the degree of clearness and vividness specified on the rating scale.

Item

	Rating
11. Sand	( )
12. Linen	( )
13. Fur.	( )
14. The prick of a pin	( )
15. The warmth of a tepid bath.	( )

Rating Scale

The image aroused by an item of this test may be:

Perfectly clear and as vivid as the actual experience.	Rating 1
Very clear and comparable in vividness to the actual experience	Rating 2
Moderately clear and vivid	Rating 3
Not clear or vivid, but recognizable.	Rating 4
Vague and dim	Rating 5
So vague and dim as to be hardly discernible.	Rating 6
No image present at all, you only ' knowing' that you are thinking of the object.	Rating 7

Think of performing each of the following acts, considering carefully the image which comes to your mind's arms, legs, lips, etc., and classify the images suggested as indicated by the degree of clearness and vividness specified on the rating scale.

Item	Rating
16. Running upstairs.	( )

17. Springing across a gutter. ( )

18. Drawing a circle on paper. ( )

19. Reaching up to a high shelf. ( )

20. Kicking something out of your way. ( )

Rating Scale

The image aroused by an item of this test may be:

Perfectly clear and as vivid as the actual experience.	Rating 1
Very clear and comparable in vividness to the actual experience.	Rating 2
Moderately clear and vivid.	Rating 3
Not clear or vivid, but recognizable.	Rating 4
Vague and dim.	Rating 5
So vague and dim as to be hardly discernible	Rating 6
No image present at all, you only ' knowing' that you are thinking of the object.	Rating 7

Think of testing each of the following, considering carefully the image which comes to your mind's mouth, and classify the images suggested by each of the following questions as indicated by the degree of clearness and vividness specified on the rating scale.

Item	Rating
21. Salt.	( )
22. Granulated (white) sugar.	( )
23. Oranges.	( )
24. Jelly.	( )
25. Your favourite soup.	( )

Rating Scale

The image aroused by an item of this test may be:

Perfectly clear and as vivid as the actual experience.	Rating 1
Very clear and comparable in vividness to the actual experience.	Rating 2
Moderately clear and vivid	Rating 3
Not clear or vivid, but recognizable.	Rating 4
Vague and dim	Rating 5
So vague and dim as to be hardly discernible.	Rating 6
No image present at all, you only ' knowing' that you are thinking of the object.	Rating 7

Think of smelling each of the following, considering carefully the image which comes to your mind's nose and classify the images suggested by of the following questions as indicated by the degrees of clearness and vividness specified on the rating scale.

Item	Rating
26. An ill-ventilated room.	( )
27. Cooking cabbage.	( )
28. Roast beef.	( )
29. Fresh paint.	( )
30. New leather.	( )

Rating Scale

The image aroused by an item of this test may be:

Perfectly clear and as vivid as the actual experience.	Rating 1
Very clear and comparable in vividness to the actual experience.	Rating 2

Moderately clear and vivid.	Rating 3
Not clear or vivid, but recognizable.	Rating 4
Vague and dim.	Rating 5
So vague and dim as to be hardly discernible.	Rating 6
No image present at all, you only ' knowing' that you are thinking of the object	Rating 7

Think of each of the following sensations, considering carefully the image which comes before your mind's and classify the images suggested as indicated by the degrees of clearness and vividness specified on the rating scale.

Item	Rating
31. Fatigue.	( )
32. Hunger	( )
33. A sore throat.	( )
34. Drowsiness	( )
35. Repletion as from a very full meal.	( )

Rating Scale

The image aroused by an item of this test may be:

Perfectly clear and as vivid as the actual experience.	Rating 1
Very clear and comparable in vividness to the actual experience.	Rating 2
Moderately clear and vivid.	Rating 3
Not clear or vivid, but recognizable.	Rating 4
Vague and dim.	Rating 5
So vague and dim as to be hardly discernible.	Rating 6
No image present at all, you only ' knowing' that you are thinking of the object	Rating 7

Appendix 1.2

A summary table of a two-way anova

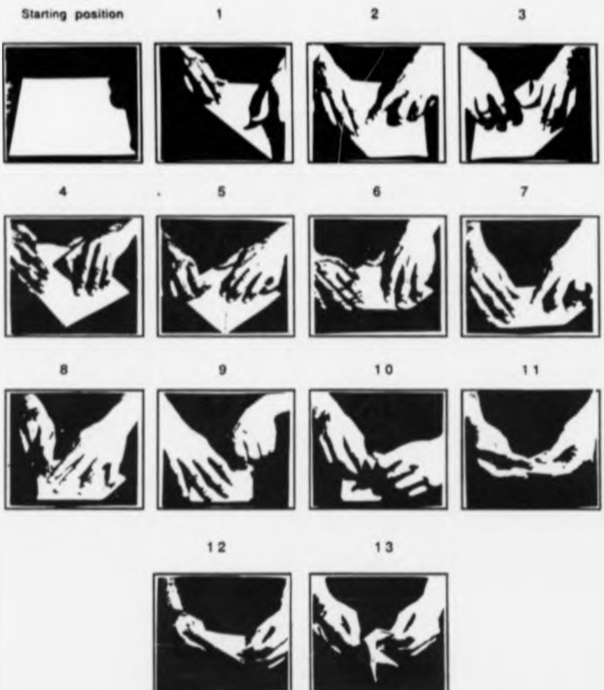
on the QMI rating scores for all subjects in the OL & VI techniques.

Experiment (I) part (1)

(B.B) (2X2)

SOURCE	SS	DF	MS	F	P
Between subjects					
Groups (OL vs VI)	2117.03	1	2117.03	10.73	0.002
Imagery	14554.23	1	14554.23	73.78	0.000
Groups X Imagery	9.03	1	9.03	0.046	0.83
Error	7101.5	36	197.26		

The 13 stills for the star origami task



Appendix 1.4

(Verbal Instructions for the star origami task)

1. Fold the top right corner on top of the bottom left corner, and press, then back to the starting position, this is just to form a crease going across from the top left corner to the bottom right corner.

2. Fold the top right corner until the tip of it reaches the centre point of the paper, and press.

3. Fold the bottom left corner until the tip of it reaches the centre point of the paper, and press.

4. Turn the paper face down, then fold the top left corner until the tip of it reaches the centre point of the paper, and press.

5. Fold the bottom right corner until the tip of it reaches the centre point of the paper, and press. At the end of this step you will have formed a square.

6. Fold the top right corner until the tip of it reaches the centre point, and press.

7. Fold the bottom left corner until the tip of it reaches the centre point, and press.

8. Fold the top left corner until the tip of it reaches the centre point, and press.

9. Fold the bottom right corner until the tip of it reaches the centre point, and press. At the end of this step you would have formed a smaller square.

10. Fold the top right corner on top of the bottom left corner, and press, to form a triangle.

11. Fold the two tips of the sharp angles on top of each other, and press, to form a small triangle.

12. Take the tip of the inside triangle downwards until it reaches the two tips at the bottom, and press hard on all edges to form a quadrilateral shape.

13. Open the bottom of the quadrilateral shape to stand up the shape that looks like a star.

Appendix 1.8

A summary table of a two-way anova

on accuracy scores for all subjects in the OL & VI techniques.

Experiment (I) part (1)

(B.B) (2X2)

SOURCE	SS	DF	MS	F	P
Between subjects					
Groups (OL vs VI)	15.63	1	15.63	6.11	0.018
Imagery	24.03	1	24.03	9.39	0.004
Groups X Imagery	46.23	1	46.23	18.07	0.000
Error	92.1	36	2.56		

Appendix 1.6

A summary table of a three-way anova on performance time experiment (I) Part (I)

SOURCE	SS	DF	MS	F	P
Between subjects					
Between groups					
OL-vs-VI	12839.29	1	12839.29	39.76	0.000
Between imagery					
High-vs-low	1340.67	1	1340.67	4.15	0.049
Groups X imagery	3.907	1	3.907	0.012	0.913
Error	11624.41	36	322.90		
Within subjects					
Trials	58307.42	5	11661.5	118.7	0.000
Groups X trials	13852.18	5	2770.44	28.2	0.000
Imagery X trials	91.45	5	18.29	0.19	0.968
Group X imagery X trials	602.26	5	120.45	1.23	0.299
Error	17683.29	180	98.241		

Appendix 2.1

A summary table of a two-way anova

on the QMI rating scores for all subjects in the OL & VI techniques experiment

(I) part (2)

(B.S) (2X2)

SOURCE	SS	DF	MS	F	P
Between subjects					
Groups (OL vs VI)	228.94	1	228.94	1.17	0.292
Imagery	8418.52	1	8418.52	42.88	0.000
Groups X Imagery	0.37	1	0.37	0.002	0.966
Error	4319.62	22	196.37		

Appendix 2.2

A summary table of a three-way anova

on verbal & motor accuracy scores for all subjects in the OL & VI techniques.

Experiment (I) part (2)

(B.B.W) (2X2X2)

SOURCE	SS	DF	MS	F	P
Between subjects					
Groups (OL vs VI)	170.38	1	170.38	1.9	0.182
Imagery	46.89	1	46.89	0.52	0.478
Groups X Imagery	293.04	1	293.04	3.26	0.085
Error	1975.74	22	89.81		
Within subjects					
Trials	113.56	1	113.56	11.92	0.002
Groups X trials	2.79	1	2.79	0.29	0.594
Imagery X trials	17.59	1	17.59	1.85	0.188
Group X imagery X trials	0.36	1	0.36	0.04	0.848
Error	209.55	22	9.53		

Appendix 2.3

A summary table of a three-way anova
on writing & performance times for all subjects in the OL & VI techniques.
Experiment (1) Part (2)
(B.B.W) (2X2X2)

SOURCE	SS	DF	MS	F	P
Between subjects					
Groups (OL vs VI)	1959.68	1	1959.68	0.23	0.639
Imagery	636.9	1	636.9	0.07	0.789
Groups X Imagery	2131.6	1	2131.6	0.25	0.625
Error	190924.37	22	8678.38		
Within subjects					
Trials	129437.3	1	129437.3	15.71	0.001
Groups X trials	17158.76	1	17158.76	2.08	0.163
Imagery X trials	13170.78	1	13170.78	1.6	0.219
Group X imagery X trials	474.15	1	474.15	0.06	0.813
Error	181263.25	22	8239.24		

Appendix 3.1

A summary table of a two-way anova

on the QMI rating scores

(B.B) (2X2)

SOURCE	SS	DF	MS	F	P
Between subjects					
Imagery	8497.23	1	8497.23	70.76	0.000
(Er & Ar) groups	5.63	1	5.63	0.047	0.830
Imagery X groups	93.03	1	93.03	0.78	0.385
Error	4323.1	36	120.09		

Appendix 3.2

A summary table of a four-way (B.B.W.W) anova on accuracy scores experiment (II)

SOURCE	SS	DF	MS	F	P
Between subjects					
Imagery	355.32	1	355.32	6.83	0.012
(Er & Ar) groups	52.56	1	52.56	1.01	0.323
Imagery X groups	14.07	1	14.07	0.27	0.612
Error	1873.89	36	52.05		
Within subjects					
(M & NM) tasks	15165.9	1	15165.9	452.53	0.000
Tasks X imagery	22.56	1	2.56	0.67	0.423
Tasks X groups	57.00	1	57.00	1.7	0.198
Tasks X groups X imagery	13.32	1	13.32	0.39	0.539
Error	1206.49	36	33.51		
Trials	4925.43	4	1231.36	167.97	0.000
Trials X imagery	52.22	4	13.05	1.78	0.134
Trials X groups	31.38	4	7.84	1.07	0.374
Trials X groups X imagery	11.93	4	2.98	0.41	0.805
Error	1055.66	144	7.33		
Trials X tasks	1279.17	4	319.79	34.13	0.000
Trials X tasks X groups	63.23	4	15.81	1.69	0.155
Trials X tasks X groups X imagery	19.07	4	4.77	0.51	0.733
Error	1349.26	144	9.37		

Appendix 3.3

A summary table of a four-way (B.B.W.W) anova on performance time experiment (II)

SOURCE	SS	DF	MS	F	P
Between subjects					
Imagery	1943.24	1	1943.24	0.76	0.392
(Er & Ar) groups	2554.06	1	2554.06	1.00	0.324
Imagery X groups	2558.46	1	2558.46	1.00	0.324
Error	91612.2	36	2544.78		
Within subjects					
Tasks	43551.6	1	43551.6	44.44	0.000
Tasks X imagery	2626.28	1	2626.28	2.68	0.107
Tasks X groups	2874.54	1	2874.54	2.93	0.092
Tasks X groups X imagery	3395.19	1	3395.19	3.46	0.067
Error	35277.1	36	979.92		
Trials	17731.7	4	4432.93	12.57	0.000
Trials X imagery	1694.66	4	423.67	1.20	0.312
Trials X groups	4581.78	4	1145.45	3.25	0.013
Trials X groups X imagery	2101.83	4	525.46	1.49	0.207
Error	50771.6	144	352.58		
Trials X tasks	697.51	4	697.51	0.47	0.759
Trials X tasks X groups	822.54	4	205.64	0.56	0.698
Trials X tasks X groups X imagery	309.04	4	77.26	0.21	0.931
Error	53263.5	144	369.89		

Appendix 3.4

A summary table of a two-way anova

on the number of reproduction trials

(E.B) (2X2)

SOURCE	SS	DF	MS	F	P
Between subjects					
Imagery	8.1	1	8.1	6.01	0.013
(Er & Ar) groups	0.4	1	0.4	0.34	0.563
Imagery X groups	0.9	1	0.9	0.77	0.387
Error	42.2	36	1.172		

Appendix 4.1

A summary table of a two-way anova
on the QMI rating scores
(B.W) (2X6)

SOURCE	SS	DF	MS	F	P
Between subjects					
Imager	40456.07	1	40456.07	33.08	0.000
Error	9784.33	8	1223.042		
Within subjects					
Conditions	5478.93	5	1095.79	31.45	0.000
Imagery X Condition	2453.73	5	490.75	14.09	0.000
Error	1393.67	40	34.842		

Appendix 4.2

A summary table of a four-way anova
on accuracy scores experiment (III)

SOURCE	SS	DF	MS	F	P
Between subjects					
Between Groups					
Active-vs-passive	195.21	1	195.21	2.56	0.116
Between imagery					
High-vs-low	651.21	1	651.21	8.53	0.005
Between stills					
13-vs-8-vs-4 stills	8393.36	2	4196.68	54.97	0.000
Group X imagery	3.000	1	3.000	0.04	0.844
Group X stills	1643.39	2	821.69	10.76	0.000
Stills X imagery	164.03	2	82.01	1.07	0.350
Group X imageryX stills	52.88	2	26.44	0.35	0.709
Error	3664.32	48	76.34		
Within subjects					
Trials	1682.53	4	420.63	58.37	0.000
Groups X trials	553.79	4	138.45	19.21	0.000
Imagery X trials	16.45	4	4.11	0.57	0.684
Stills X trials	103.30	8	12.91	1.79	0.081
Group X imagery X trials	16.13	4	4.03	0.56	0.692
Group X stills X trials	152.21	8	19.03	2.64	0.009
Imagery X stills X trials	68.91	8	8.61	1.19	0.304
Group X imagery X stills					
X trials	40.59	8	5.07	0.70	0.688
Error	1383.68	192	7.21		

Appendix 4.3

The means and means differences on accuracy of recall for all six conditions experiment (III)

	Cond. (1) (20.48)	Cond. (2) (24)	Cond. (3) (18.84)	Cond. (4) (11.04)	Cond. (5) (9.6)	Cond. (6) (9.04)
Cond. (1) (20.48)	—	3.52	1.64	9.44	10.88	11.44
Cond. (2) (24)		—	5.16	12.96*	14.4*	14.96*
Cond. (3) (18.84)			—	7.8	9.24	9.8
Cond. (4) (11.04)				—	1.44	2
Cond. (5) (9.6)					—	0.56
Cond. (6) (9.04)						—

*$P < 0.05$
Note: Each value in the body of the table represents the difference between the column and row values.
n= 10, MsError= 76.34, K=6, qk=4.3
Critical value (means)=qk MsError/n = 11.87

Appendix 4.4

A summary table of a four-way anova on performance time experiment (III)

SOURCE	SS	DF	MS	F	P
Between subjects					
Between Groups					
Active-vs-passive	142.28	1	142.28	0.07	0.799
Between imagery					
High-vs-low	108.82	1	108.82	0.05	0.824
Between stills					
13-vs-8-vs-4 stills	20189.24	2	10094.61	4.635	0.014
Group X imagery	0.32	1	0.32	0.000	0.9
Group X stills	8860.63	2	4430.31	2.03	0.14
Stills X imagery	944.85	2	472.43	0.22	0.805
Group X imageryX stills	2556.73	2	1278.37	0.59	0.560
Error	104544.39	48	2178.01		
Within subjects					
Trials	3025.12	4	756.28	3.21	0.014
Groups X trials	29623.62	4	7405.9	31.44	0.000
Imagery X trials	715.27	4	178.82	0.76	0.553
Stills X trials	2576.55	8	322.07	1.37	0.213
Group X imagery X trials	463.85	4	115.96	0.49	0.741
Group X stills X trials	1771.26	8	221.41	0.94	0.49
Imagery X stills X trials	2691.54	8	336.44	1.43	0.187
Group X imagery X stills X trials	3276.02	8	409.50	1.74	0.092
Error	45232.82	192	235.59		

TITLE THE EFFECT OF IMAGERY ABILITY ON

IMITATION

OF A CLOSED-MOTOR TASK

AUTHOR Adel. S. Abdulgabbar.

INSTITUTION and DATE University of Warwick (1990)