

THE MEASUREMENT OF NONVERBAL MEMORY

by

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## Abstract

In this monograph, the concept of nonverbal memory (NVM) is introduced and it is argued that NVM is an important explanatory construct which is dissociable from related higher-order functions such as perception, learning, and verbal memory. The first four chapters provide comprehensive reviews of the literature relevant to the history and current status of NVM. In subsequent chapters, evidence as to the "nonverbalness" of five types of stimulus material is first surveyed and then these materials are contrasted directly, as to their potential for verbal mediation, in an experimental study. A model for the measurement of NVM is presented and finally, three new clinical tests of NVM are described.

The Introduction begins with a working definition of NVM, emphasizing its task-dependent nature and restricting the scope of interest to those studies which include visually presented memoranda, a retention interval, and some stated intent to measure NVM. Within these limits, the reviews are considered to be exhaustive in coverage of both the basic theoretical work and the memory-disorders literature. As such, they constitute the first systematic treatment of the

topic of NVM.

Chapter 1 presents a brief interpretive summary of how the concept of NVM has been regarded during the history of psychology. Cyclical fluctuations in popularity are described and the major trends which have led to the present revival of interest are identified.

The issue of multiple kinds of memory is evaluated next followed by a review of theories and data which suggest that NVM operates in some fundamentally different way from verbal memory. Here, consideration is given to controversial topics of high current interest, such as the existence of a short-term memory stage in NVM and the status of NVM deficits in "amnesic syndrome" patients.

The extensive body of literature pertaining to the question of cerebral lateralization for NVM is then evaluated with sources of evidence organized by type of patient population. Several problems with, or arguments against, the viability of the NVM construct are next examined. In the final section of Chapter 4 the argument is advanced that the resolution of all these issues is primarily dependent upon progress in developing better methods of measurement.

In the last four chapters, attention is focussed

mainly upon the problem of designing valid NVM tasks. Five kinds of material are first considered as to their adequacy for use in the construction of NVM tasks. For each material, the typical ways in which the commonly available stimuli have been employed in NVM tasks are reviewed. Particular consideration is given to those factors which may influence the degree of "nonverbalness" of each stimulus material.

In chapter 6, methods which may be used to attempt to empirically validate memory tasks as being nonverbal in nature are first reviewed briefly. Shortcomings of each of these are indicated and one procedure, communication accuracy, is chosen as the best possibility for further elaboration. An experiment is then described using this method to evaluate the comparative "nonverbalness" of the five kinds of material just presented. The results of this study permit the selection of specific items which appear to be the least amenable to verbal encoding.

A discussion of some general principles relevant to the measurement of memory of any kind is presented next. The definition of memory is considered and a simple model is suggested to operationally specify the essential components of a memory task and to

dissociate memory from related concepts.


Finally, detailed descriptions of three new clinical tests of NVM are presented. Each test illustrates ways to minimize the involvement of verbal mediation by following the material selection/arrangement suggestions of chapter 5 and the empirical item analyses of chapter 6. Moreover, these tests also demonstrate how the basic principles of memory measurement, as described in chapter 7, can be operationalized using a variety of NVM materials and procedures.


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## Introduction

At present, there is no unequivocal way of defining what is meant by the term "nonverbal memory" (NVM). In spite of this limitation, the construct has become increasingly popular in recent years and cannot be exempted from critical examination merely because of definitional ambiguities. Anyone attempting to evaluate the history and current status of the concept, however, must first of all resolve the issue of what is to be included as relevant.

In selecting the sources of information to be evaluated for this review, several decision criteria were employed in order to determine whether or not a particular report should be considered. These inclusion criteria are made explicit in the following paragraphs and together they provide a preliminary or working definition of NVM. The intent of this elaboration is to communicate some understanding as to what is meant by the term NVM for the purposes of this survey.

Before dealing with definitional problems more specifically, a few other and more general considerations may be apposite. First of all, it is important to note that the primary focus of this monograph is on methodology rather than

theory. There have been extremely few reports, however, in which methodological issues specific to NVM have been of major concern. In most of the studies considered here, NVM measures have been used to collect data regarding some independent variable(s) of theoretical interest. In this review, the emphasis is placed on evaluating the adequacy of measurement rather than on interpreting the meaning of the substantive results of these investigations.

Like any hypothetical construct, the existence of NVM is inferred from behavioural observations. Because NVM is task-dependent, and can only be understood in terms of the measurement operations used to define it, it would appear obvious that a critical examination of task parameters is the most fundamental way to begin exploration of the concept. It seems evident also that it would be unwise to proceed with hypothesis-testing regarding substantive issues until measurement problems have been resolved, or at least made explicit, and some consensus reached as to the value and limitations of our measuring instruments.

In the review chapters, sources of information are included for consideration if they meet three criteria. A report is deemed appropriate for inclusion here if it deals primarily with memory, if that memory can in some way be considered as NVM, and if the mode of presentation of the

to-be-remembered stimulus (the memorandum) is visual.

The first and last of these criteria are relatively easy to specify operationally and present few difficulties in categorizing sources as to their relevance for this critical analysis. The second criterion, however, offers interesting complexities (which are examined more extensively in later sections of the monograph) and which necessitate, at least initially, a somewhat more flexible inclusion criterion. In a few instances, reports which do not meet one or more of these criteria are discussed because they are particularly relevant in some other way. Those studies in which there is some claim as to the measurement of NVM for visually-presented materials are the primary focus of the literature reviews, however, and for this type of report an attempt has been made to be exhaustive in coverage.

Memory is defined operationally in accordance with the common understanding of the term. The minimum requirements necessary for a task to be considered a measure of memory are: (a) a memorandum is presented once, (b) the memorandum is removed, (c) some time delay, however brief, ensues, and (d) the subject is requested to demonstrate retention of the memorandum in some way. The important point here is that procedures which are not reducible to

this simple paradigm are not considered to be measures of memory and are not included for review here. Thus, tasks which involve only concurrent matching-to-sample are considered measures of perception, while those which involve repeated presentation of a memorandum are considered measures of learning. (The operational dissociation of memory from related processes is considered in greater detail in chapter 7). Reports which utilize these procedures are considered to be outside the primary focus of this survey.

Studies which have employed visually presented memoranda are the major concern of the surveys mainly because the great preponderance of work relating to NVM has been done in this modality. In addition, however, the visual situation appears to offer possibilities for the most straightforward procedural analysis, whereas the use of other sensory modes of presentation involves special problems of interpretation which are best left for consideration in a separate review. Again though, some studies which have employed auditory and tactile presentations of memoranda are included where they appear to offer particularly cogent insights into NVM in general.

The situation with regard to defining what is meant by the term "nonverbal" is much the same as that with any pre-

scientific concept (i.e., everyone uses the term in her/his own way and there is little general agreement as to what is really meant by it). As yet, no one appears to have even attempted a formal or rigorous definition of the idea of "nonverbalness" and surprisingly, there is almost no serious controversy over meaning. This equanimity appears to be the result of a general avoidance of the issues involved rather than a consensus based on some fundamental understanding of the concept.

Many investigators have devised tasks which they have claimed are measures of NVM. Other workers have generally accepted and used these methods uncritically, or have assembled "new" tasks of their own, often apparently on the basis of expediency and with little regard for previous work. The rationale for choosing a particular task as a measure of NVM is rarely given and when it is, it has seldom been anything other than face validity. Because of this lack of concern for critical evaluation of methodology, and because contributions have tended to be isolated in nature, rather than cumulative, little progress has been made in achieving an acceptable level of construct validity for the concept of NVM.

A major purpose of the critical and empirical work described here is to provide the background information necessary for the eventual attempt

at a more compelling definition of "nonverbal" memory. Since it was felt that the application of any a priori criterion, based on some arbitrary definition, might limit the range of information to be considered and could thus potentially be counter-productive, the widest possible basis for inclusion was chosen. Specifically, reports have been judged appropriate for review simply if the author(s) claimed to be dealing with NVM or if the method used has been generally regarded by others as a measure of NVM. The use of such a comprehensive inclusion criterion ensures that no report of any significance to the measurement of NVM is omitted and permits comparisons across all studies as to differences in the adequacy of the methods used.

Different authors have asserted that their methods have been valid measures of NVM, based on differing assumptions regarding the concept. Although there appear to be several somewhat overlapping understandings of the term, at least two usages can be identified which are encountered with the greatest frequency.

At the simplest level, the term is employed to describe memory for any stimulus material which is not explicitly composed of linguistic units (i.e., letters, words, digits, etc.). A considerably more restrictive use of the

term occurs when it is taken to refer to memory for any stimulus material which cannot be translated easily into a verbal code, or to which a name or label cannot readily be assigned. Clearly, these "soft" and "hard" definitions of the term can be in conflict. Thus, following from the former conception, many studies have used pictures of common objects as nonverbal memoranda whereas these would be patently inadmissible by the latter definition. Differing understandings as to the scope of the term have led, of course, to confusion in trying to interpret the results of studies using dissimilar indices of measurement.

CHAPTER ONE: HISTORY OF THE CONCEPT  
OF NONVERBAL MEMORY

Experiencing Nonverbal Memory

Memory, as Hughlings Jackson emphasized, is a subjective phenomenon. We each remember some subset of our own personal experiences and these recollections are not directly accessible to anyone else. In attempting to understand memory, then, the method of introspection would appear to offer a fundamental way to begin. Phenomenologically, much of what we remember appears to be non-verbal in nature. It seems intuitively obvious that we encode, store, and retrieve a considerable amount of information without recourse to the use of words or linguistic symbols of any kind. Many of our experiences, in fact, involve sensory data for which descriptions, if possible at all, do not appear to be readily evoked.

We look at a painting and remember that we have seen it before. Perhaps we have encountered it only once a long time ago and still we are able to recognize it as familiar. If pressed, we may be able to describe the painting in words, even if it is quite "abstract". Yet it does not seem likely that when we first saw the painting we translated the visual image into a verbal description and then stored this collection of words. Nor does it

appear plausible that upon seeing the painting a second time we again transformed it into words and matched up this verbal description from the one before to determine that the painting was familiar. Introspectively, it appears to us that we have somehow retained an imaginal representation of the painting which was veridical enough to allow us to recognize the two experiences as identical. Making identity matches such as this on the basis of verbal descriptions alone just seems absurd.

It would appear that many other aspects of our common experience are also remembered without the aid of language. We hear a piece of instrumental music, for example, and cannot only recognize it as familiar or not but we are remarkably sensitive to even slight variations in the way it is played. Again, it does not seem possible that our memory for the vast range of musical information that we typically receive can be verbally mediated.

We can learn and remember a complex series of motor skills, such as in the art of juggling, and are able to recall the correct movements without any apparent verbal involvement at all. In fact, it is common experience that attempts to verbally control complex and rapidly-performed motor skills often disrupts the smooth flow of the normal performance.

There are, of course, many other aspects of our everyday experience which appear to be beyond adequate description in words and yet we remember these things quite well. Faces, colours, and environmental scenes can be classified by verbal tags, but they cannot be completely described in this way. Moreover, it would seem that they surely cannot be labelled well enough in words to permit the kind of fine distinctions we typically make from memory, when the stimuli involved are highly similar.

On introspective and intuitive grounds alone then, it appears necessary to conclude that we possess a memory system which allows for the encoding, storage, and retrieval of information without the necessity for the involvement of the language processor at all.

### Early Importance of the Concept

Many of the historically-prominent theorists in psychology had something significant to say about NVM. Partly because of its intuitive appeal, the topic was a popular one during the first part of this century, generating considerable speculation and some interesting data. During this era, a Zeitgeist prevailed in which mentalistic constructs and introspective methods were fashionable and this climate also contributed to increased interest in NVM.

Bartlett (1932), for example, considered NVM as an individual differences variable. In interpreting his classic facial recognition studies, he concluded that there are two types of subjects, viz., "...those who in remembering relied mainly on visual images and those who were predominantly determined by the use of language clues" (p. 59).

The original Gestalt theorists (e.g., Kohler, 1929) were also influential in promoting a view of memory in which verbal factors were of little, if any, consequence. They emphasized the use of visual forms as memoranda and argued that stored images undergo progressive changes toward better "gestalten", regardless of how they are described in words.

Many early investigators from other theoretical persuasions were also interested in configural stimuli, and the 1920's and 1930's especially may be seen as a time of very active exploration of memory for all kinds of non-verbal forms. Riley (1962) has provided an extensive review of this early period, emphasizing the conflict between the Gestalt theorists and the early behaviourists, while Paivio (1971b) has considered it from the perspective of the development of the imagery concept.

Even Ebbinghaus, who is generally regarded as having had enormous influence in directing experimental psychology toward the study of verbal materials, stressed the importance of NVM. Noting that, "Differences in the content of the thing to be reproduced are of great influence", he then discussed how memory for forms, colours, melodies, and other images decay and become "pale shadows of themselves" (Ebbinghaus, 1885, p. 3).

### The Period of Neglect

During the time of William James and his contemporaries, NVM enjoyed considerable popularity both as a theoretical construct and as a topic of empirical investigation. In spite of this early recognition and regardless of its obvious importance, the concept of NVM was then largely ignored for several decades until a revival of interest began to occur during the 1960's. There appear to be several reasons for the neglect of NVM during this period. These factors are worth considering, at least briefly, since many of them are relevant to the understanding of the current status of the concept.

First of all, Ebbinghaus' influence increased steadily during the first half of this century and a verbal-learning tradition developed which became so predominant, in North American psychology at least, that the study of memory in general came to be the study of verbal memory almost exclusively (cf., Crowder, 1976, p.90). One consequence of this trend was not just a neglect of NVM but an outright denial that NVM processes exist at all. Glanzer and Clark's (1964) verbal-loop hypothesis may be seen as a good example of this extreme position. A weaker version of this view, which was also popular, was that NVM may exist but is

trivial (i.e., it is of little practical or theoretical significance). Illustrations of this notion can be seen in the early information-processing models of memory (e.g., Broadbent, 1958; Sperling, 1960) in which iconic stores of very brief durations were postulated. This line of thought has continued in various modified forms up to the present. Thus, we see major theories of memory such as those presented by Norman (1970), in which it is implied that all memory is semantic memory and that all sensory information is encoded in a propositional/analytical form.

A second factor which militated against the continued development of interest in NVM was the domination of the associationist model of memory (e.g., Anderson and Bower, 1973) along with its methodological corollary, the paired-associate technique. While in principle there is no reason why nonverbal materials could not be used in the context of this paradigm, there have been remarkably few attempts to do so. The associationist approach emphasized the study of the acquisition of linkages between items and these bonds were invariably conceived of in verbal terms. Some kinds of stimuli appear to be more suited to particular procedures than others and the implicit semantic character of associationism led

to an almost exclusive preoccupation with verbal materials. It may also be that the task demands inherent in the paired associate paradigm predispose the subject to search for verbal labels for the arbitrarily paired items, even when these stimuli are not explicitly verbal. Milner (Milner & Teuber, 1968), in fact, has argued on this basis that the paired-associate procedure is just not suitable at all for the investigation of NVM.

A third force acting to discourage interest in NVM was also of philosophical origin. The period from the 1920's to the 1960's was a time when the new ideas of logical positivism, behaviourism, and the doctrine of operationalism held sway in psychology almost without serious opposition. Such things as nonverbal images, which could not be readily specified in words, or in any other way for that matter, were regarded by most theorists as mentalistic concepts and not part of the purview of an emerging psychology that was to be rigorous and scientific (cf., Paivio, 1975b). Even for those who did not necessarily oppose the study of NVM because of doctrinaire considerations, there was little incentive to explore a subject that was so contrary to the prevailing intellectual climate.

With the move away from phenomenology and the method of introspection, any attempt to invoke NVM as a hypothetical construct would be vulnerable to criticism unless

adequate operational definitions were provided. A large part of the reluctance to accept NVM as a worthwhile topic of investigation stemmed from the difficulty in finding a measurement paradigm that was suited to the use of non-verbal materials and also logically compelling. Anyone who claimed to be studying NVM would have to have some basis for arguing that the task used minimized the possibility of verbal mediation and that whatever retention was observed was in fact most likely due to nonverbal processing. Most memory investigators of this period, however, worked almost exclusively within the framework of a few standard verbal-learning methods and there was not much interest in producing innovative measurement techniques. In addition, since the vast preponderance of learning and memory studies used highly verbal college students as subjects, the task of devising methods of measuring NVM was made even more difficult.

Another reason why verbal memory methods were used so extensively, to the exclusion of NVM tasks, was that verbal materials were considered so much easier for the investigator to work with. Not only could letters, words, or sentences be presented orally or in written form but retention could be measured easily by either recall or recognition; furthermore, the subject could give either a written or an oral response. This great flexibility in

the way verbal materials could be manipulated made them the memoranda of choice for investigators who preferred to generate data quickly or invest their time in theoretical debate rather than in the preparation of novel and/or elaborate stimuli.

In contrast to verbal materials, nonverbal memoranda were seen as difficult, if not impossible, to work with. Except perhaps for simple configural forms, nonverbal materials were regarded as time-consuming to prepare, and as imposing much greater restrictions as to mode of presentation, type of retention measure and output modality. Moreover, communication regarding the precise specifications of nonverbal materials was often difficult also, making replications by other investigators problematical, whereas verbal stimuli allowed for easy and precise referencing.

Lack of interest in NVM in the experimental lab was paralleled by a concurrent disinterest in (or unawareness of) possibilities for the assessment of NVM in the clinic. Until just recently, memory tests and batteries devised for use with patients, have been almost totally concerned with verbal memory. The popular memory scales created by Wells and Martin (1923) and by Wechsler (1945) are examples of this disregard for NVM functions, although the former does include one subtest of picture recognition, and the latter

one figure-drawing task.

Similarly, studies of patients with memory disorders and theories regarding the "amnesic syndrome", both of which have been quite popular for the last hundred years, have seldom incorporated NVM as an explanatory construct. Talland (1965), for example, in his marathon series of experiments evaluating Korsakoff patients, used almost every conceivable measure of verbal memory but paid scant attention to memory for materials to which a verbal label could not readily be ascribed. Talland did, however, use a few tasks, such as picture recognition, pattern reproduction, and memory for spatial location, which could be considered to tap NVM. Results from these measures are not integrated into his interpretations, however, and he, like virtually everyone else from this era who wrote regarding memory disorders, made no mention of NVM as a variable of importance.

For those interested in brain-behaviour relationships, concern for verbal memory was a natural extension of the consistent emphasis, historically, on language and left-hemisphere functions generally. The capacities, mnemonic or otherwise, of the "silent" right hemisphere were not only largely unknown but were not even extensively investigated before the 1960's. As Benton (1972) has illustrated in

his review of the history of thought regarding the right hemisphere, nonlanguage functions have rarely been accorded the importance of those of the "dominant" hemisphere. The present high level of interest in right-hemisphere capabilities, and by extension, nonverbal processes, is a recent phenomenon.

Luria's work nicely illustrates the neglect of NVM. Although his major statement on memory disorders (Luria, 1976) bears a recent publication date, his approach, rather than being contemporary, is much more representative of the classical era in neurology and psychology. His extensive monograph includes novel assessment approaches, detailed case reports, and broad-ranging theories of memory disorder. Yet in all of this there is no mention of the possibility that NVM might be important to consider.

### Revival of Interest in Nonverbal Memory

During the 1960's NVM came to be considered once again as an important concept. The reasons for this re-emergence from decades of neglect are several. At least four separate trends can be identified, which converged to promote this resurgence of interest. Several new theoretical ideas, new sources of data, and changes in emphasis, although coming from disparate areas of psychology, when taken together can be seen as creating a milieu which permitted and even encouraged renewed exploration of NVM.

### Information-processing Theory

The first major development contributing to the re-focussing of attention on NVM was the emergence of information-processing theory and the concurrent decline of the simple associationist models of memory.

Broadbent's early ideas (e.g., 1958) were especially influential in this regard and he is generally considered to be the first to apply the information-processing approach convincingly to the analysis of memory.

Broadbent proposed that human cognitive functions may best be understood by viewing them as analagous to the sequential way a computer handles data. Central to his schema was the notion that, after some very brief period, incoming sensory information is "categorized", i.e., identified linguistically, or interpreted/labelled in some way, by making contact with the more or less stable classification system in long-term storage. After categorization has occurred, the new information is processed solely in terms of its verbal label from that point on.

Broadbent saw the "precategorical" visual trace as just an unstructured buffer with a very limited storage capacity. Since he believed it lasted only for a few milliseconds and then vanished completely, he did not ascribe much importance to it as a matter for further

investigation. In spite of this denigration, his model still provided the first secure foothold for the concept of NVM in modern memory theory. Many of those who followed Broadbent in developing and elaborating information-processing theory also enlarged upon the role played by the "precategorical" visual trace.

Sperling (1960, 1963), for example, demonstrated that the visual trace does have some interesting properties of its own. His elegant studies not only introduced the idea of a unique and separate visual store into general awareness but also stimulated a spate of investigations into the characteristics of nonverbal storage of visual information.

Broadbent's ideas and Sperling's experiments created a considerable amount of curiosity regarding memory for visual stimuli and at least raised the issue of how quickly verbal classification may occur. Much of the early work has been reviewed by Neisser (1967), who also introduced the term "iconic memory" to refer to this very brief visual storage system.

As the properties of the precategorical memory store were further investigated, evidence began to accumulate that the icon might not necessarily disappear completely within less than a second following presentation.

Gradually, the view began to emerge that the "pure" sensory trace may persist for much longer periods of time, either in parallel with its verbal representation or without the necessity of verbal recoding occurring at all.

One of the most influential proponents of this new view of information-processing has been Michael Posner. Using innovative memory tasks, including such memoranda as dot patterns, positions in space, and kinesthetic distance, he has argued persuasively (e.g., Posner & Konick, 1966; Posner, 1967) that the nonverbal attributes of a stimulus actually compete with its verbal characteristics for processing capacity. In summarizing the evidence available he concluded, "Of course there are compelling reasons to hold that the nervous system can code visual information on a more or less permanent basis without the necessity of verbal labels" (Posner, 1969, p. 186).

The notion of a nonverbal visual store that is durable enough to play a role in both short-term and long-term memory was a radical idea when first proposed. Since that time, however, the possibility that the nonverbal trace may be enduring has become the generally accepted view as presented in most survey texts. Baddeley (1976), for example, concludes, "It is clearly the case then, that visual memory extends over periods considerably beyond the duration of the icon" (p. 211).

## Imagery

A second major trend contributing to the recent renewal of interest in NVM has been the development of a line of research concerned with exploring the properties of visual images. Paivio's influence has been considerable here. His extensive series of insightful investigations (many of which are summarized in his 1971 book) have provided strong evidence that memories can persist perhaps indefinitely in unlabelled form. Paivio has also presented an exhaustive history of the concept of nonverbal imagery and has shown that even during the long period of general neglect of such cognitive concepts, interest in imagery was never really suppressed entirely. In Paivio's view, the recent re-awakening of serious concern for exploring such topics as visual imagery and NVM is part of a larger movement toward greater interest in internal processes generally. This "neomentalism" (Paivio, 1975b), however, is now seen as supported by a defensible methodology.

Paivio has surveyed a great deal of data (much of it produced by him and his co-workers) on such topics as eidetic imagery, transformations of visual representations, material-specific interference, and picture recognition memory. On the basis of this evidence, he has proposed a dual-trace hypothesis which suggests that there are two

fundamentally different memory systems. One is conceived of as being visual-spatial in nature and the other as verbal-temporal. According to Crowder's (1976) estimation, Paivio's model has had far-reaching impact, influencing theories of language, perception, and cognition, as well as memory.

One of the major thrusts of Paivio's work has been to demonstrate that nonverbal imagery plays an important role in the encoding of nonverbal materials. His findings and interpretations have done much to focus attention on the possibility that something other than purely verbal encoding may occur when a subject attempts to remember verbal memoranda. His work has succeeded, to some extent, in broadening our view of what is involved in memory, especially in suggesting that there may be more than one fundamental process.

The early work on imagery also has had a significant impact in that it worked to loosen the stifling grip of associationist verbal-learning theory on the study of memory. In addition to offering fresh ideas regarding process, imagery research has widened our conception of what kinds of materials we should be studying in order to understand memory better.

Dual-trace theory has also been influential in

shaping thought regarding brain-behaviour relationships and has prompted the search for structural correlates of the two proposed memory systems. Perhaps the clearest example of Paivio's influence in neuropsychology can be found in the work of Robertson and Inglis (1977, 1978) who have made extensive use of the dual-trace concept in organizing their reviews and experimental work regarding the effects of electroconvulsive therapy on memory.

A further result of Paivio's theorizing, which has implications for the study of NVM, is that attention has now been focussed upon the interaction of verbal and non-verbal processing in tasks used to study memory. This influence can also be seen clearly in Robertson and Inglis' work, especially in their recent (1978) efforts to rank order tasks in terms of the relative proportions of verbal vs. nonverbal processing required. Paivio's views have thus prompted a closer examination of task characteristics, especially in terms of the verbal/nonverbal dimension. Additionally, his work has created a general awareness that it may be important to consider the extent to which non-verbal mediation may influence memory for verbal materials.

Although Paivio's work may be the best known, many others have contributed significantly to the burgeoning growth of interest in visual imagery. After many years of

neglect, eidetic imagery is once again a popular topic. (The modern work in this controversial area has been reviewed by Gray & Gummerman, 1975.) Case reports of persons who appear to be exceptionally skillful in using (eidetic?) imagery as a mnemonic device have also stimulated thought regarding visual representational processes and their relation to language. The most dramatic of these appears to be Luria's (1968) subject "S" whose synesthetic experiences appear to have existed in a dimension other than that of language.

Bower's studies (e.g., 1972) demonstrating the usefulness of nonverbal imagery in facilitating the recall of verbal material have also been influential. One of the sequelae from this line of work has been the attempts to teach nonverbal imaging techniques to aphasics (Patten, 1972) and to Korsakoff patients (Cermak, 1975) in order to enable them to improve their retention of verbal materials.

### Material-specific Memory Disorders

A third line of work which has had considerable effect in stimulating a re-awakening of curiosity about NVM has been Brenda Milner's extensive studies of memory function in temporal-lobectomy patients. In the early phase of this work, which has been summarized in a number of places (e.g., Milner, 1966), Milner has demonstrated an impressive double dissociation between memory deficits for verbal materials, associated with left temporal lobe lesions, and memory deficits for nonverbal material following right temporal lobe lesions. On the basis of these data, Milner (e.g., 1968a) has proposed a theory of material-specific memory impairments. According to her model, some memory disorders may be highly circumscribed and limited to a particular type of stimulus material only.

Although the existence of verbal memory deficits following left hemisphere lesions had been generally accepted before Milner's work, her carefully controlled series of studies directed attention to the possibility that there may be a separate system in the brain for the retention of nonverbal material and that this system could be interfered with selectively.

There are several reasons why Milner's work had a profound impact on thought regarding NVM. First of all,

her investigations offered the most powerful evidence yet presented for the existence of a separate NVM function. Moreover, her data linked this NVM system to specific brain structures for the first time. Milner also showed that the phenomenon of NVM is reliable, as measured by several different methods and she demonstrated that it was probably not modality-specific but rather cut across the visual, auditory, and tactile information-processing systems. Finally, her imaginative methods of measuring NVM (e.g., Milner & Teuber, 1968) provided for the first time a whole range of possibilities for the operational specification of this elusive concept.

Milner's studies have had important implications for clinical work also. In discussing her data she stressed that NVM and verbal memory were in practice clearly dissociable and emphasized the importance of thoroughly evaluating the nonverbal aspects of memory when examining a patient. In considering the pitfalls of inadequate assessment of memory disorders she noted that, "Despite these clearcut differences, a marked degree of verbal memory impairment is frequently diagnosed as a generalized impairment of memory, simply because the nonverbal aspects of memory are not adequately examined" (Milner & Teuber, 1968, p. 330). She drew attention also to the even more

probable error of concluding that a patient has intact memory functioning generally because a high level of performance is seen in the standard (i.e. verbal) tests of memory.

Kimura's work also gave impetus to the emerging view that NVM processing may exist independently of the verbal memory system. Her methods (Kimura, 1963; Kimura & Durnford, 1974) were innovative as well and although often more concerned with perception than memory, much of her work contributed to the growing interest in linking the right hemisphere to the processing of nonverbal information.

Unquestionably, Milner and Kimura's work has been effective in heightening our awareness of NVM functions and in showing the relationship of these processes to temporal lobe structures. In reviewing the influence of the early work regarding material-specific memory disorders, Iversen (1977) concludes that these studies have been one of our most important achievements in the last ten years. It appears that the dissociation of memory function based on type of material is now a widely-accepted fact. In his impressive review of the biological bases of memory, Rozin (1976), for example, comments on the significance of this work as follows:

The clear double dissociation of verbal and nonverbal memories raises many important questions. The definition of precisely what type of memories are dealt with selectively by each hemisphere will provide great insight into cognitive function, and memory in particular....Whatever the precise description of the lateralized deficits, it is clear that there are two very different memory systems in the brain. (p. 30)

Besides having significant impact on thinking in both clinical and experimental neuropsychology, the concept of material-specific memory disorder has had considerable influence on general memory theory as well. Models of memory have had to be revised to take the new idea into account and this has been one of the few instances where data from neurological cases have had an effect on theorizing regarding normal memory functions. Again, Rozin (1976) expresses this point most concisely:

The neat fractionation of the amnesic syndrome has important implications for the psychological issue of the coding mechanism in memory. The notion that virtually all information is encoded verbally (Glanzer and Clark, 1963 sic ), and that STM is thus only a verbal memory, seems untenable. (p. 31)

### Right-hemisphere Functions

A fourth major trend which has contributed greatly to the recent growth of interest in NVM has been the increased attention paid to the capabilities of the nonlanguage hemisphere generally. The emergence of human neuropsychology as an experimental science during the 1960's was an especially significant factor in fostering the examination of brain functions that were hitherto largely ignored. The methodological rigor of the new human neuropsychology further created a conceptual framework which prompted a search for new ways of operationally specifying the components of all kinds of information processing. Thus, concepts (often taken from the earlier neurological literature) which were vague or ambiguous, were given task-dependent meanings. This new emphasis on specificity in measurement made it possible for NVM to be studied in a scientifically respectable way, provided that what was meant by the term was made explicit in terms of task operations. Since the single major emphasis in human neuropsychology has been the search for hemispheric asymmetries in cognitive functioning generally, it is not surprising that memory processes would be examined in terms of left vs. right brain structures and that the role of the right hemisphere in memory would be extensively explored.

The explosion of interest in right hemisphere processes during the last 20 years cannot be as easily identified with the work of one or two individuals as is the case for the other major trends which prompted the reconsideration of NVM. Many workers have contributed and several seemingly diverse lines of work have converged to promote interest in nonlanguage brain functions. Since most of these sources are well known (e.g., See Joynt & Goldstein, 1975) there is little need to document them again.

CHAPTER TWO: EVIDENCE FOR THE EXISTENCE OF  
NONVERBAL MEMORY AS A SEPARATE SYSTEM

Memory as a Unitary Process

The mainstream view of memory has always been that, whatever the stages involved, all information is handled in basically the same manner. This assumption was implicit in most of the early models of memory, but Osgood (1957) may have been the first to explicitly propose a common representational system for both verbal and nonverbal information. Osgood's ideas have been very influential in promoting this most popular conception of the organization of memory. More contemporary expressions of the unitary view can be seen in the models presented by Rumelhart, Lindsay and Norman (1972) and by Pylyshyn (1973). In both of these schema, a common memory system, in logical/propositional form, is envisaged for both linguistic and nonlinguistic information. The appeal of a single formulation is understandable in that it offers the hope that there is only one memory system to understand, not several with each possibly operating in a different way.

The unitary assumption, which had not been seriously questioned before the 1960s, has not only dominated thinking about the fundamental nature of memory but has also shaped the views of those who have tried to assess memory disorders. Thus, we have seen, as common clinical practice until fairly recently, the use of a single score (e.g., the Wechsler Memory Scale quotient) to measure "the" memory function. The implicit expectation here has been that performance on all types of memory tests should be highly correlated and so the presence and severity of a memory disorder can be determined by the use of any one of them.

If memory is conceived of as a unitary system, this single-trait strategy is perfectly reasonable; the level of memory efficiency should be apparent regardless of the type of materials or procedures used, provided only that the task is sufficiently sensitive to "memory in general". There are obvious parallels here with the unitary views of intelligence and the early attempts to develop the single best measure of "g". If memory is regarded as being uncompounded then, it is justifiable to assume that memory disorders should be relatively uniform as well. Thus, all memory disorders may be seen as basically the same, possibly occasioned by the same pathogenesis and differing only in degree of severity.

This position was widely held by the earlier investigators like Talland (1965) and Barbizet (1970) who, although sophisticated enough to employ multiple measures of memory, were still led by the unitary model to search for the basic underlying cause of the "amnesic syndrome".

The division of retention into sequential stages, such as immediate memory, short-term memory and long-term memory was not inconsistent with the unitary model, since these subdivisions were considered to be just different temporal phases of the same fundamental system, and all information was assumed to flow through each stage in roughly the same way.

The first serious challenge to the notion that memory is indivisible came from Milner's (e.g., 1968a) demonstration of material-specific memory disorders following unilateral temporal lobectomy. Milner illustrated that clear and apparently permanent impairments in memory could be seen for certain kinds of materials and not for others. Moreover, these material-specific memory disorders could be doubly dissociated with reference to the side of the lesion. These facts were, of course, very difficult to reconcile with the unitary conception of memory, and their publication caused many to begin to consider the reality of

separate memory systems. Milner's experiments also gave impetus to the work of other investigators who have since proposed additional ways in which different kinds of information could be processed differently.

Tulving (1972), for example, suggested the distinction between semantic and episodic memory, Posner (1973) described separate verbal, visual and motor codes, Paivio (1971b) proposed a separation of memory for verbal-sequential inputs from memory for those that are imaginal and synchronous, and Luria (1976) argued for the modality-specific bifurcation of memory. The cumulative effect of these popular multiple-systems views has been to weaken the supposition, which prevailed for so long, that memory is of a single piece and contemporary thought is now much more receptive to the idea that there may be more than one kind of memory. This shift in thinking can be best illustrated by considering the comments of those who have recently reviewed the literature on memory and memory disorders.

Crowder (1976), for example, surveyed the experimental work and found that, "Indeed, evidence has been accumulating rapidly that events can be stored in multiple codes, among which nonverbal imagery occupies a more or less co-ordinate role with verbal traces"

(p.90). Ervin and Anders (1970) conclude their review of memory disorders with the simple statement, "1. Memory is not a unitary function." (p. 173). Gazzaniga (1976) considered the results of commissurotomy studies and summarized, "There is good reason to believe that there is no unitary mechanism responsible for the encoding of information in the brain" (p. 64).

### Dissociation of Verbal and Nonverbal Memory

Since the beginning of the recent renewal of interest in NVM, many investigators have attempted to explore the characteristics of this processing system. From this work, a considerable amount of evidence has accumulated which suggests that NVM operates differently in some ways from the verbal memory system. The following sections consider those observations which indicate that nonverbal memoranda are processed in some fundamentally different way from verbal memoranda.

## Processing Differences

The early information-processing theorists proposed that nonverbal materials were dealt with quite differently from verbal materials. Broadbent (1958), for example, hypothesized that, unlike verbal information which he felt is degraded primarily by intervening activity, nonverbal information simply decays as a function of time. Sperling (1963) elaborated on this theme and suggested that all visual information first enters a large-capacity sensory store, where it decays in less than a second. Visual information in the store will be overwritten by continuing input and thus completely lost unless it is transferred into a limited-capacity auditory short-term store where it may be retained by linguistic rehearsal.

Sperling's trace-scanning procedure and his multi-stage models were influential in promoting the view that, in contrast to verbal material, nonverbal information is retained only in a highly transient and nonspecific fashion. Many of those working within the information-processing tradition have since rejected this limited conception of the nonverbal system. Deutsch (1975) in particular, has argued persuasively for recognizing the importance of NVM. Working primarily with auditory memoranda, she has accumulated much evidence

to demonstrate that this view of the nonverbal store as an unstructured buffer is grossly insufficient. Her methodical studies investigating the properties of memory for pure tones have provided convincing demonstrations that we can retain nonverbal stimulus attributes over substantially longer periods of time than was predicted by the early information-processing models. Deutsch has also illustrated that the rate of decay, for tonal memory at least, is much slower than was initially believed and that information loss is much faster in the presence of interfering activity. She has concluded that the storage system for nonverbal information in general can be shown to possess a degree of organization and specificity rivaling any found in verbal memory studies.

Considering the same issue from another perspective, Paivio (e.g., 1975a) has also argued forcefully that the way in which the NVM system processes information is fundamentally different from the way in which the verbal memory system operates:

Thus the imagery system is assumed to be specialized for relatively direct processing of information concerning concrete objects and events: it organizes elementary units

of information (images) into higher-order structures that have a synchronous or spatial character, and it is functionally dynamic and flexible in that the organized cognitive information can be quickly re-organized, manipulated, or transformed. The verbal system, on the other hand, is specialized for dealing with abstract information involving linguistic units and organizing such information into higher-order sequential structures. (p. 59)

Evidence that the verbal-representational system is specialized for sequential processing, while the nonverbal system is not, is provided by studies (e.g., Paivio & Csapo, 1969, 1971) which compare memory for pictures with memory for words. While pictures are generally remembered better than words, the reverse is true if the subject is required to remember the order in which the memoranda were presented. Thus immediate memory span and serial reconstruction tasks show a clear superiority for words over pictures, unless the subject is given time during the presentation to name each picture and thus convert it into a verbal code.

Paivio (1975a) regards nonverbal representations and images in particular, to be analogical structures.

The perceptual or pictorial metaphor associated with the concept of imagery, and the idea of synchronic or spatial organization of information suggests that imagery involves an analog process rather than the discrete digital process that seems characteristic of the linguistic system. (p. 66)

A number of studies dealing with internal comparisons and transformations of mental images are surveyed in support of this assertion.

Support for the contention that verbal memory and NVM are separable may be found in an intriguing report of the experimental study of a mnemonist. Hunt and Love (1972) presented a detailed evaluation of one subject, "V.P.", who possessed extraordinary mnemonic abilities. This subject performed at a level far superior to normal (college student) subjects on all of the carefully controlled memory tasks which were given to him, except for one involving memory for stereoscopic images, which he was completely unable to do. His performance, although good, was also substantially below his usual level of perfection on another task requiring memory for high imagery nominalizations, taken from Paivio's (1971a) list.

On a test developed by Frost (1971), in which pictorial stimuli can be grouped for later recall either by semantic similarity or by visual orientation, college student controls consistently clustered the drawings according to their visual appearance, but V.P.'s responses demonstrated an organization completely determined by semantic likenesses. Finally, Hunt and Love note that in contrast to V.P.'s phenomenal efficiency with verbal memoranda, he reports, and they confirmed anecdotally that he has some difficulty in remembering faces of people he has met (!). Unfortunately, memory for faces or any other nonverbal material was not evaluated formally.

### Storage Differences

Most modern memory theorists hypothesize that all sensory information is processed in turn by each of a number of sequentially ordered holding mechanisms. Some recent observations have suggested that the sequential processing path for non-verbal information, however, may be quite different from that which is commonly assumed for verbal information. In order to better appreciate the meaning of these data, it is first necessary to consider the general notion of multi-store models of memory and to make more explicit the ways in which the temporal dimension has been partitioned in each.

In most models of memory, the chain of processing is divided into hypothetical stages and each is seen as having unique characteristics as to capacity, duration, etc. There have been, of course, innumerable models, each suggesting variations as to the number of memory stages or stores and the characteristics of each of these. In spite of the differences among the theories it has been fairly widely accepted (e.g., see Murdock's, 1971, "modal model") that the memory process can be divided into three temporally sequential stages, viz., sensory registers, short-term memory (STM) and long-term memory (LTM). Although there has been an extensive

controversy regarding the nature of each of these stores, many general features seem to be fairly well agreed upon (Craik & Lockhart, 1972) within the context of the multi-store idea.

The sensory registers are generally seen as pre-attentive, given to literal representation of information, modality-specific, characterized by their large capacity and a rapid rate of information loss due to further inputs. The STM store is usually seen as driven by attentional and rehearsal processes, primarily auditory-verbal in character and defined by its limited capacity, slower rate of forgetting and its susceptibility to information loss via displacement or interference. The LTM store is most often considered to be largely semantic in nature, of unlimited capacity, and characterized by a very slow rate of forgetting.

Another highly influential model of memory, also of the multi-store variety but in which there is a somewhat different emphasis, is the system proposed by Waugh and Norman (1965). These authors took William James' (1890/1950) original concepts of primary and secondary memory and proposed that these two hypothetical stores can be operationally separated by emphasizing the role of rehearsal. The basic idea here is that information

which is consciously being attended to is handled by a process fundamentally different from that which stores information which is no longer the focus of attention. One of the glaring weaknesses of those models which have employed STM/LTM concepts has been their inability to specify when the former changes into the latter. The apparently simple distinction between primary and secondary memory has thus been very appealing and Waugh and Norman's terms have gained widespread acceptance.

There have been many other multi-stage models of memory proposed, of course, but most of the work in NVM has been cast in terms of the STM/LTM or primary/secondary memory distinction. Differences in defining the temporal limits of each stage, however, make comparisons across studies hazardous.

Although by no means universally accepted (e.g., See Craik & Lockhart, 1972, for a much different approach), the sequential stage view has to a large extent shaped our thinking regarding the way in which the memory function operates. Inherent in this view is the notion that all information must pass through one stage in order to get to the next and thus sensory data is processed by

each store in succession. Sequentially ordered, multi-store models were created by theorists working almost entirely with verbal materials, however. When it finally became more permissible to study NVM, a startling possibility began to emerge. Some observations indicated that nonverbal materials may not be processed by the STM mechanism at all, but may instead move from the sensory registers directly into LTM.

Milner appears to have been the first to suggest this possibility. She reported the surprising finding that, in a facial recognition task, normal subjects made no more errors with a 90-second delay interval than they did at zero delay (Milner & Teuber, 1968). This result is in sharp contrast to the usual findings with verbal materials which show a very reliable loss of information over this time period. Since a very slow rate of forgetting is a defining characteristic of the LTM store, Milner proposed that facial memoranda may enter this tertiary stage very soon after registration has occurred.

Further observations relevant to this point came from Milner's investigations of the case of "H.M.". Using verbal materials only, she had previously established that H.M.'s STM appeared to be relatively normal and

thus she concluded that his severe amnesia was due to an almost complete lack of a long-term storage system. However, when H.M. was evaluated using Prisko's (1963) nonverbal STM tasks, which involved delayed comparisons of stimuli such as flicker rates, shades of red, and nonsense patterns, he was found to be severely impaired on all measures used.

Sidman, Stoddard and Mohr (1968) also reported that H.M. had great difficulty in performing delayed matching tasks when ostensibly nonverbal memoranda (ellipses of varying radii) were used and the retention interval was more than a few seconds. This impairment was in sharp contrast to his good performance when trigrams were used.

Although these two findings were consistent, "The failure on these tasks was, however, unexpected and remains puzzling since all our other data on this patient indicate that his STM is essentially normal" (Milner & Teuber, 1968, p. 343). Milner concluded that either these delayed comparison tasks using nonverbal memoranda require something other than STM or H.M.'s STM is selectively impaired for this type of material.

When the nonverbal delayed comparison tasks of Prisko and of Sidman et al. were administered to

normal subjects it was found that they showed virtually perfect retention of these materials over the delay intervals tested. This result confirmed that H.M.'s rapid forgetting of the nonverbal memoranda was indeed grossly abnormal and also served to demonstrate that other nonverbal materials, in addition to faces, are retained over brief intervals with very minimal information loss. Both of these facts appeared to be congruent with the idea that the NVM system may not utilize a STM store.

Warrington and Taylor (1973) have also argued that nonverbal information is processed by LTM directly and thus skips the STM stage which may only be relevant for audio-verbal information. In support of this contention, they present data from two experiments comparing memory for faces with memory for surnames in both normal and amnesic patients. In the first study, Warrington and Taylor devised a memory span procedure in which subjects were presented with strings of memoranda of increasing length followed by immediate recognition testing. The results showed no differences between amnesic patients and normals when surnames had to be remembered and no overlap between the two groups when span of apprehension for faces was assessed. Since amnesic patients

are considered by general consensus to have intact STM and defective LTM, Warrington & Taylor regarded their results as *prima facie* evidence that memory for non-verbal memoranda must be mediated by LTM.

Their second procedure involved a single presentation of three memoranda followed by either an immediate or a delayed recognition test. In the delay condition, subjects were given a 30-second addition task. The data for surnames showed the expected decrements in performance over the delay interval with no differences between amnesic patients and normals. Conversely, the results for the facial memoranda revealed the patients to be markedly inferior to the normals on this task at both retention intervals, but most significantly, neither group showed any loss of information over the 30-second delay. Warrington and Taylor concluded that these findings emphasized the absence of a STM component in memory for faces.

In reviewing these and other related findings, Iversen (1977) presents a flow-chart to summarize the hypothesized differences in processing between the verbal and NVM systems. She cautions that, although it is a very appealing idea, we need to investigate many other kinds of nonverbal materials before coming

to any definite conclusion that NVM does not involve a short-term storage stage.

Contradictory evidence has in fact been offered. Wickelgren (1968) re-assessed H.M.'s NVM using a tonal recognition task. In contrast to the other NVM measures used with H.M., this method produces a rapid decay function in normal subjects over the brief delay intervals used. Wickelgren interpreted H.M.'s performance on this task as being within average limits (i.e., he also showed a rapid loss of tonal information).

In a more recent study, Warrington and Baddeley (1974) confirmed this finding using a measure which involved memory for the position of a single dot. They found that when retention intervals of from zero to 60 seconds were used, both normals and amnesic patients showed the same short-term forgetting curves. The two groups were neatly separated, however, by a similar task which used a 2-minute delay interval. Warrington and Baddeley argued here that these results are essentially the same as those which are seen when verbal memoranda are used and, thus, there is no basis for concluding that NVM is fundamentally different in terms of storage characteristics.

Warrington and Weiskrantz (1973) surveyed the

evidence related to STM/LTM defects in amnesic patients and cautioned that ceiling effects may have obscured the meaning of previous work with nonverbal memoranda. They conclude, "On balance it would seem that the short-term forgetting of stimuli not readily verbalizable is within the normal range, as is the short-term forgetting of verbal items" (p. 371).

Other reviewers disagree. Rozin (1976), for example, has recently reviewed the evidence regarding nonverbal STM disorders in global amnesic patients. He comes to quite a different conclusion:

Since the difference between normals and amnesics appears to lie in the ability to place or gain access to recent events in LTM, the interesting possibility arises that this ability is needed to retain nonverbal materials in STM, while verbal rehearsal or recirculation strategies suffice to hold verbalizable material in STM. (p. 27)

According to Ervin and Anders (1970), Evidence suggests that nonverbal information either has a separate memory buffer that serves a similar function (as the verbal memory buffer) or that it enters the next

more stable memory process (secondary memory)

direct from the sensory system. (p. 166)

Ervin and Anders support their position by reference to studies of memory for the extent of a motor response (Posner & Konick, 1966) in which normal subjects were found to show no differences in memory performance regardless of the length of the delay interval or the type of distractor task used. Again, this result is strikingly different from the usual finding with verbal materials in which interpolated tasks create considerable forgetting and the loss of information is proportional to delay interval length. Ervin and Anders conclude that results such as these strongly suggest that primary memory does not play an integral part in the storage of nonverbal information.

Madigan, McCabe, and Itatani (1972) reach a similar conclusion in interpreting the results of their study comparing immediate and delayed recall of words vs. pictures in normal subjects. They propose that pictures might make direct contact with LTM immediately on presentation rather than proceeding through a STM buffer.

Paivio (1975a) agrees, and adds that overall, the research on imagery consistently shows that visual images are not generally processed by the primary memory

system: "Imagery conditions facilitate recall from secondary memory because they ensure the arousal of independent memory codes" (p. 72).

At present, the issue of the relative importance of the STM concept in NVM remains unresolved. The situation appears to be akin to that in attempting to solve an equation with two unknown factors, since neither STM nor NVM have been unambiguously defined as yet. If the nature of the relationship between the two concepts can be clarified this may have important implications for the understanding of amnesic deficits and may also deepen our insights into normal memory processes. It would be premature to attempt a resolution of the issue at this time, however. Instead, the intent of this brief review is simply to illustrate an area in which the concept of NVM has theoretical as well as practical importance. Clearly, little progress can be made here until some agreement is reached regarding how NVM should be measured. The primary purpose of this monograph is to aid in achieving that consensus.

### Sparing of Nonverbal Memory in Amnesic Patients

Since Korsakoff (1889) first popularized the idea of a "global" amnesic syndrome, much effort has been expended in attempts to specify more precisely the nature of the memory disorder seen in patients who are given this eponymous diagnostic label. In recent years, increasing attention has been paid to the status of NVM in amnesic patients. The usual approach in these studies has been to compare NVM and verbal memory functions and when differences are found to argue that the dissociation supports some theory or another regarding the fundamental nature of the "amnesic syndrome". In this section, consideration is restricted to those studies which have employed as subjects, patients with presumed diffuse or bilateral cerebral pathology. Studies involving patients diagnosed as having unilateral brain lesions only are the subject of the following sections.

Ervin and Anders (1970) were among the first to comment on the possibility of a discontinuity between NVM and verbal memory in patients with retention disorders. They evaluated much of the amnesic syndrome literature produced during the 1960's and noted that, in contrast to the usually deficient performance of amnesics, these patients were found to remember much

more proficiently when three kinds of tasks were used. Good retention was seen for motor skills, for the products of learning via operant or classical conditioning, and for what they described as perceptual learning or the retention of "raw sensory data". Ervin and Anders surmised that the one common feature of these three kinds of tasks was that they all involve the acquisition of nonverbal information. They concluded, "One thing that is clear from the literature is that the amnesic patient may be amnesic mainly for verbal information" (p. 169).

A more direct experimental test of this assertion was provided by Butters, Lewis, Cermak and Goodglass (1973) who compared retention for verbal and nonverbal memoranda in each of three different presentation modes. Here, the visual nonverbal stimuli used were computer-generated random shapes from the set developed by Vanderplas and Garvin (1959), while the auditory nonverbal memoranda were sequences of five random piano notes and the tactile stimuli were raised irregular figures. Groups of letters were used as the verbal memoranda in each sensory mode. Following presentation of each memorandum, retention was tested either immediately or after delays of 9 or 18 seconds. In the delay

conditions, subjects were required to count backwards by two's to prevent overt rehearsal. In the recognition phase, a comparison stimulus was presented and a same or different judgment elicited.

Butters et al. interpreted their results as indicating that, overall, there were no differences in performance on the NVM tasks among groups of Korsakoff patients, alcoholics without memory disorders, and normals. By contrast, when verbal materials were substituted using the same procedures, the Korsakoff patients showed severe performance deficits in the delay conditions as compared to the two control groups. Moreover, this pattern of results was reported as consistent across all three modes of presentation. On the basis of these data, the authors argued that the material-specific deficit of their Korsakoff patients is due to an inability to employ semantic encoding.

Butters and Cermak (e.g., 1975) have since advanced the semantic encoding deficit hypothesis as the fundamental explanation of all memory disorders in amnesic patients. A logical corollary of this proposition is that any material which does not require verbal processing should be retained by amnesic patients at a level similar to that seen in normal subjects. While

the Butters et al. (1973) study appears to offer support for this contention, an inspection of their data reveals that normal retention of the nonverbal materials was actually found in only the zero and 9-second delay interval conditions. By 18 seconds, the Korsakoff patients were markedly impaired on both the visual and tactile tasks. A later report (DeLuca, Cermak & Butters, 1975) indicated that these inter-group differences were in fact statistically reliable, and thus suggested that the Korsakoff patients used in this study could indeed be shown to have nonverbal memory deficits providing the retention interval was long enough.

Warrington (1974) also provided evidence that the amnesic syndrome does not selectively spare NVM. She investigated recognition memory for words, faces, and representational paintings in four amnesic patients and found that they were severely deficient, as compared with normal controls on all types of materials used. Warrington's procedure also involved retention intervals much longer than a few seconds.

Since Peterson and Peterson's (1959) original demonstration, the use of distractor tasks during a delay interval has been a popular way of attempting to prevent overt rehearsal of the memoranda. By having

the subject immediately engage in an unrelated but attention-demanding task, the assumption has been that the "natural" rate of forgetting can be observed without confounding by inter-subject differences in extent of conscious rehearsal. There have been suggestions, however, (e.g., Brooks, 1968; Shiffrin, 1973) that the degree of similarity between the memoranda and the distractor task materials may be critical in determining the amount of information loss. On this basis, the results of the study by Butters et al. (1973) might be considered suspect. Since only a verbal distractor task was used, verbal memoranda only may have been affected.

In order to clarify this point, DeLuca et al. (1975) compared varying types of distractor activities as to their differential effects on verbal memory and NVM independently. Random shapes were again used as the nonverbal memoranda and the nonverbal distractor tasks included tracking of musical tones and matching-to-sample of "snowflake" figures each for a delay interval of 20 seconds. The pattern of their results was complex but one clear finding was that Korsakoff patients were impaired in their retention of the random shapes regardless of whether the distractor task was verbal or nonverbal and regardless of the modality of the distracting activity.

De Luca et al. further determined that these patients showed a retention deficit for the non-verbal memoranda, both as compared to controls and as compared to their own level of performance with verbal materials, even when no distractor task was used and the delay interval was left unstructured. An additional finding of interest was that the nonverbal distractor tasks, both auditory and visual, had no effect on the patients' retention of verbal materials. These results added to the cumulative impression that different kinds of processing are involved in nonverbal as opposed to verbal memory.

One of the insights gained from the work of the early 1970's has been the realization that it is not reasonable to apply the traditional (verbal) distractor task procedure to the study of short-term forgetting of non-verbal materials. Whereas with verbal materials, the distractor technique produces quite predictable results, the effects seen with NVM have been much more variable.

In their review of STM processes and the amnesic syndrome, Kinsbourne and Wood (1975) considered the findings from several studies and concluded, "It is now apparent...that verbal and nonverbal tasks do not interfere with each other as target item vs. distractor

task in the Peterson and Peterson paradigm" (p. 274). They cautioned that the prevention of rehearsal for nonverbal memoranda should only be expected when a nonverbal distractor task is used. But even when this is done, it may be, as in the DeLuca et al. study, that forgetting occurs no more rapidly than if the delay interval is unfilled. The question raised by findings such as this is whether it is at all appropriate to conceive of "rehearsal" as likely or even possible for at least some kind of non-verbal materials.

Uncertainty regarding the appropriateness of using distractor tasks in the study of NVM has clouded attempts to resolve the original question of whether the amnesic syndrome is primarily (or strictly) a verbal memory disorder. Most reviewers, however, do not find the evidence convincing.

In surveying the work of the Boston group, Piercy (1977, p. 20) comments that if the concept of a "semantic" encoding deficit were broadened to include nonverbal codes, their hypothesis would accommodate a considerably larger range of data.

Rozin (1976), in his review of theories of amnesia, finds similarly that the weight of the evidence supports

a more general encoding impairment and suggests that the amnesic syndromes are likely composed of combinations of partial impairments in both NVM and verbal memory.

"Furthermore, ... the enormous deficit in memory for nonverbal materials is hard to explain as a semantic deficit as is the fractionation of the amnesic syndromes into verbal and nonverbal components" (p. 32).

A recently reported study (Strauss & Butler, 1978) has confirmed the impression that the Korsakoff impairment encompasses both NVM and verbal memory. These investigators used haptic verbal and haptic nonverbal memoranda and evaluated the effects of tactile distractor tasks using either verbal or nonverbal materials. Irregular wooden block shapes served as nonverbal memoranda while the nonverbal distractor task involved arranging in order by size a series of graduated plastic rings. Raised block letters were used as the verbal comparison materials. Strauss & Butler's results showed that, as in previous studies in other modalities, verbal memory was most disrupted by a verbal distractor task but that retention of the nonverbal material was not differentially affected by the verbal/nonverbal nature of the distractor task. Strauss & Butler comment,

Our findings...supported the notion that verbal and nonverbal memory systems operate differently. The support derived not from any finding that the Korsakoff patients performed better on nonverbal than on verbal tasks but rather from the observation that the two systems were differentially affected by interference strategies. (p. 82)

At present, all investigators are in agreement that amnesic patients have memory disorders of some kind for verbal materials. The issue of whether their impairment extends to nonverbal materials remains a source of controversy, however. Again, the matter may have more than just theoretical import. Besides more clearly elucidating the basic nature of the amnesic syndrome deficit and contributing to a better understanding of the relationship between the verbal and NVM systems, significant practical consequences may follow from the resolution of this issue. If the amnesic syndrome was in fact found to be verbal material-specific, this outcome would likely promote efforts to develop rehabilitative strategies using the relatively intact NVM system. Here then, is another area in which substantial progress awaits the resolution of measurement problems in NVM.

CHAPTER THREE: HEMISPHERIC SPECIALIZATION FOR  
NONVERBAL MEMORY

If the NVM system does in fact process information in some way which is fundamentally different from the way in which the verbal-memory system operates, then it is reasonable to suspect that different brain structures might be implicated in each case. Since it is well established that in most people the left hemisphere plays a leading role in subserving language functions, many writers have speculated that the right hemisphere may be principally (or solely) involved in mediating non-language processes. In opposition to this view is the historically robust supposition, often associated primarily with Lashley, that in the retention of sensory experience, all neural tissue is equipollent.

Evidence to support or disconfirm the cerebral lateralization of NVM hypothesis has come from several diverse kinds of studies. In organizing these sources of data and opinion, reports using similar subject populations have been grouped together so that the findings from each type of investigation may be more easily compared. In addition to summarizing the evidence regarding right-hemispheric specialization for NVM, a review of these studies also serves to illustrate the diversity of the methods that have been used to measure NVM.

### Temporal Lobectomy

Those who carried out the early investigations of memory disorder following unilateral temporal-lobe resection found little evidence to suggest that right-sided removals caused any significant mnemopathology. Meyer (1959), for example, studied a series of right-temporal lobectomy (RTL) and left-temporal lobectomy (LTL) patients and concluded that, for the former, memory functions remained practically unchanged postsurgically. Meyer used a battery of six paired-associate tests which included presentations in auditory, visual, and tactile modalities, and sampled both recognition and recall performance. Three of his tasks employed explicitly verbal stimuli while the others used object pictures and unspecified designs and patterns. If Meyers' "nonverbal" materials were in fact easy to label verbally, this would account for his negative results. As is the case with so many studies of NVM, the description of the memoranda used was extremely meagre and it is not possible to estimate even roughly the potential for verbal mediation.

The work of Milner and her students during the 1960's produced the first clear evidence that the functioning of the NVM system is critically dependent on the integrity

of the right-temporal lobe. (See Milner, 1966, for a survey of the early data and Iversen, 1977, for a review of the more recent studies.) The methodical investigations reported by the Montreal group illustrated convincingly that RTL patients were impaired when required to remember stimuli to which a verbal label could not readily be assigned. The design of many of these studies permitted the investigators to conclude that the performance deficits seen were not primarily perceptual in nature (i.e., they did not occur when the retention interval was reduced to zero). In addition, Milner and her co-workers demonstrated that these RTL patients had normal memory for verbal materials and that LTL patients showed precisely the obverse deficit pattern, being severely impaired for verbal memory tasks yet performing unremarkably on the NVM measures.

Kimura (1963) was one of the first to contribute to this general finding. She illustrated that RTL patients had great difficulty in identifying recurring "nonsense figures" in a continuous recognition paradigm. In the following year, Milner and Kimura (cited in Milner & Teuber, 1968) confirmed that this deficit was specific to right-temporal lobe lesions and NVM. They used verbal materials in the same paradigm and found that this time

it was the LTL patients who were unable to recognize the recurrent stimuli.

Prisko (1963) also used these nonsense figures but in a quite different format. A single memorandum was presented followed by a delay interval of up to 60 seconds and then a test stimulus. Here, the patient was required to indicate if the second figure was the same as the first. Prisko found that RTL patients were markedly inferior in this task as compared with LTL patients. There was no difference between the groups, however, when other ostensibly nonverbal materials, such as differing shades of red or light flicker rates were used. Again, these other stimuli may have been verbalizable, but not enough description was given to evaluate this possibility.

Milner (1965) and Corkin (1965) next demonstrated that RTL patients were impaired on both the visual and the tactile forms of a stylus maze, while LTL patients had no difficulties with either. These results were considered as further evidence that NVM deficits were predictable sequelae of right-temporal lobe excisions.

In a later series of experiments, Milner (1968b) found RTL patients to be significantly inferior to LTL patients on a facial recognition task over a 90-second

delay interval filled with a visual distractor task. This result was then replicated with the distractor task omitted. Finally, the delay itself was eliminated and no differences were found between the two groups in this immediate recognition version. This last control nicely ruled out perceptual factors as determinants of the delayed recognition deficits shown by the RTL patients.

Additional evidence relating NVM disorder to right-temporal lobectomy has come from the work of Taylor (1969) who adapted the classic Rey-Osterrieth figure for use in a delayed reproduction format. Patients were asked to copy this complex design as accurately as possible and then forty minutes later, and without previous warning, were asked to draw it again from memory. Patients in both temporal-lobectomy groups were able to copy the figure about as well as normals but after the lengthy delay, the RTL patients showed a grossly disproportionate loss in accuracy as compared with the LTL patients.

By the end of the 1960's the association between NVM and the right temporal lobe was well established. The next report to consider material-specific memory disorders following unilateral temporal lobectomy presented

discordant results, however. Perhaps significantly, it was not from the Montreal group and employed a new sample of patients and quite different assessment methods. Samuels, Butters and Fedio (1972) used a procedure in which each memorandum was presented tachistoscopically for 500 msec. Patients were then required to immediately identify the previously shown stimulus from a multiple-choice array. Delay intervals of 3, 9, and 18 seconds, each filled with a backwards counting task, were also used. The designated nonverbal memoranda used by Samuels, et al, were "unfamiliar geometric patterns" which were not illustrated or described any further. Retention of these patterns was compared with that for visual and auditory trigrams.

The results showed that RTL patients, LTL patients, and normals were not distinguishable by either of the visually presented tasks at any of the delay intervals. Since both temporal lobe groups performed poorly on the auditory presentation task, the authors interpreted their results as supporting a modality-specific, rather than a material-specific view of temporal lobe mnemonic functions. Samuels et al did suggest, however, that the lack of impairment for the RTL patients on the geometric patterns may have been due to the verbalizable nature of the

designs. If the patterns were in fact easily labelled then the two temporal-lobe groups may have achieved normal levels of performance through the use of different strategies, i.e., the RTL patients by verbal mediation and the LTL patients by processing the designs as nonverbal memoranda. The Samuels et al. report illustrates how important the selection of memoranda is if the results of NVM studies are to be unambiguously interpreted.

Until recently, there has not been a satisfactory way to assess NVM "span" in a manner analagous to the popular digit recall procedure. Corsi (1972), however, has offered an ingenious solution. He devised a block-tapping apparatus which is similar to that used in the familiar Knox Cube Imitation Test (Arthur, 1947), but which seemingly offers much less opportunity for verbal coding. Corsi affixed nine identical one-inch cubes to a square board, positioning each randomly such that it would be difficult to describe in words the location of any block in the array. His procedure involved touching several cubes in succession and then requiring the patient to immediately reproduce the sequence. As in digit span testing, progressively longer sequences were administered until consistent failures occurred.

A second NVM task used by Corsi comprised a variation of Posner and Konick's (1966) method in which the patient was required to reproduce the position of a cross on a line after an occupied or unoccupied delay interval. On both of Corsi's measures the findings were consistent with the double dissociation seen in previous work from the Montreal group. RTL patients were impaired on both NVM tasks while their performance on formally similar tests using verbal memoranda was indistinguishable from normals. As usual, the converse was true for LTL patients.

The work of Milner and her students continues to be provocative. In the most recent report, Jones-Gotman and Milner (1978) present evidence to suggest that visual imagery may be mediated by right-hemisphere structures. In this study, RTL patients were taught to use imagery as an aid in remembering a long list of pairs of concrete words. The results indicated that these patients were impaired on this task with respect to a normal control group. In a comparison task, there was no difference found between the RTL group and the normals when pairs of abstract words linked by sentences were used as memoranda.

Overall, Milner's temporal lobe studies have provided many important contributions to knowledge regarding NVM.

The reciprocal specialization of the two lobes has been shown to be a robust phenomenon, appearing in both recall and recognition tests, in different samples of patients, and across various sensory modalities (but see Hecaen & Albert, 1978, p. 349 for a dissenting opinion). Besides the substantive evidence linking NVM to right temporal lobe structures, Milner's seminal work has prompted exploration and development of many new approaches to the measurement of NVM.

### Extent of Hippocampal Removal

According to Milner (1971), the typical unilateral operation for temporal lobe epilepsy includes the removal of not only the lateral neocortex but also the amygdala and parts of the hippocampus and hippocampal gyrus on the medial aspect of the hemisphere. Since severe memory disorders have resulted from bilateral medial temporal lobe excisions (e.g., Scoville & Milner, 1957), the question naturally arose as to whether the severity of the memory impairments seen after unilateral temporal lobectomies were also related to the medial extent of the resections. Many of the studies surveyed in the previous section included further analyses in which the relationship between the memory disorder and the extent of medial temporal lobe tissue loss was explored. In these analyses, the total sample of patients for each side of operation was typically divided into subgroups based on the surgical reports of the extent of the hippocampal removals.

Comparisons across the LTL groups as to severity of verbal memory disorder yielded a very consistent pattern. On this side, the greater the amount of hippocampal tissue excised the more pronounced the verbal-memory impairment (Milner, 1970). This result was found to be

replicable using several different procedural variations. Samuels et al. (1972) again report negative results, finding no differences in verbal memory performance between patients with no hippocampal loss and those with small removals.

The pattern of results linking nonverbal memory deficits to extent of right hippocampal removal is more complex and also more intriguing. It appears that NVM tasks may be sorted into two kinds, namely, those for which degree of impairment is inversely proportional to the amount of hippocampal tissue spared, and those for which the extent of right hippocampal removal does not predict degree of impairment.

Specifically, the more radical the resection of the right hippocampal structures, the more marked the inability seen to do tasks such as visual or tactile mazes (Milner, 1965; Corkin, 1965), facial recognition (Milner, 1968b), block tapping or position reproduction (Corsi, 1972), and imagery-mediated paired-associate learning (Jones-Gotman & Milner, 1978).

Of these studies, Corsi's was the most directly concerned with the hippocampal issue and illustrates the best experimental controls. Corsi was able to subdivide his patients into four groups, each matched for mean

extent of lateral removal, but each having a progressively greater percentage of hippocampal excision. His results showed a very orderly increase in forgetting rates as he evaluated each group in turn. Corsi's data (presented in Milner, 1974), from his task requiring memory for the position of a small circle on a line, revealed that not only were the groups dissociable but the degree of separation increased progressively as the delay interval was extended. Thus, the performance of those RTL patients with complete sparing of the hippocampal structures was indistinguishable from the LTL patients or normal controls at all delay intervals. By comparison, the most radically excised hippocampal group not only made larger errors at the brief delay intervals but increased the degree of their relative impairment as they were required to retain the information over longer periods.

On the other side of the ledger, the extent of hippocampal removal has been found to be unrelated to the severity of memory impairment seen in such tasks as recurring nonsense figures (Kimura, 1963), and the delayed reproduction of the Rey-Osterrieth figure (Taylor, 1969; Jones-Gotman & Milner, 1978). According to the latter two authors, this is the case because these

memoranda can be considered abstract visual patterns. Jones-Gotman and Milner suggest that, by contrast, those visual memory tasks in which the severity of deficit after right temporal lobectomy has been most clearly linked to the amount of hippocampus removed have involved either sequentially organized or perceptually simple memoranda. One rationale given for this difference is that tasks which involve careful perceptual analysis of novel configurations may depend as much for their performance upon the integrity of the right temporal neocortex as upon that of the right hippocampus.

Although this is an appealing notion, not all the data fit well. Severity of facial recognition deficit was found to be related to extent of hippocampal removal (Milner, 1968b), for example, and it is difficult to argue that faces are perceptually simple memoranda. Since the left hippocampus appears to be so essential for the retention of all types of verbal memoranda and since one common feature of these materials is that they can all be rehearsed or recirculated in some way, perhaps the right hippocampus performs a similar function for the NVM system. It may be that the two kinds of nonverbal memoranda are distinguishable in that those which are disproportionately affected by hippocampal loss are

rehearsable materials while those for which hippocampal loss is not especially disabling are normally stored in some manner which does not involve or permit rehearsal.

### Amytal Procedure

Since Wada and Rasmussen's (1960) demonstration, the intracarotid injection of sodium amobarbital has been widely used as a method of determining the cerebral lateralization of speech prior to neurosurgery. Less well known perhaps, is the fact that the same procedure can also be used to estimate the risk of memory loss following unilateral excisions. Milner, Branch and Rasmussen (1962) were the first to explore this possibility while later demonstrations (Kløve, Trites & Grabow, 1970; Blume, Grabow, Darley & Aronson, 1973) expanded the scope of the method. Although in most of the studies reported, "memory" has been taken to mean verbal memory, recently there have been some attempts to assess NVM as well.

In Milner's procedure (e.g., 1975), the patient is shown a series of pictures of common objects during the first few minutes following the injection. The patient is requested to name each picture as it is presented. After the drug effects have cleared and all functions have returned to normal, retention of the pictures is evaluated by recall and then by recognition testing.

Milner remarks (Milner & Teuber, 1968) that if the injection is given to the artery which subserves the

speech-dominant hemisphere, the patient will be unable to name the pictures on presentation because the anaesthetic will have rendered him/her temporarily aphasic. Patients with injections of this kind will often, however, be able to recognize the memoranda pictures on post-recovery testing, thus illustrating that the nonlanguage hemisphere is functioning normally to process and retain information when speech functions are unavailable.

Conversely, Milner notes that patients given injections which perfuse the nonlanguage hemisphere are usually able to recall correctly the names of the pictures shown but generally fail to recognize the same pictures as identical on later multiple-choice testing. In these instances, where the "minor" hemisphere is dysfunctional during presentation, pictorial information apparently does not get encoded sufficiently for later recognition to be successful.

The standard procedure in these clinical investigations is to anaesthetize the hemisphere which includes the area of proposed removal. In this way, it is presumed that the severity and type of memory disorder seen during the Amytal effect will be representative of that which will occur following the surgery. Occasionally, when the

hemisphere containing the epileptogenic site is inactivated, a global amnesia ensues, i.e., the patient is not able to remember the memoranda pictures on either verbal recall or visual recognition testing. In these cases, the inference is drawn that the patient must be harbouring an additional (and possibly unsuspected) lesion of the mesial temporal region of the opposite hemisphere. The originally planned resection would then be clearly contraindicated under these conditions.

Blume, et al. (1973) have employed a similar procedure for their Amytal studies of memory "representation" and have used easily named shapes in addition to object pictures. Their results are difficult to interpret, however, because they do not report recall and recognition scores separately. These investigators have been concerned only with identifying possible global memory losses rather than examining the severity of material-specific memory deficits.

Gazzaniga (1976) has discussed observations similar to those reported by Milner while using the sodium amobarbital test to explore the "multiple neural coding" of memory. In Gazzaniga's procedure, only left-sided injections are given and these are administered only to nonaphasic

left-brain-damaged patients. During the right hemiparetic period, objects are placed in the patient's left hand for blind palpation. After recovery from the drug effects, Gazzaniga notes that the patient is generally unaware that anything was placed in his/her hand and verbal probing is typically unsuccessful in attempting to elicit recall of what it might have been. When presented with a recognition array which includes the memoranda objects, however, the patient can easily make the appropriate choices. Here again, it appears that the nonlanguage hemisphere is able to encode, store, and retrieve information without the necessity for linguistic processing, or even in this case apparently without conscious (verbal?) awareness. Gazzaniga interprets these observations as follows:

What we think is occurring here is that information stored in the absence of the language and speech system is not necessarily available to that system when it returns to normal functioning. It is as if the information is stored in neural code X whereas the normal neural code of language and speech is Y, the two being mutually exclusive.

(p. 64)

Up to the present time, there have been only a very

few studies using the Wada technique in which suggestions as to possible hemispheric specialization effects for NVM have been offered. Moreover, the evidence for the separate representation of NVM is mainly of an anecdotal nature in these reports. Here is a unique situation in which a great deal could likely be learned about the characteristics of NVM and yet not a single well controlled study has been published. Given the growing awareness of nonlanguage functions, more accurate estimates of NVM loss would seem to be essential also for neurosurgical decisions.

### Commissurotomy

Further data suggesting a right hemisphere "dominance" for NVM has come from the few studies which have explored mnemonic functions in patients with midline sections of the interhemispheric commissures. Milner and Taylor (1972), for example, used tactile (bent-wire) nonsense figures presented for blind palpation to a small group of split-brain patients. Each hand (and thus presumably each hemisphere) was tested separately in a delayed-matching procedure. Using the left hand only, almost all patients were able to effect accurate matches after delays of up to 2 minutes.

In the converse situation, delayed testing using the right hand only was not evaluated since most patients were unable to match to sample even at zero delay. Here it appeared that the isolated left hemisphere was not able to process this complex nonverbal material at all. Milner and Taylor concluded that this striking deficiency of the left hemisphere, when compared with the good performance of the nonlanguage hemisphere, argues strongly that verbal coding is neither necessary nor sufficient for the retention of this kind of configurational information.

Data corroborating Milner and Taylor's interpretation have been reported by Kumar (1977) using a smaller subset of the same commissurotomy patients, plus two additional cases, each having the splenium spared. Kumar developed tactile versions of the 15 designs from Graham and Kendall's (1960) Memory-For-Designs Test. In his procedure, each of the raised figures was presented in turn to the patient who explored it by touch only and then attempted to make an immediate reproduction by drawing it with the same hand. The designs were presented one at a time to the left hand first and then the sequence was repeated using the right hand only. The results showed that reproductions from memory were clearly superior when the memoranda were processed by the left hand and the right hemisphere.

A separate analysis of Kumar's results indicated that, although there was a trend in the predicted direction, the data for the partially sectioned patients did not show statistically reliable between-hand differences, suggesting that the right hemisphere may have been able to make some contribution to the right hand's performance in these patients. For the completely commissurotomized patients, however, the isolated left hemisphere was not able to adequately retain the configural information even

over the brief delays needed to accomplish the reproduction.

Although the right hemisphere greatly surpassed its left-sided counterpart in the performance of this task, the left hemisphere was able to show some partial retention of the designs, in contrast to Milner and Taylor's (1972) findings, where immediate matching-to-sample was not even possible. Kumar interpreted this partial success of the left hemisphere as due to the greater ease of finding meaningful relationships among the component lines of the relatively more verbalizable Graham-Kendall designs.

Taken together, these reports by Milner and Taylor and by Kumar offer preliminary evidence for the lateralization of NVM at least in the tactile mode of presentation. Although it would be interesting to compare the results from similar studies using visually presented memoranda, none appears to have been reported as yet. In fact, there have been surprisingly few attempts to explore memory functions of any kinds in commissurotomy patients. Virtually all the the work with this population in which visual nonverbal stimuli have been employed (e.g., Nebes, 1974; Levy, 1974), has been primarily concerned with examining perceptual asymmetries and retention

intervals have not been included in the procedures used. Other investigations which have been directly concerned with memory (e.g., Zaidel & Sperry, 1974) have presented the memoranda such that they are available to both visual fields and thus conclusions regarding hemispheric differences are unwarranted.

Considering the paucity of relevant work that has been produced to date and the obvious advantages of using commissurotomy patients as subjects, there appears to be a unique opportunity here for exploring the lateralization of mnemonic processes, especially if adequate measures of NVM can be devised.

### Electroconvulsive Therapy

Fifteen years ago, it was common clinical practice in treating depression to administer ECT bilaterally. Since that time, however, it has been repeatedly demonstrated (See D'Elia, 1970, for a good summary of the evidence) that unilateral administration is much more advantageous for the patient in terms of reducing undesirable concurrent effects. This development has led predictably, to a series of studies in which unilateral (speech) dominant (UD), unilateral nondominant (UND) and bilateral (BI) placements of electrodes were compared as to the type of memory disorders produced. Much of this work is relevant to the issue of hemispheric specialization for NVM and is also of interest because it illustrates a wide variety of approaches to the problem of measuring retention which is ostensibly unmediated by language.

Cohen, Noblin, Silverman, and Penick (1968) were among the first to explore the relationship between side of electrode placement and type of memory disorder and their prototypic design was adopted by many later investigators. Cohen et al. used a paired-associate procedure in which the patient was required to complete a previously presented design when shown only part of it during the

test phase. The actual designs used were not specified but the findings revealed that, in comparison to pre-ECT levels, performance on this task suffered more following UND-ECT than after UD-ECT. The data from a similar paired-associate task using words as memoranda showed the expected converse effect, while memory for both designs and words was impaired following BI-ECT.

In a more recent report from this group, Berent, Cohen and Silverman (1975) presented scores on the same measures taken from a new group of UD- and UND-ECT patients and have concluded that these data replicate their earlier findings. In this latter study, only one ECT session was given before testing as compared with the five treatment sessions that were administered in the Cohen et al. (1968) experiment. Although the pattern of the results remained consistent, the magnitude of the effects was decreased, however. Again, the UND-ECT group showed significant posttreatment deficits, as compared to their pretreatment level of functioning when the learning of unfamiliar designs was required. By contrast there were only slight and nonsignificant pre- to post-ECT changes in performance levels on this task seen in the UD-ECT group. The data from the word pairs test again revealed a complementary pattern. Here, right-

sided ECT was ineffective in eliciting pre- to posttest performance decrements, whereas left sided treatments produced significant negative changes.

In another of the early investigations of lateralized ECT, Halliday, Davison, Browne and Kreeger (1968) used the Rey-Davis pegboard (Zangwill, 1946) as a NVM test. This task requires that the patient remember the position of a single fixed peg on each of a series of boards which have as well a number of moveable pegs. The ability to do this spatial-position task was found to be compromised when patients who had received UND-ECT were tested a few days after the fourth treatment. Verbal memory was unaffected in these patients but was found to be selectively impaired in those who had received UD-ECT while the BI-ECT results again produced a double deficit pattern.

Miller (1973) used Kimura's (1963) Recurring Figures Test as a measure of NVM and found that smaller post-treatment deficits were observed following UD-ECT as compared with UND-ECT. Furthermore, these results were statistically reliable for both retrograde (memoranda presented before treatment) and anterograde (memoranda presented after treatment) effects.

D'Elia, Lorentzson, Raotma and Widepalm (1976) used a selection of verbal memory and NVM tests first developed

by Cronholm and his associates (e.g., Cronholm & Ottoson, 1963). In this study, patients were tested for recognition of 30 faces, geometric figures, and object pictures which were presented a few hours after the second or third ECT treatment. Facial recognition was found to be the only task on which performance deteriorated after UND-ECT in this anterograde design. This result was consistent for both immediate assessment of retention and for testing done after a 3-hour delay. The authors suggested that the geometric figures and the object pictures may not have shown a UND effect because they could all be easily coded verbally.

In a recent study, Patterson, Lawler, and Rochester (1978) developed a NVM task which used line drawings of common objects from several different categories as memoranda. Each category included five unique exemplars of that object (e.g., five different drawings of lamps). One drawing from each category was used as the memorandum while the other four were employed as the incorrect alternatives (canards) in a multiple-choice array. Since all drawings within a particular category would likely be given the same verbal label, it was expected that verbal encoding would not be a significant factor in mediating retention. When this test was given to a group

of patients receiving UND-ECT it was found that their performance on it was inferior to their performance on a similar recognition test using only verbal memoranda. This difference was not quite large enough to be considered statistically reliable, however.

Although virtually all of the data from these studies have been consistent in implicating UND-ECT as the cause of NVM deficits, there have been some negative findings reported. For example, two teams of investigators (Strain, Brunschwig, Duffy, Agle, Rosenbaum, & Bidder, 1968; and Cronin, Bodley, Potts, Mather, Gardner, & Tobin, 1970) compared the effects of UND- and BI-ECT on subsequent memory performance and concluded that neither of these treatments impaired NVM. Interestingly, both studies used Benton's Visual Retention Test as the measure of NVM.

Iversen (1977) has reviewed the unilateral ECT studies which have been concerned with retention and according to her interpretation, the results of this work support the material-specific view of memory functioning. She concludes,

The general consensus of evidence demonstrates that dominant ECT produces severe confusional and verbal memory deficits...albeit not as

severe as after bilateral ECT. Nondominant ECT does not produce equivalent impairment. In view of the evidence on unilateral temporal lobe lesions it should not be surprising to find that N-D ECT has no effect on verbal memory.... However, if appropriate and sensitive nonverbal tests are used, it can be demonstrated that N-D ECT does indeed produce anterograde amnesia as would be predicted from the surgical cases discussed earlier. (pp. 179-180)

Since "appropriate and sensitive" nonverbal tests are not widely available, the evidence for regarding nonverbal memory disorders as predictable sequelae of UND-ECT is not as extensive nor as unambiguous as is the case with UD-ECT and verbal memory disorders.

Robertson and Inglis (1977) have also provided an extensive summary and integration of the findings from studies which have compared the effects of lateralized ECT on memory functions. They conclude,

UND-ECT has been found to be associated with less post-treatment deficit than UD-ECT in performance on verbal tasks, whereas UD-ECT has typically been less detrimental than UND-ECT to performance on nonverbal tasks. (p. 293)

These authors (Robertson & Inglis, 1978) also attempted to directly vary the apparent verbalizability of stimulus types by using low-imagery nouns, high-imagery nouns, object pictures, geometric designs, and originally prepared random shapes as memoranda. These stimuli were chosen to represent successive points along a supposed verbal-nonverbal continuum. After UND-ECT, retention scores for the five types of material were found to be depressed (as compared to pretreatment levels) to an extent exactly predicted by the above ordering. Thus, memory for the abstract nouns declined the least while that for the random shapes was the most impaired. BI-ECT interfered with memory for all kinds of stimuli equally.

In summary, the unilateral ECT studies provide another source of evidence that the "silent" hemisphere is more critical for NVM than its more verbal counterpart. All of the studies are open to methodological criticisms of one sort or another, but the trend of the data is remarkably consistent. From a measurement viewpoint, the lateralized ECT studies nicely illustrate the extensive range of methods that have been used to tap NVM. Whereas, there is a great deal of similarity among studies in

terms of the verbal materials used (usually words), there is very little consensus as to what kind of task is the most appropriate measure of NVM. In addition, none of the studies cited included any rationale as to why the particular NVM task used was selected. Here, as in all other areas in which NVM has been assessed, the credibility of the method employed rests on face validity alone.

### Subcortical Stimulation

Two laboratories, one associated with George Ojemann and the other with Paul Fedio, have produced a lengthy series of reports dealing with the disruptive effects of memory seen during electrical stimulation of various subcortical sites. The patients in these studies typically have received multiple and chronically implanted electrodes and the behavioural observations are taken to assist in determining the most appropriate locations for coagulation as a treatment for various dyskinesias or chronic pain. One theme of interest in these investigations has been the comparison of stimulations at homologous left and right sites as to their effects on different kinds of memory tasks. While much of this work deals only with verbal memory, two studies in the series provide substantial evidence as to the laterality of NVM and also illustrate the authors' elegant measurement procedure.

Ojemann (1971) reported data from a single case in which an electrode implanted in the region of the right mammillothalamic tract and medial zonal incerta was stimulated at various times while the patient was performing a NVM task. Random shapes (from the series prepared by Vanderplas & Garvin, 1959) were used as memoranda and

were presented in a sequential recognition procedure during which the patient was required to indicate for each shape presented whether it had been shown before or not. The method also included a simultaneous matching-to-sample phase for each memorandum, as it was first presented, to verify that the patient did, in fact, perceive it accurately.

Results indicated that brief stimulations during this task disrupted performance significantly as compared to performance on a control task using verbal memoranda, in which no errors at all were made when the current was activated. More interestingly, the interference with NVM function was found to be very selective, occurring only when stimulation was administered during the initial presentation of the memorandum. When this was done, the patient was able to correctly identify a new memorandum shape as novel but was unable to recognize it as familiar when it was presented again, eight seconds later. When stimulation was administered instead during the recognition phase of the test, the patient had no difficulty in making the correct choice at that time. Furthermore, stimulation administered during the matching-to-sample phase did not prevent the patient from making the identity match correctly.

From these data, Ojemann concluded that perception and

retrieval functions are unaffected by this kind of stimulation and that its impact is to selectively disrupt the encoding or storage stage of the NVM process. It is noteworthy that this registration block has not been seen in previous studies of electrical stimulation of subcortical structures which have used verbal memory tasks (e.g., Ojemann & Fedio, 1968; Ojemann, Blick, & Ward, 1971). Thus, it appears that the effect may be specific to NVM.

Fedio and Van Buren (1975) used an adaptation of Ojemann's (1971) random shapes task to measure NVM in a group of patients receiving electrical stimulation at various subcortical sites. As before, the patient was required to first match to sample and then, a few seconds later, to find the same memorandum again among a new multiple-choice array which involved five canards. Those trials on which the patient was unable to match to sample correctly were eliminated from the analysis of memory performance.

Fedio and Van Buren found that stimulation of sites in the right pulvinar and right parietal white matter produced a comparable and highly reliable degree of impairment in the delayed recognition of these shapes. Current applied to homologous left-brain locations, while interfering with the recall of verbal memoranda (pictures

of common objects), did not produce a significant decrement in NVM. Stimulation of either left or right thalamic sites anterior and inferior to the pulvinar had negligible effects on random shape recognition. Considering these observations and those of previous studies, the authors suggest that, "An asymmetry in the functional organization of linguistic and nonverbal processes appears to exist at the level of the lateral thalamus" (p. 94).

### Subcortical Lesions

A few reports of unilateral damage to infrapallial structures have also contained suggestions that the neural representation of NVM may not be symmetrical. In these studies, data have been collected from patients who have long-standing and highly selective subcortical lesions, originally effected either by surgical intent or by accidental trauma.

Vilkki (1978) measured recognition memory for Holtzman inkblots in patients who had been given a ventrolateral thalamotomy or pulvinotomy. As compared with pre-operative levels, the number of correctly recognized memoranda decreased significantly after right thalamic coagulations but not after similar left sided lesions. This deficit was not apparent when recognition testing immediately followed presentation of the memoranda, but appeared only when a one-hour delay interval was introduced. As expected, recall of verbal responses made to each blot was impaired following left-sided thalamotomy but unaffected after stereotaxic right-sided ablations. No changes of any kind were seen in the post-operative performance of the right pulvinotomy group, although their lesions were typically more than twice the size of those made in the ventrolateral nucleus.

Vilkki concluded that these results argue for a functional differentiation between left and right thalamus, which is directly related to the pattern of cortical specialization. By contrast, this dissociation was not seen as extending to the level of the pulvinar. Here, the left pulvinar was found to contribute to verbal memory but no similar relationship was apparent between right pulvinotomy and NVM deficit.

In a companion article, Andersen (1978) reported a comparison of left and right amygdalotomy patients evaluated several months after treatment. As part of an extensive battery of tests, Andersen used one NVM task which assessed immediate and delayed (one hour) retention for "complex designs or Gestalts" (which were not described or illustrated). A unique feature of her procedure was the presentation of successive parts of the memorandum figure as prompts during the retention test phase. Using this method, she determined that there was no reliable change on the task pre- to postoperatively and that performance levels were not related to side of lesion.

Reports of accidental subcortical lesions which offer evidence as to the lateralization of NVM have rarely

been published. One carefully studied case, however, was first described by Teuber, Milner, and Vaughan (1968). This patient received a stab wound to the basal brain and although the precise location of the lesion could not be determined it appeared to be clearly left sided. The authors evaluated "N.A." using delayed reproduction of the Rey-Osterrieth figure (Osterrieth, 1944) and Kimura's (1963) Recurring Figures Test, as well as several measures of verbal memory. In summarizing their results, Teuber et al. observed, "It is clear that N.A.'s residual amnesia shows a marked asymmetry, verbal material being more difficult for him to retain than material that cannot readily be verbalized" (p. 278).

This patient has recently been re-evaluated (Squire & Slater, 1978) using a selection of verbal memory measures plus delayed reproduction of the Rey-Osterrieth figure. Also included was an adaptation of Corsi's (1972) task requiring memory for the position of a circle on a line after increasing delay intervals filled with distracting activity. The authors reported that again N.A.'s verbal memory was impaired to a greater extent than his NVM and concluded that this asymmetry appears to be a persistent feature of his amnesia.

Taken together, these few studies encourage the

supposition that the lateralization of mnemonic processes may extend relatively close to deep midline structures. Whether or not asymmetries are found appears to depend a great deal on which specific group of nuclei are rendered dysfunctional. Some portions of the right thalamus appear to be reliably involved in NVM processing while other right-sided thalamic areas do not seem to be similarly implicated. Clearly, work on this problem has only just begun and much attention must be paid to defining the site and behavioural variables more precisely. Of the three measurement tasks, procedures for lesion localization and verbal memory assessment are relatively well developed in comparison to our understanding of how to quantify NVM.

### Unilateral Brain Damage

In previous sections, NVM lateralization data have been considered from studies employing patients who have incurred lesions as a result of some form of medical or surgical treatment. In most of these procedures the extent of the tissue loss or dysfunction could be specified with some precision. This section surveys those studies in which NVM data have been collected from large samples of patients who have suffered from accidental cerebral damage. Here, the pathogenic factors are diverse (although cerebrovascular accidents appear to be the most common) and more importantly in these cases, the extent of the lesion is generally not well known.

Patients in these investigations are typically classified as left-hemisphere brain-damaged (LHMBD) or right-hemisphere brain-damaged (RHMBD) on the basis of neurological signs, sometimes supplemented with EEG, brain scan, or neuroradiological findings. In spite of the obvious criterion problems, most authors have been willing to accept the assumption that a patient classified by neurologists as having a unilateral lesion is likely to have an adequately functioning contralateral hemisphere. Most studies do not include those patients

with obvious signs of bilateral or diffuse pathology, however.

Implicit in these studies is the supposition that if NVM functions are in fact subserved primarily by the right hemisphere, then it should follow that patients with left-sided brain damage only should not be markedly impaired in their ability to remember materials which cannot be readily coded linguistically.

Although the neuropsychological literature is replete with studies comparing LHMBD and RHMBD groups, surprisingly few have considered the lateralization of NVM directly. Several reports have been offered, which contain data relevant to the issue and these are summarized here. In these works, the primary intent of the authors has not generally been to examine the question of right hemisphere "dominance" for NVM but rather to explain deficit performance on certain NVM tasks as a function of some other factor such as the presence of aphasia or a visual-field defect. Although the results of these analyses are included here where relevant to the lateralization question, more detailed consideration of the relationships between NVM and language disorder or visual-field defect is left for later sections of this monograph which deal with the issues of verbal mediation

and with perceptual determinants.

Curiously, many lines of work in NVM have evolved as geographically specific products. Whereas temporal-lobe investigations are primarily associated with the Montreal Neurological Institute and studies of NVM in Korsakoff patients have come, to a large extent, from the Boston area, virtually all of the unilateral brain damage research in NVM has a decidedly Italian flavour. In these studies, large groups of (presumed) unilateral brain-damaged patients are compared as to their performance levels on measures which the authors represent as having some potential for NVM encoding.

In one of the earliest investigations in this series, De Renzi and Spinnler (1966a) compared unilateral brain-damaged patients on a facial recognition task involving the selection of four previously presented faces from a large array with no delay interposed. On this measure, the performance of the RHMBD group was found to be consistently poorer than that of the LHMBD patients.

In a contemporaneous report, De Renzi and Spinnler (1966b) used pictures of common animals as memoranda and tested retention via immediate choice from an array and also by a continuous recognition procedure after a 60-second delay interval. On the non-delay task the LHMBD group

was significantly inferior to their right-sided counterparts and in the LHMBD group aphasics were the poorest of all. Since the memory scores and the aphasia test scores were uncorrelated, however, De Renzi and Spinnler concluded that the immediate retention of (verbalizable) visual pictures is related to a factor represented in the left hemisphere but not necessarily language. On the delayed memory task, although aphasic patients scored reliably below nonaphasic patients, there were no overall hemispheric differences and the authors' analyses indicated that performance on this delayed retention task was contingent instead upon the presence of visual-field defects.

Boller and De Renzi (1967) next reported data from two paired-associate tasks, one using common object pictures as memoranda and the other employing original "meaningless" figures, which were similar to, but simpler than those prepared by Kimura (1963). Contrary to the authors' predictions, the results revealed that LHMBD patients were inferior on both tasks and that efficient performance was reliably linked to the presence of aphasia. Boller and De Renzi concluded that their patients most likely tried to encode all memoranda verbally and thus, aphasics would be particularly

disadvantaged in this task.

In the same year, Boller and Spinner (1967) described an investigation of memory for colours using two different sets of materials. In both tasks patients were shown a colour memorandum and then, after a 10-second delay, were required to locate it again in a multiple-choice array. The tasks differed mainly in that the canards in the first task were of clearly different hues, whereas those in the second task were different "shades" of the same fundamental hue. The expectation that the first task would be verbally mediated, whereas the second would not be, was not supported by the data which indicated that LHMBD patients performed poorest on both measures. Further analyses revealed that within the LHMBD group, the presence of aphasia was not a significant factor in accounting for the performance deficit on either task. The authors concluded that the left hemisphere is "dominant" for colour memory and that this specialization exists independent of its linguistic functions.

De Renzi, Faglioni and Spinnler (1968) also evaluated memory for faces, both with and without an interpolated delay and determined that although RHMBD patients were reliably impaired on both these tasks,

this deficit was almost entirely accounted for by the visual-field defect factor. No analysis of the contribution of the aphasia covariant was included in this report.

In an integrative monograph, De Renzi (1968) summarized previous findings and reported on further extensions of this work. He described a previously unpublished experiment by Faglioni and Spinnler in which novel meaningless figures were prepared for use in a continuous recognition procedure. These figures appeared to be considerably more complex than those used by Boller and De Renzi (1967) and more comparable to Kimura's (1963) memoranda. In contrast to Boller and De Renzi's findings, this time RHMBD patients had significant difficulty with the task. Again, however, the presence of visual-field defects accounted for most of the variance and there was no analysis of the aphasia factor.

The next report to appear came from British investigators (Warrington and Rabin, 1970b) who also used a continuous recognition procedure but prepared four types of novel memoranda which were intended to minimize the influence of verbal labelling. Patients were required to recognize the re-occurrence of repeatedly presented dot patterns (both with and without a boundary),

meaningless shapes having the appearance of ink blots, and silhouettes of flowers. Results were reported only for all four tasks combined and on this measure there was no difference in total error score between LHMBD and RHMBD patients. Further analysis disclosed, however, that the right temporal-lobe lesion group produced a significantly higher false-negative error rate while a significantly higher false-positive error score was associated with the right parietal lesion group. The authors suggest that this latter group may have done poorly on the task because of perceptual difficulties whereas the impaired performance of the right temporal lobe group may be attributed to an unconfounded retention disorder.

Bisiach and Faglioni (1974) next used as stimuli the set of random shapes selected by Clark and Knoll (1969) presenting them individually and requiring the patient to select the memorandum from a multiple-choice array after an unfilled delay of five seconds. They found that LHMBD patients performed more poorly on this task (but only in the case of low association-value shapes). In addition, when Token Test scores were introduced as concomitant variables, the hemispheric effect disappeared (except for the visual-field defect interaction) thus suggesting, according to the authors at

any rate, that both language functions and the recognition of random shapes may be subserved by overlapping neural structures in the left hemisphere.

A year later, De Renzi and Nichelli (1975) adapted Corsi's (1972) block-tapping task to the study of "spatial span" in unilateral brain-damaged patients. Here, a similar random array of unmarked and identical cubes was used and the patients were required to reproduce increasingly longer strings of taps immediately after each had been presented by the examiner. The results showed that the laterality of a lesion was not a significant factor in explaining performance deficits on this task. Rather, it was the anterior-posterior dimension which was critical. Specifically, patients with retro-Rolandic injuries had reliably lower spatial spans than those with more anterior damage. In addition, the presence of aphasic symptomology did not influence the relationship, and this was found to be true even when separate comparisons were made by each diagnostic type (Broca's, Wernicke's, etc.). In attempting to explain this unexpected finding of lowered performance on the block-tapping task by (posterior) LHMBD patients, the authors suggested that this group may have been the most severely impaired in their ability to attend to the

presentation of the memoranda.

The block-tapping procedure was next expanded (De Renzi, Faglioni and Previdi, 1977) to include a delayed performance condition, in which immediate reproduction was followed by retention intervals of 8 seconds or 16 seconds during which the patient was either engaged in counting activity or allowed to remain silent. A single supraspan sequence was also presented repeatedly and the patient was required to learn it to a criterion of three successive errorless trials. After a 5-second delay, (s)he was then requested to reproduce this string of taps again. On the immediate span procedure, patients with retro-Rolandic brain damage were again found to be slightly but significantly impaired (relative to a normal control group this time) and the overall laterality factor was non-contributory. In the delayed conditions, either with or without a distractor task, the RHMBD group with posterior lesions was markedly deficient in comparison to both the LHMBD and the RHMBD groups with presumed pre-Rolandic damage and the right posterior group was also reliably less able to learn the repeated sequence. Moreover, increased forgetting of the supraspan string was found to be predicted by the presence of posterior lesions. The relationship between these deficits and

the presence of a language disorder was not examined in this report.

Benton, Hannay and Varney (1975) devised a NVM task in which the patient was presented briefly with a straight-line memorandum which could be oriented at any one of the 18-degree steps around the arc of a semi-circle. After a 2-second delay interval, the patient was required to select the previously shown line from an array illustrating the 11 possible orientations. In a second version of the task, two memoranda lines were presented simultaneously. The authors determined that RHMBD patients performed reliably worse (on both tasks) than LHMBD patients and that the latter group of subjects was not distinguishable from normal controls.

In a recently reported study, Gainotti, Caltagirone, and Miceli (1978) presented single designs taken from the Raven Coloured Progressive Matrices and required their patients to locate each memorandum again among an immediately following array of similar stimuli. LHMBD patients were discovered to be slightly but significantly poorer than RHMBD patients on this task. Further analyses confirmed that performance deficits were reliably associated with visual-field defects and even more likely to occur in the presence of a language disorder.

In summary, this series of studies over the past several years has suggested that RHMBD patients are relatively impaired only on NVM tasks which include such memoranda as faces, line slants, and complex "meaningless" figures. On the other hand, LHMBD patients have been found to be reliably poorer on a wide range of ostensibly NVM measures, including immediate memory for object pictures, and the delayed retention of such memoranda as simple "meaningless" figures, "verbalizable" or "non-verbalizable" colours, random shapes, and Raven designs. Finally, no significant differences between the unilateral brain-damaged groups were revealed by tasks involving delayed memory for object pictures, or both immediate and delayed block tapping.

It is difficult to estimate the value of these studies as contributions to the resolution of the laterality of NVM issue. Prima facie, it appears that the weight of the evidence favours the left hemisphere as the most likely seat of NVM function. An equally plausible conclusion, however, would be that these results serve to separate the truly NVM tasks from those that are, in fact, linguistically mediated. The likelihood of this possibility is enhanced by the observation that performance on most tasks which showed a left hemisphere dependence was even

more depressed by the presence of aphasia.

The occurrence of visual-field defects in many of these patients similarly confounds the issue. The procedures used do not permit the investigator to decide whether deficit performance is due to perceptual or mnestic factors.

It seems clear that the question of hemispheric specialization for NVM cannot be addressed successfully by unilateral-lesion studies until some basic measurement problems are resolved. Among the difficulties which must be overcome are first, the matter of independently defining in some way what is meant by the term "NVM" and secondly, the problem of operationally dissociating perception from memory.

### Hemifield Presentations

Since Mishkin and Forgay's (1952) seminal report there has been a spate of work exploring various performance differences, in normal subjects mainly, following presentation of stimuli to the left visual field (LVF) or the right visual field (RVF). The hemispheric specialization hypothesis, advanced by Kimura (e.g., 1966) and others to account for these performance differences, has similarly provided impetus for studies of this type and especially for investigations in which verbal and nonverbal materials are compared. Needless to say, methodological problems abound here. White (1969, 1972) has provided incisive critiques of the earlier work but no one, apparently, has attempted a review or synthesis of the more recent data. Several authors (e.g., Marshall, 1973; Colbourn, 1978) continue to elucidate measurement problems, however.

Much of the visual field asymmetry work would seem to be of potential interest here insofar as it deals with stimuli which are represented as being "nonverbal" and in that it is concerned (ostensibly at any rate) with hemispheric differences. The hemifield literature is not of primary relevance to this survey, however, because virtually all of it is concerned with perception rather

than memory per se. Most of the various presentation paradigms employ either a concurrent matching task or one in which the subject's response immediately follows removal of the stimulus. In neither case is there an appreciable retention interval. While the results of these studies may be of interest in explaining hemispheric asymmetries in the perception of nonverbal materials, they do not appear to be directly useful as evidence regarding the lateralization of nonverbal memory.

Some of the hemifield investigations, while not directly applicable to the hemispheric specialization of NVM question, do provide insights regarding the relationship between perception and NVM, and those that are relevant are included for consideration in the following section dealing with this topic.

There have been a few visual half-field studies, using nonverbal materials, in which some appreciable delay has been deliberately interposed between the presentation of the stimulus and the demand for a recognition response. In these instances, the stimulus can legitimately be regarded as a memorandum. These reports are considered here both because of the evidence they provide as to the lateralization of NVM and to illustrate the approaches to measurement that have been used.

Dee and Fontenot (1973) appear to have been the first to directly investigate the effects of substantial retention intervals in the visual half-field paradigm using nonverbal memoranda. They chose high- and low-complexity random shapes from Vanderplas and Garvin's (1959) series and presented these in either the LVF or RVF at very brief durations. After a delay of zero, 5, 10, or 20 seconds, the subject was shown a test stimulus and required to make a same or different judgment. In one condition, the delay interval was unfilled and in another the subject was asked to study additional random shapes which were continually presented. The results, collapsed across the delay factor, indicated that when the shapes were presented in the LVF they were remembered better than when they were presented in the RVF. More interestingly, this LVF superiority was negligible at zero delay and increased markedly as the retention interval was lengthened. The same pattern of results was found, moreover, regardless of whether the distractor task was used, but was present only for high complexity shapes. The authors argued that the supposed right hemisphere superiority in processing nonverbal forms such as these, arises from hemispheric differences in memory rather than in perception.

Hannay, Rogers and Durant (1976) used the same set of random shapes and a similar procedure but included only a 10-second delay interval without a distractor task. Contrary to Dee and Fontenot, these investigators found a RVF superiority for both high- and low-complexity memoranda. In interpreting their findings, they concluded that there does not appear to be any readily available explanation for this discrepancy.

A recent report by Birkett (1978) completes the possible range of outcomes for this type of study. Here, high complexity random shapes were also used in a similar procedure with a 10-second unfilled delay interval followed by selection from a multiple-choice array. Using accuracy on the delayed recognition test as the criterion, Birkett found his subjects to be about equally divided in terms of visual field superiority. Thus, no memory advantage was found to follow brief presentation of the memoranda to one visual field or the other.

Turning to a different kind of nonverbal material, Malone and Hannay (1978) investigated memory for colours in four experiments using the tachistoscopic laterality paradigm. In all of these explorations, colour memoranda were presented briefly to one visual field or the other followed by a delay interval of either 1.6 seconds or

10 seconds and then a comparison stimulus was presented. The incorrect alternatives (canards) differed, in either hue or saturation, from the memorandum and the four tasks were designed such that they represented successive points along a continuum of supposed ease of verbal mediation. Thus, the first task could be adequately performed by using only the verbal labels associated with each memorandum, whereas this was the most difficult in the fourth task. Malone and Hannay discovered a significant RVF superiority in the first two experiments and no reliable visual field differences in the latter two studies. Although recognition was more accurate overall after the shorter delay interval, there was no interaction between duration of retention and field of presentation. The authors concluded that there was no evidence for right hemisphere specialization in any of these "nonverbal" memory tasks.

Although there have been only a very few studies which have attempted to investigate NVM following hemifield presentation of the memorandum, the results that have been obtained so far nicely parallel those seen when perception has been the primary focus of interest. In reviewing those reports (in which retention intervals were negligible) White (1969) concluded,

Thus, a functional asymmetry of the sort observed with various auditory inputs does not seem apparent when visual--verbal and nonverbal--material is used....Certainly, no definite LVF superiority has been observed with the presentation of either geometric or nonsense forms.

(p. 401)

Studies published over the last 10 years do not appear to have changed this conclusion significantly.

Besides the inconsistent pattern of evidence, there are methodological problems here as well. The addition of a memory component further complicates inferential dilemmas already inherent in the hemifield presentation paradigm. Since any appreciable delay between the presentation of a memorandum and the test of retention allows for the possibility of inter-hemisphere communication of information in the intact brain, it is not clear how this paradigm could be used to measure hemispheric differences in memory (of any kind), unconfounded by perceptual determinants.

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### Conclusions

The reports surveyed in this review of cerebral lateralization for NVM encompass a wide range of patient populations and of measurement ideas. In spite of this variability, there is a fairly consistent pattern evident. In its broadest outlines, this relationship may be stated as follows: Memory for certain kinds of visual stimuli, which appear to be difficult to describe in words, is impaired if right-brain structures are rendered dysfunctional. Patients displaying this particular kind of disability are typically able to demonstrate adequate retention when verbal stimuli are substituted in formally similar tasks. Furthermore, patients with temporarily or permanently dysfunctional left-brain structures are generally able to adequately retain and retrieve the information contained in the nonverbal memoranda which their right-sided counterparts find so difficult to remember. Milner's material-specific hypothesis, originally proposed to explain the differences between the memory disorders of left- and right-temporal-lobe patients, has thus been confirmed with several other kinds of patient populations and extended to

include many new types of nonverbal memoranda.

Not all of the results have supported the supposition that the right hemisphere is prepotent for the processing of nonverbal information over time, however. If the hypothesis is in fact true, negative findings may be explained in one of two ways. Firstly, those right-sided neural mechanisms which are critical for the retention of nonverbal information may not have been affected by the supposedly disabling trauma. This outcome may be expected to occur frequently in patient groups, such as those with ostensible unilateral-brain pathologies, in which the exact extent of the lesion is generally unknown.

Secondly, a right-hemisphere effect would not be found if the tasks used were not sensitive and appropriate measures of NVM. If the "nonverbal" memoranda could, in fact, be verbally coded then both left- and right- brain-dysfunctional patients may be able to achieve normal levels of performance, albeit through the use of different strategies. The patients with left-brain lesions may be able to process the memoranda nonverbally and the patients

with right-brain lesions may be able to employ verbal mediation successfully.

A serious fault with many of the studies reviewed here is that the descriptions given of the materials is too meagre to allow for even a subjective estimate of the potential for verbal coding. Often, the stimuli used are described only very briefly, in words, and are not illustrated. In these situations, we have only the authors' assurances that the memoranda cannot readily be transposed into linguistic symbols. This problem is particularly acute in those studies in which original or idiosyncratic materials are employed. If these are not portrayed or specified in sufficient detail to allow for some evaluation of the verbal mediation possibility, the results are of little value as evidence regarding NVM.

Whereas there is a great deal of similarity among studies in terms of the verbal materials (usually words) employed as comparison memoranda, there is very little consensus as to what kinds of stimuli are the most appropriate for the measurement of NVM. The studies reviewed here illustrate the extensive range of methods that have been used to tap NVM but none of the reports cited have included any rationale as to why the

particular NVM task used was selected. In each case, the credibility of the method rests on face validity alone. It seems clear that the question of hemispheric specialization for NVM cannot be addressed successfully until some way is found of independently defining what is meant by the term "nonverbal".

CHAPTER FOUR: CURRENT ISSUES IN  
NONVERBAL MEMORY

In the following sections, several problems with and questions relating to the general concept of NVM are considered. The difficulties that have been raised regarding the idea of NVM as a separate entity range from those which, if accepted, would deny its existence entirely to those which acknowledge its usefulness as a construct but are concerned with how it should be related to other cognitive processes.

### Modality-specific Memory Disorders

Although there is much agreement that memory is not a unitary function, some theorists have eschewed the verbal-nonverbal dichotomy and have preferred instead to fractionate the construct along sensory modality lines. Much of the early information-processing work, for example, appeared to indicate that memory possesses modality-specific characteristics. Thus, this idea became incorporated into general models of memory, such as that proposed by Atkinson and Shiffrin (1968), in the form of separate auditory and visual STM stores.

Innumerable studies within the verbal memory tradition have compared inputs from different modalities as to their effects on retention. Those reviewing these findings (e.g., Penny, 1975) have generally concluded that there is a slight but consistent superiority in the retention of materials presented via the auditory channel, as compared to formally similar memoranda presented visually.

Others who have reviewed the evidence from special populations, have come to a similar conclusion. Craik (1977), for example, surveyed the modality-specific work done with the aged and interpreted these results as indicating that memory for auditory presentations remains intact longer than that for visually presented memoranda.

When more clearly impaired populations are considered, the evidence supporting an auditory/visual dissociation seems to be even more persuasive. Surveying the data regarding this question that has been collected from amnesic patients, Warrington and Weiskrantz (1973) conclude simply, "There are strong reasons for postulating the existence of modality-specific short-term memory systems" (p. 391).

When verbal memoranda only are being considered then, it appears that sensory modality may be a potent factor in influencing retention. But is this the case with the NVM system? Perhaps not surprisingly, few studies have directly considered this question. Those from which some relevant data may be gleaned have generally been designed with one of two intentions in mind. The first of these has been to determine if patients showing NVM disorders, when assessed using one mode of presentation, will also demonstrate impairment when similar nonverbal materials are presented via another sensory mode. A second and related approach has been to present amnesic patients with both verbal and nonverbal memoranda, each in different modalities, and to determine whether the pattern of deficits seen is more modality- or more material-specific.

At issue here is the generality of the NVM concept. If patients with visual NVM disorders can be shown to be similarly impaired in other modalities, then NVM may be seen as a robust construct. If NVM disorders are limited to only one modality, however, this interaction creates difficulties in interpretation. It may be, as some have argued, the visual nature of the memorandum, rather than its degree of "verbalness", which is the important characteristic in determining whether or not a patient will remember it.

Luria (e.g., 1976) was one of the chief proponents of the modality-specific view. He argued that memory deficits may be either global or modality-specific, and amassed a congeries of clinical observations illustrating various auditory and visual memory "syndromes". Virtually all of his investigative methods employed only verbal memoranda, however. In spite of the extensiveness of his writings on memory, he almost completely omitted any reference to NVM (or to right-hemisphere functions in general, for that matter). Nevertheless, he characteristically offered his opinion: "We still know very little about the nature of memory disorders arising in lesions of the lateral zones of the right temporal region, but there is no doubt that they also are modality-specific

in character in their own way" (Luria, 1973, p. 298). In general, Luria (e.g., 1975) saw these modality-specific memory disorders as being more akin to perceptual/gnostic processing disorders rather than as "true" disorders of memory which he felt were only found in the global patterns of loss seen with subcortical lesions.

In Milner's original formulation, material-specific memory disorders were seen as independent of sensory modality:

Thus, left anterior temporal lobectomy in the dominant hemisphere for speech causes a lasting impairment in memory for verbal material... regardless of whether auditory or visual presentation is used and regardless of the precise testing technique....Conversely, right temporal lobectomy has been found to impair memory for both visual and auditory patterned stimuli to which a verbal label could not be readily assigned. (Milner & Teuber, 1968, p. 330)

Milner and her associates assembled a substantial quantity of evidence to document the fact that the verbal memory disorders seen following left temporal lobe lesions occurred regardless of the sensory channel used. Support for the modality-independent nature of NVM

deficits, however, was much more equivocal. The original basis for extending the assertion to the non-verbal situation came from observations that the same right temporal lobectomy patients who had been shown to be impaired in visual NVM were also deficient in performing some auditory NVM tasks, such as remembering changes in melodic pattern (Milner, 1962) and in recognizing briefly presented excerpts from instrumental music (Shankweiler, 1966). Other studies which used more carefully matched inter-modal comparisons yielded mixed results, however.

Meyer (1959) constructed procedurally similar paired-associate tasks using the visual and tactile modes for the presentation of "designs" (unspecified) and found that right temporal lobectomy patients were not impaired on either of these measures. By contrast, left temporal-lobe patients were discovered to be deficient in remembering auditorially presented, but not visually presented words, using the same procedure.

Kimura (1963) had previously demonstrated that right temporal lobectomy patients were significantly impaired on a task requiring visual recognition of meaningless figures. However, when the same procedure was used with auditory inputs (bird and insect noises), these patients were found to be no more impaired than left temporal -

lobectomy patients (Milner & Teuber, 1968, p. 346). Corkin (1964) next developed a tactile version of the same task using bent-wire figures and again found no differences in performance between left and right temporal lobectomy patients. Thus, when this recurring stimulus procedure was used, NVM disorders were found only in the visual modality, after comparisons using closely matched auditory and tactile analogues.

A subsequent series of studies, however, illustrated that right temporal lobectomy patients were impaired as compared to left temporal lobectomy patients in learning a stylus maze and that this deficit was present regardless of whether the task was attempted visually (Milner, 1965) or tactually (Corkin, 1965).

In one of the few relevant temporal lobectomy reports not produced by the Montreal group, Samuels, Butters and Fedio (1972) found that both right and left temporal lobectomy patients evidenced severe retention deficits on a test of auditory-verbal STM but that normal performance was seen on two visual tasks, one verbal and the other using geometric figures as memoranda. The authors concluded that there are thus modality-specific anatomically-separate short term stores for auditory and visual inputs and that these

stores operate regardless of whether the memoranda are verbal or nonverbal. No direct comparison of auditory nonverbal versus visual nonverbal memoranda was actually made in this study, however.

Investigators have seldom considered information derived from senses other than sight, hearing, and touch. Patten (1972b), however, evaluated recognition memory for tastes and smells in a sample of patients with various types of brain damage and reported that NVM in these two modalities was often relatively well preserved in cases showing impairment in recognition memory for faces.

One of the few studies to directly test the material-specific versus modality-specific hypotheses was reported by Butters, Lewis, Cermak, and Goodglass (1973). These investigators explored the coincidence of memory disorders in a population of Korsakoff patients using both verbal and nonverbal memoranda, each of which were seen, heard, and felt. The materials intended to be nonverbal were computer-generated random shapes, sequences of five random piano notes, and "unfamiliar" tactile figures. All tasks employed the same procedure involving the presentation of a single memorandum, a delay interval of zero, 9 or 18 seconds and then the presentation of a test stimulus for a same or different judgment. A counting

backwards task was used during the delay intervals to prevent rehearsal. The results were remarkably consistent; in all three modalities the Korsakoff patients demonstrated normal NVM but severe memory deficits for verbal materials.

In a follow-up study, De Luca, Cermak, and Butters (1975) compared the effects of auditory versus visual distractor tasks employing nonverbal materials (musical tones and snowflake figures) on the retention of random shapes. The reasoning here was that if NVM has in fact modality-specific characteristics, it would be expected that a visual distractor task would interfere more with the retention of visual memoranda than an auditory distractor task would. These authors found no difference between the two types of interfering activity, however. Further investigation disclosed that the Korsakoff patients did just as poorly with no distractor task at all, suggesting that the task used to measure NVM may have been just too difficult to reveal any kind of interference differences.

More recently, Strauss and Butler (1978) have shown that distractor tasks can, in fact, create more potent interference effects when these activities require use of the same modality as that used for the memoranda

presentation. These authors used tactile nonverbal memoranda (irregularly shaped wooden blocks) and found that in their sample of Korsakoff patients, retention of these forms was most severely impaired when the interfering task was also tactile (as opposed to auditory) and that this relationship held regardless of whether the distractor task employed verbal or nonverbal materials.

Finally, some support for the modality-specific position, in terms of the initial stages of processing at least, can be found in the visual half-field studies with normal subjects. Here, according to White (1969), modality differences interact with type of material to determine processing lateralities: "A relationship between cerebral dominance and locus of auditory stimulation has been fairly well demonstrated; the same cannot be said for a relationship between dominance and visual stimulation" (p. 401).

This potpourri of data and opinion regarding the question of modality-specific effects in NVM is probably of limited evidential value. Few studies have considered the critical question directly and much of the information available has come from experiments in which modality comparisons were of secondary interest or even incidental to the main hypotheses.

Most frequently, studies purporting to compare NVM in different modalities have used quite dissimilar procedures and types of materials. It appears obvious that conclusions regarding modality comparisons can be valid only if the modality is the sole factor allowed to vary. Whereas this condition is quite easily met when verbal memoranda are used (the same word can be seen, heard, or even felt) exactly how a similar kind of control can be achieved in the case of nonverbal materials is not at all clear. Without some assurance that NVM tasks in different modalities are formally similar in terms of type of materials and procedure, however, any differences seen among them may be attributable to variations in overall task difficulty, for example, or to other variables.

It may be that the reason it is easy to design similar tasks in different modalities with verbal memoranda is simply that all input of this kind is quickly converted to the same (linguistic) code. The various sensory presentations may thus be just superficially different representations of the same basic symbols. Since there does not appear to be a common nonverbal code, however, (or perhaps we are just not aware of it as yet) each type of NVM task may be unique. Thus, it may not be possible to make formally similar inter-modal comparisons within this

"system" at all.

Here again, we need to know a great deal more about the possibilities for measuring NVM before questions such as these can be answered. By judicious selection of task parameters it may be possible in fact, to develop methods by which the inter-modal comparability demand can be met. Although it may not be feasible to devise an auditory task which is directly comparable to facial recognition, it is possible to conceive of auditory and even tactile analogues of say, flicker rate as a memorandum. Before beginning to investigate the modality-specific issue with any precision, much effort will likely be needed to develop a broad range of NVM measures within several different sensory modes.

Perceptual Determinants of Nonverbal Memory

Our findings suggest that in memory tasks the human subject tries, whenever possible, to convert meaningless patterns into meaningful ones, which too can be mastered by the use of verbal tags....On the other hand, when the patient has to rely entirely on perceptual clues in building up the trace, the importance of the right hemisphere comes to the fore. In such cases, however, the effect of memory may be conceived as simply enhancing a hemispheric asymmetry already existing at the very moment of perception. (De Renzi, 1968, p. 187)

De Renzi and the Milan group accepted the material-specific hypothesis, but argued that the performance deficits seen were actually due to perceptual impairment and were not true memory disorders at all. Support for this interpretation has been derived from several studies in which patients with visual field defects (VFD) have been found to be disproportionately impaired on NVM tasks. In a series of reports, right-hemisphere brain-damaged (RHMBD) patients were found, as expected, to be significantly poorer than left-hemisphere brain-damaged

(LHMBD) patients on NVM tasks such as facial recognition (De Renzi & Spinnler, 1966a; De Renzi, Faglioni & Spinnler, 1968), identifying recurring meaningless figures (De Renzi, 1968), and block-tapping reproduction (De Renzi, Faglioni, and Previdi, 1977). When the presence of VFD was introduced as a covariate, however, the hemispheric differences disappeared in each instance. These analyses thus indicated that it was only those RHMBD patients with VFD who were actually deficient on these measure of NVM.

De Renzi's results raised possibilities which were difficult to incorporate within the traditional (i.e., Milner's) view of impairment on NVM tasks. Since VFD are almost invariably sequelae of posterior cerebral damage, the association between anterior/posterior locus of lesion and impaired performance on these tasks is the converse of what would be expected if memory was indeed the critical factor. The finding that many RHMBD patients (i.e., those without VFD) do not show decrements on several NVM tasks suggests that here also the role of more anterior right hemisphere structures may not be as prepotent as Milner's studies have suggested.

The conflict between the two positions is further illustrated by De Renzi et al.'s (1968) report that in the right-hemisphere VFD group, memory for faces was

impaired on an immediate recognition test as well as after a delay. This result contrasts sharply with Milner's (1968b) observation that in her right-hemisphere-lesioned patients, facial recognition deficits showed up only when testing occurred after a delay interval.

The presence of a VFD has also been shown to be a significant factor in accounting for results of several studies, using ostensibly NVM tasks, in which RHMBD patients have not been the more impaired. Thus, patients with VFD were found to have reliably greater difficulty in remembering "nonverbalizable" colours (Boller & Spinnler, 1967), and Raven figures (Gainotti, et al., 1978), both of which were more poorly retained by LHMBD patients overall. In addition, the VFD factor also accounted for a significant percentage of the variance in tasks such as the delayed recognition of high association-value random shapes (Bisiach & Faglioni, 1974) and block-tapping reproduction (De Renzi & Nichelli, 1975) in which no overall hemispheric differences in performance emerged.

Of all the work of De Renzi and his colleagues using NVM tasks, apparently only one study (Boller & De Renzi, 1967) has been reported in which the presence of VFD was not found to influence the results. In this investigation, patients were required to remember

"meaningless" figures presented in a paired-associate format and interestingly, here it was the presence of aphasia which was reliably linked to deficit performance.

The bulk of the evidence from the Milan group therefore, clearly implicates the presence of VFD as an important factor in explaining performance deficits on NVM tasks. Moreover, this factor may interact with the effect of either left- or right- brain damage in lowering retention scores, or it may operate in a manner orthogonal to the pattern of hemispheric differences.

One problem in interpreting these findings is that a somewhat inconsistent criterion has been used to define "VFD". In the earliest studies (e.g., De Renzi & Spinnler 1966a) the authors spoke of the presence of hemianopsia as the defining characteristic, while in other investigations any kind of field defects, as measured by "confrontation testing" served as the criterion. More ambiguity has been introduced into the later work (e.g., De Renzi & Nichelli, 1975) where those patients having radiological evidence of a posterior lesion were included for analysis in the VFD group, even if their fields were intact on assessment! More recently (e.g., De Renzi, et al., 1977) patients with signs of hemi-

inattention have been excluded from the study altogether. The most conservative interpretation of the "VFD" factor would seem to be to regard it as simply indicative of a high probability of retro-Rolandic pathology.

The simplest explanation of the VFD findings is that some patients with posterior lesions just do not "see" the memorandum when it is initially presented and therefore fail on a later test of retention. De Renzi and his associates have argued (e.g., De Renzi & Spinnler, 1966b), however, that these patients are not significantly impaired, relative to controls, in simply identifying visual stimuli when no demands on memory are made. In a lengthy series of studies employing nonmemory procedures (e.g., De Renzi & Spinnler, 1967; Basso, Faglioni & Spinnler, 1976) VFD patients have been shown to be particularly at a disadvantage, however, when complex perceptual discriminations have been required. De Renzi et al. thus reject the "crude" visual defect hypothesis for a more refined alternative:

Thus, at least for the right hemisphere patients, a simple defect of recognition is untenable. The perceptual hypothesis, however, may be restated in other terms: patients with V.F. defects suffered from a subtle

impairment in perception, which did not prevent recognition, but was sufficient to determine a weak memory trace. Recall after a few seconds was not affected, but, when the demands on trace-activity were increased, i.e. when visual stimuli had to be recollected after a longer time interval, the defect emerged. (De Renzi & Spinnler, 1966b, p. 334)

Here, the authors argued that "visual impairment", means something more than just selective blindness, viz., a higher-order processing failure which blocks the normal course of registration and storage, making later retrieval impossible. This position is actually just one variation on a theme which recurs frequently in the ongoing theoretical debate regarding the basic nature of memory. The most popular current representation of this thesis may be seen in Craik and Lockhart's (1972) view of memory as a byproduct of the depth of perceptual analysis.

The perceptual hypothesis has been considered here in some detail because it has important methodological ramifications. Specifically, it leads to a particular kind of definition of what makes a NVM task "nonverbal". Whereas most others (e.g., Milner & Teuber, 1968) have

emphasized that unfamiliarity and/or the nonverbalizable nature of the stimuli are the critical factors (at least in eliciting inferior performance in RHMBD patients) the Milan workers (e.g., De Renzi, Faglioni & Spinnler, 1968) have consistently maintained that it is the perceptual complexity of the materials that is the crucial characteristic. Thus, patients who fail on these tasks do so because subtle discrimination and integration of visual cues is required and these individuals are particularly handicapped in their ability to detect small formal differences.

Interestingly, in the one study (Bisiach & Faglioni, 1974) in which the perceptual complexity factor was systematically varied (high vs. low complexity random shapes), no interaction with the VFD factor was found, although as expected, patients with VFD did more poorly than patients without these defects when the scores were collapsed across complexity levels. More surprisingly, LHMBD patients did the poorest on this task and the presence of VFD plus high association value covaried to predict poor performance. The authors concluded that these results do not lend themselves to a "straightforward" explanation.

Curiously, those non-Italian workers who have

evaluated the relationship, have not found a similar association between VFD and impaired performance on NVM tasks. Milner (1968b), for example, reported no relationship between extent of VFD and performance on a delayed facial recognition test. Similarly, Benton, Hannay and Varney (1975) found that the presence of VFD did not predict difficulty in remembering the slope of briefly exposed lines. As expected, in both of these studies, RHMBD patients were more severely impaired than their left-sided counterparts.

Other studies which have not considered the VFD factor directly, but which have examined the effects of anterior versus posterior lesions in the right hemisphere have also produced results inconsistent with the Milan hypothesis.

Warrington and Rabin (1970b), for example, used a series of memoranda including dot patterns, "meaningless" shapes, and silhouette drawings of flowers, presenting each in a recurring stimuli procedure to groups of patients with unilateral lesions. Although no reliable intrahemispheric differences in overall performance levels were found, a further analysis by type of error revealed a clear double dissociation between right temporal and right parietal patients, the former making

significantly more false-negative errors and the latter making significantly more false-positive errors. Since the right parietal group was also specifically impaired on a purely perceptual measure as well (Warrington & Rabin, 1970a), the authors made the interpretation that the basis for the performance deficit in this group was perceptual while that of the right temporal-lobe group could be considered to be due to memory loss. They further suggested that their results argue for the separate representation of perception and retention of visual materials.

Methodologically, the significant issue in all of this work is that inferences regarding retention of a memorandum are of little value unless there is some assurance that registration of that same memorandum has occurred. None of the studies reviewed here provide this kind of control and thus their data are confounded, making it impossible to resolve the question with the procedures they have used. Certainly, some RHMBD patients have sensory and/or perceptual impairments which will reduce their ability to perform successfully on NVM tests simply because they will not be able to form a veridical percept of the memorandum. Any method which purports to be a measure of memory must first provide a

way to determine if the input phase has been accomplished successfully. In those cases where registration cannot be verified, any further attempts to assess retention are meaningless.

In the reports considered so far in this section, the authors have all used similar strategies in drawing inferences regarding the adequacy of perceptual functions in the patients they have studied. In one type of analysis, results from separately administered tests of perceptual matching or identification have been compared with those from memory measures to estimate the effect of registration deficits. By entering VFD as a covariate, De Renzi et al. have similarly used a post-hoc, statistical-analysis approach to controlling the perceptual factor. A more compelling way to separate perception and retention, however, can be achieved by methodological rather than statistical means.

If tasks are designed appropriately, determinations regarding the adequacy of perception can be made for each patient on each memorandum presentation. This tactic is more elegant, of course, in that it allows the investigator to avoid the error variance produced by group comparisons. In effect, in the statistical-separation approach, the investigator tries to estimate the amount

of influence that perception has on memory by measuring perception and memory together, by measuring perception separately, and then by subtracting the latter from the former. If tasks can be devised such that memory and perception, for the same memorandum, are evaluated separately, a much more powerful analysis will be possible.

Further evidence as to the relative importance of the "storage" as opposed to the "registration" aspects of information processing in NVM tasks has come from those studies in which retention is measured immediately after presentation and compared to a similar assessment following some delay interval. Taylor's (1969) work with the Rey-Osterrieth figure is representative of this approach. Here, right temporal-lobectomy patients were found to be relatively unimpaired, as compared to normal controls, on an immediate reproduction test, but their level of performance dropped disproportionately when required to draw the figure from memory again 40 minutes later.

Similarly, Dee and Fontenot (1973) presented random shapes to normal subjects using a hemifield procedure in which they varied the delay interval between memorandum presentation and the presentation of the comparison

stimulus for a same-or-different choice. No reliable visual field differences were found with the minimum delay but as the retention interval increased toward a 20-second duration, a left visual-field superiority became more apparent. Thus, the authors argued that the apparent dominance of the right hemisphere in processing nonverbal information is due to memory rather than perceptual factors.

An alternative way to explore the relationship between perception and memory is to vary the duration of presentation of the memorandum and then to observe the effect of this manipulation on subsequent accuracy of retention. This approach is illustrated by Dale's (1973) report in which the position of a single spot in a blank square had to be reproduced after a variable delay interval. Although presentation times as brief as .5 seconds were found to be adequate if the reproduction was requested immediately, with longer delay intervals (up to 64 seconds), longer presentation durations produced higher rates of accuracy. The presentation-time function appeared to reach an asymptotic level at about three seconds, however. Dale interpreted these results as indicating that there is a considerable difference between the time required for perception and

that required for memorization.

In studies such as these, the implicit assumption is made that memory measured after a short retention interval is somehow more under the control of perceptual determinants than memory measured after a longer interval. Whether or not this is true, this design only permits the comparison of one memory performance with another and offers no direct evidence regarding the adequacy of perception if performance on the brief retention interval test is poor. Again, the most direct approach is to measure perception first and then to assess memory for the same information.

Some additional support for the view that NVM performance deficits are indeed mnemonic, rather than perceptual, failures comes from Milner's finding (e.g., Milner, 1974) that the severity of these impairments, for some kinds of nonverbal materials at least, is directly proportional to the amount of hippocampal tissue excised. This argument rests on the fact that there is little evidence which suggests that the hippocampus is intimately involved in perceptual (i.e., nonmemorial) processing, whereas its participation in storage/retrieval processes is well documented (e.g., see Isaacson & Pribram, 1975). Although this notion is widely accepted, the reasoning

here is somewhat circular and a more direct test of these assumptions is not possible without methods which allow for the measurement of memory unconfounded by perceptual factors.

The position that perception and memory do indeed have separate neural representations is further strengthened by observations (see Milner & Teuber, 1968, for an extensive review) that clinical syndromes involving one but not the other function are quite common. Thus, patients with perceptual anomalies are not necessarily deficient in remembering when tested only for what they do perceive. Similarly, even severely amnesic patients (e.g., H.M.) appear to show normal perceptual capacities.

Finally, the claim that hemispheric differences seen in processing nonverbal information are due more to perceptual, rather than mnemonic, functions, would be more credible if a clear right-hemisphere advantage could be shown for the simple perception of this kind of material. The pattern of the results from the hemifield presentation literature does not support this contention, however. As indicated in the previous section in which visual field asymmetries for nonverbal stimuli were considered, no clear left visual-field superiority has been

found across different kinds of material purported to be nonverbal and much inconsistency has been reported from study to study, even using the same materials. If anything, the data from procedures using various kinds of brief unilateral presentations of stimuli may be taken instead to support the view that laterality differences are memory based. White (1969), for example, considered the relative length of retention intervals in hemifield versus dichotic listening studies and concluded, "Functional asymmetry may thus be directly related to the ability to 'hold' stimulus information rather than the ability to immediately process it" (p. 402).

### Verbal Mediation in Normal Subjects

Attempts to infer the status of nonverbal capacities from the scores obtained on well-known psychometric tests have often been justifiably criticized (e.g., Benton, 1962) as naive since, in many of these tasks, successful performance can clearly be achieved by simply recoding the "nonverbal" materials into verbal analogues.

Two recent reports, however, have suggested that there may be a growing awareness of the influence of verbal mediation responses in tasks which are often considered to be measures of NVM. In these studies, left-hemisphere brain-damaged patients were found to perform more poorly than right-hemisphere brain-damaged patients on the Tactual Performance Test memory component (Meyers & Lezak, Note 1) and on delayed reproduction of the Rey-Osterrieth figure (Archibald, Note 2). The authors in both communications argued, therefore, that successful performance on these tasks requires an intact verbal processing system.

The great flexibility and apparent ubiquity of the verbal encoding response in humans has made it difficult to construct measurement situations in which labelling and linguistic transformations of memoranda are minimized. The idea that memory for ostensibly nonverbal

stimuli is actually accomplished by some kind of verbal recycling is an old one in psychology and several complex controversies are involved here. In this section, those issues which seem most relevant to the construction of better NVM tasks are considered.

Perhaps the hoariest question of all has been whether or not memory for an ambiguous form is influenced when a verbal label is provided for that form. Bartlett (1932) was among the first to suggest that the labelling of faces, for example, causes memory distortion in the direction suggested by the verbal description. In the same year, Carmichael, Hogan and Walters (1932) published an influential study which demonstrated that ambiguous visual figures were remembered as being more like the images suggested by verbal labels given to them than like their original visual representations. In the decades that followed, many investigators attempted to resolve this aspect of the verbal mediation problem (See Riley, 1962, for an historical review of this work) but interpretative problems remain.

Interest in the effects of verbal labels upon memory for visual forms has continued into the current era and has come to include recognition, as well as reproduction, methods of assessing retention. In an ingenuous study

with a more contemporary approach, Daniel (1972) devised novel stimuli which varied in equal-interval-distortion steps along a physically defined shape continuum, extending from a familiar form (e.g., a duck) at one extreme to an unfamiliar form (similar to a random shape) at the other. Subjects were presented with the midpoint form as a memorandum and given with it the verbal label for the familiar form of which it was a variant. When all of the continuum possibilities were presented, after delays of 5 minutes, 20 minutes, or two days, the subjects' recognition errors were found to be systematically trending in the direction of the familiar form suggested by the label, rather than toward the equally distorted but unlabelled alternative.

Daniel's result is representative of the current consensus that verbal labels can have a potent modifying effect on memory for ambiguous stimuli. Important though this caveat may be, it is not central to the problems of estimating or reducing the amount of interference caused by language when none is desired.

In the following pages of this section, attention is focussed primarily on examining the evidence for and against the contention that some degree of verbal processing is always present even in the most "nonverbal"

of memory tasks. This controversy has also been a vigorous one in the history of psychology and the arguments that have been offered here have ranged from those in which the existence of a completely verbal-free memory is defended to those in which the need to postulate any nonverbal processes at all is challenged.

The central idea at issue here is whether or not verbal mediational responses do, in fact, have an effect on memory for supposedly nonverbal materials. The question of interest is thus one of the necessity of verbal labelling, coding, etc., rather than its sufficiency.

The view that all memory is verbal memory and thus there is no need whatsoever to postulate a separate NVM system has been a recurrent theme in cognitive theory, appearing in many forms (e.g., See Neisser, 1967). Although this idea is implicit in many models of memory, it has been most clearly elaborated in the work of Glanzer and Clark (e.g., 1962). These authors proposed that perceptual processing of even supposedly nonverbal materials always includes a covertly

verbalized interpretation and that it is this verbal recoding which is recycled and thus remembered. This "verbal-loop hypothesis" was supported by several studies which demonstrated that the best predictor of the degree of difficulty in remembering a complex visual stimulus is the number of words that subjects typically use to describe it. In one illustrative report (Glanzer & Clark, 1964), the materials used were irregular figures which had been previously rank-ordered (Fehrer, 1935) in terms of the number of brief exposures needed to achieve an accurate reproduction of each one. Subjects were asked to write a succinct verbal description for each figure and the word counts for these verbalizations were found to be highly predictive of the memory difficulty data as well as the independent ratings of "complexity" for each figure. The authors contended that this length-of-verbalization measure exhausts the meaning of the term, "perceptual organization".

Cohen and Granstrom (1968b) used a smaller set of the same figures as used by Glanzer and Clark and also compared memory performance with written descriptions. In their analysis, however, subjects were rank-ordered in terms of delayed-reproduction accuracy and also in terms of ability to describe the figures such that

another person could draw them correctly using only the written words. As expected, there was a significant positive correlation found between the ability to describe a figure accurately and the ability to reproduce it. No relationship was evident, however, between either of these skills and the number of words used to describe a memorandum. The authors interpreted their findings as support for the view that verbalizing plays an important role in memory for figures but suggested that the number of words used to describe the memoranda may not be the best indicator of the relative importance of the verbal component.

Other investigators who have attempted to evaluate the generality of the verbal-loop hypothesis have also been unable to document the value of counting the number of words or syllables used to describe nonverbal materials. Thus, both Brown and Lenneberg (1954) and Lantz and Stefflre (1964) reported that length of verbalization was not a good predictor of memory for colours and Ammon (1973) found no relationship between the ability to verbally code memoranda and subsequent recognition performance in either normals or aphasics.

Glanzer and Clark argued that verbal responses to a memorandum are more important than the physical characteristics of the stimulus in determining information-

processing accuracy. Because stimulus parameters and response measures are often highly correlated, however, both may reflect an underlying dimension of complexity or "nonverbalness". Also, just because some difficult-to-verbalize stimuli can be described in words does not imply that they are, in fact, mediated this way normally. Although the length-of-verbalization measure may prove useful as an index of the complexity of memoranda, the major contention of the verbal-loop hypothesis remains as yet unproven.

Some of the strongest evidence against the idea that verbal mediation is essential for memory has come from the commissurotomy studies. Milner and Taylor (1972), for example, demonstrated that patterned materials presented to the left hand only could be retained for at least two minutes. To qualify as supporting the existence of verbal-free memory, however, two assumptions must be made; namely, that the information is not transferred to the left hemisphere in some unknown fashion and that the isolated right hemisphere is incapable of generating verbal mediational responses. Some support for the veracity of these assumptions can be adduced from the additional finding in the Milner and Taylor study that the same memoranda when presented to the right hand only

could not be matched correctly, by most patients, even at zero delay. Overall, the results of this study have been taken by the authors to advance the position that, "verbal coding is neither necessary nor sufficient for the retention of complex perceptual material" (p. 1).

If verbal mediation of supposedly nonverbal memoranda does, in fact, occur automatically, can memory performance for difficult-to-verbalize materials be enhanced by training subjects in the use of verbal coding? This question was examined by Malpass, Lavigueuer and Weldon (1973) by giving normal subjects extensive (eight hours) practice in creating and using verbal descriptions of faces. Although subjects improved greatly in their ability to describe and communicate about faces, no detectable improvement was found in delayed recognition performance. By contrast, a short training procedure involving visual practice only showed substantial gains in subsequent facial recognition abilities. The authors concluded that no evidence could be found in their data for the contention that verbal processes are important in remembering faces.

A study by Goldstein and Chance (1970) nicely illustrates the fine-grained level of analysis needed to adequately address the verbal mediation question. These

investigators first determined that both immediate and delayed recognition memory was best for a set of faces, next best for inkblots and poorest for snowflake figures, using identical presentation and test procedures for each type of memorandum. Other subjects were then shown the same stimuli and requested to write a verbal description of each. In this task, subjects were instructed to record a response only if the picture shown looked like something, or reminded them of something they could describe in words.

As expected, faces elicited the most verbal associations, followed by inkblots and then snowflakes. Although this result could have been taken as support for the verbal mediation hypothesis, the authors next conducted a more detailed analysis which revealed otherwise. Within each set of stimuli rank-order correlations between the recognition rate of each memorandum and its association frequency were calculated and found to be small and/or negative. Thus, it appeared that those stimuli which elicited the most verbal associations were not necessarily remembered the best.

Goldstein and Chance next addressed the question of whether "associations" to memoranda are representative of the kind of verbalizations that a subject would actually

use to encode the stimuli. In this study, subjects were instructed to "write something about the picture that would help you recognize it were you to see it again later on" (p. 240). A comparison of these responses to those given under the association instructions revealed several differences. The encoding set produced more words per response and fewer instances of no response to a memorandum. Whereas the encoding responses tended to be descriptive conjunctions using multiple cues, the associative responses were characterized by a great deal of similarity across memoranda from the same category.

On the basis of this invariance, the authors concluded that "associations" are probably unrelated to the actual way in which a subject would attempt to verbally encode a complex visual stimulus. In their view, verbal responses may be readily generated for any kind of non-verbal memoranda, but the subject may not necessarily make use of these cues in the memory process. At the very least, Goldstein and Chance's work demonstrates the importance of instructional set in attempting to obtain measures of verbalizability.

More recently, Malone and Hannay (1978) explored visual-field differences in several tasks involving memory for colours and found the pattern of results

related to the availability of verbal labels for the stimuli. In their procedure, a colour memorandum was briefly presented to one visual field or the other and then either immediately, or after a delay of ten seconds, a comparison stimulus was shown and an identity judgment required. Four experiments were reported, each involving a progressively more difficult discrimination than the last. This increase in difficulty was obtained by selecting canards (incorrect alternatives) which were relatively closer to the memorandum colour in either hue or saturation. After each task was completed, all the stimuli were shown again one at a time and the subject was asked to name each. In the first two experiments, subjects did in fact assign different descriptive labels to the memorandum and canard stimuli and as expected, a right visual-field effect was found in both these tasks. In the third and fourth experiments using much more closely matched memoranda and canards, no visual-field effects emerged. Unfortunately, however, the naming-similarity measures were not reported for these latter studies.

There have been suggestions (e.g., Baddeley, 1976, p.216) that the importance of verbal factors in memory may depend upon the type of retention

task used. In this view, recall of nonverbal materials tends to rely on verbal coding whereas recognition of the same memoranda is apparently unaffected by linguistic cues. Support for this dissociation is available only from indirect sources of evidence, however.

Bahrick and Boucher (1968), for example, presented drawings of 16 different common objects and then asked subjects to both recall the names of the objects shown and to recognize each memorandum object among a set of similar drawings of the same object which were different only in detail. They found that the probability of recall of an object's name was uncorrelated with the accuracy of recognition of that same object by the same subject. Moreover, this discontinuity appeared to be quite robust, being unaffected by increased number of presentation trials, instructions to verbalize the name of the object, or retention intervals up to two weeks.

Cohen and Granstrom (1968a) also reported finding a dissociation between recall and recognition of nonverbal materials and attributed this result to the involvement of verbal mediation in the former process but not in the latter. In their study, an original complex figure was presented to the subject, a delay interval of 10 seconds followed, and then the reproduction

or recognition test was administered. When the delay interval was unfilled, no differences in memory performance were found between the reproduction and recognition conditions. When a paired-associate distractor task was introduced, however, reproduction scores dropped markedly, while recognition performance remained essentially unchanged. Furthermore, this effect occurred regardless of whether the paired-associate task involved spoken words, easily labelled figures, or both. The authors concluded that recognition memory has a major nonverbal component whereas reproduction memory may be strictly verbal.

In a later report, Cohen and Granstrom (1970) used the same memoranda and procedure for assessing reproduction and recognition following a delay interval of 20 seconds. This study also included a posttest phase in which the subject was required to write a verbal description of the memorandum. Each verbalization was scored by counting the number of false alternatives to which it could also apply. A high positive correlation was found between reproductive and descriptive accuracy but the relationship between the recognition and description scores was negligible. This pattern of results was seen regardless of whether the delay interval was taken up with a backwards-counting task or was unfilled.

In further experiments reported in this paper, the type of material used in the distractor task was varied (faces versus names) using the same memoranda and procedures as before. In these investigations, the results indicated that, in comparison to names, the use of faces in the delay interval significantly reduced performance in the recognition task, while performance in the reproduction condition was markedly improved. The authors argued that, for nonverbal material, reproduction and recognition involve quite different processes in that verbal mediation appears essential in the former and may be completely absent in the latter.

Considered from a broader perspective, the verbal mediation possibility is just one aspect of a more general "linguistic relativity hypothesis", usually associated with the work of Whorf (e.g., 1956). In this model, language is seen as not just a way of expressing what we perceive, rather it is regarded as directly determining the nature of our perceptions and limiting what we are able to encode. The Whorfian hypothesis would maintain that verbal labelling of memoranda is not only essential but that there is no information processing possible without it. Since, in this view, anything that cannot be described linguistically cannot even be perceived, NVM would be regarded literally

as a "meaningless" concept.

Although there have been many attempts to evaluate the plausibility of the linguistic relativity hypothesis, the evidence remains inconclusive (See, for example, Lenneberg, 1961, for a review of the work with colours) and the problem may prove to be especially refractory because of its broad scope and the assumptions involved regarding nonobservable processes. Like many speculations of this type in psychology, the Whorfian model may not qualify as a scientific theory at all, at least in Popper's (e.g., 1959) sense of being refutable. One way to disprove the linguistic relativity hypothesis, however, would be to demonstrate the reality of NVM. Although it may never be possible to prove the total absence of verbal mediation in any one situation, (indeed, it may be logically impossible to do so) the attempt to develop many tasks, in each of which the relative contribution of verbal factors appears to be minimal would, if successful, provide a kind of convergent validity for NVM. Whether successful or not, this effort may be the best way to test the predictions of the linguistic relativity hypothesis and allow for the possibility of disconfirmation.

This issue may have pragmatic as well as theoretical ramifications. Milner (Milner & Teuber, 1968), for example, has considered at length the relevance of the

verbal-mediation problem for the construction of NVM tests in her extensive discussion of methodological factors in the assessment of memory disorders. She notes that regular geometric figures, of the kind that are widely used for NVM testing, are particularly susceptible to verbal recoding, especially if an inspection period of any appreciable length is given. Observing that some of her right temporal-lobectomy patients would resort to explicit verbal classifications as an aid to memory, she determined that while labelling can clearly be an adaptive compensatory strategy in some situations, in other cases it can be quite misleading as well. Thus, while immediate reproduction of complex geometric forms was accomplished adequately by right temporal-lobectomy patients, presumably with the aid of some verbal cuing, delayed testing revealed severe deficits as compared with the left temporal-lobectomy group (Taylor, 1969). Here, it appeared that the quickly improvised labels worked to produce distortions in the absence of a veridical visual representation.

Milner has further argued that while verbal mediation may be a very common response among normal subjects, its role is likely even greater in the presence of a right-hemisphere lesion which could well interfere with the

more direct storage of visual information. More specifically, she suggested that intelligent patients with right temporal-lobe lesions may become very adept at finding ways to apply verbal tags to nonverbal material. Milner cautioned that unless the NVM task is carefully designed to counter this compensatory strategy, these patients may be able to mask a significant memory disorder during clinical testing.

In addition to its distorting effects in reproduction tasks, verbal self-cuing may also have an important confounding influence in tests using the recognition method of assessing retention. According to Milner, where inter-item similarity is low, successful performance may be achieved by encoding only those few features of each memorandum which are the easiest to verbally label and which will allow for discrimination among the items. This then is seen as a cogent argument for using stimuli with high inter-item similarity where distinctions must be based upon slight variations in pattern which cannot be readily verbalized: "In the application of recognition techniques to the elucidation of memory defect after brain lesions, it is such tasks which have proved most sensitive to right hemisphere lesions as opposed to left" (Milner & Teuber, 1968, p. 338).

In order to minimize the potentially interfering effects of verbal mediation, attention must be given to the procedural aspects of the NVM task as well as to the memoranda used. For example, as Milner has pointed out, the longer the patient is given to inspect the memorandum the more likely it is that verbal classificatory aids will be generated. Moreover, the presentation phase is not the only situation in which increased time periods may encourage the use of assistance from the verbal processing system. Any task which includes a delay interval, (i.e., a time period between the removal of the memorandum and the test of retention) is especially vulnerable to verbalizing influences. Patients commonly rehearse verbal material, either overtly or covertly, during this time delay in an attempt to prevent loss of the information.

Whether or not truly nonverbal memoranda can be "rehearsed" in some nonverbal way is a moot point (See Graefe & Watkins, 1980, for one opinion) but, in either event, subjects may use the unoccupied delay-interval time to create and recirculate verbal mnemonic cues. The primary purpose in developing the Peterson and Peterson (1959) distractor technique was to prevent this kind of rehearsal and it appears to be successful with verbal materials at least. When nonverbal memoranda are

used, however, the way to proceed is unclear. Should a nonverbal distractor task be used, as Kinsbourne and Wood (1975) suggest on the assumption that it will block nonverbal rehearsal best or, as Baddeley (1976, p. 210) argues, should a verbal distractor task be employed so as to ensure that verbal recoding does not occur?

Control of language-mediating responses may also mean the elimination or restructuring of several classic presentation procedures, according to some authors. In Milner's view (Milner & Teuber, 1968), one method which particularly invites recoding is the paired-associate paradigm. She notes that patients frequently seem to be striving to "make sense" out of pairs of meaningless stimuli so that they can be verbally linked in some way. Furthermore, this effort after meaning occurs even with materials that may apparently be processed nonverbally when other presentation procedures are used. Interestingly, in those studies (e.g., Meyer, 1959; De Renzi, 1968) in which the paired-associate format has been used with nonverbal memoranda, no performance differences have been found between left- and right-hemisphere-lesioned patients. Milner comments, "One would therefore conclude that paired-associate learning is an inappropriate method for studying the nonverbal aspects of memory" (p. 353).

Another class of procedures in which verbal mediation seems unavoidable is that of the span tests used to measure so-called "immediate" memory. In assessing verbal memory, these tasks have used alphanumeric materials almost exclusively, as these memoranda are of uniform difficulty, highly practiced, familiar, normally used in sequences, and can be referred to easily by their labels. Milner (Milner & Teuber, 1968) observes, "An equivalent set of nonverbal measures has still to be developed and may prove hard to achieve" (p. 333).

One problem in attempting to develop a nonverbal span task is that if it is to be used with a recall, rather than a recognition, demand then the material must lend itself to being reproduced by the subject (i.e., it would not be possible to employ many commonly used nonverbal materials, such as faces). A second problem is that the material must allow for relatively rapid output by the subject since any appreciable delay occasioned by a long reproduction time, as would be the case if a series of geometric figures was used, would turn an "immediate" memory task into one of delayed recall. The problem then, in attempting to devise a NVM span test, is to find materials that can be sequentially ordered, rapidly reproduced, and still not plausibly mediated by verbal labels.

Warrington, Kinsbourne, and James (1966) tried to resolve some of these difficulties by using as memoranda simple curved and straight lines varying in orientation. Following a brief presentation of a row of these stimuli, the subject was required to quickly reproduce as many as (s)he could remember. It was found that, in normal subjects, memory span for this kind of material was reliably lower than that for the traditional alphanumeric stimuli. In addition, difficulty increased as a function of the heterogeneity of the array, suggesting that subjects were finding ways to verbally recode the less variable sequences. The authors drew the inference that many of their nonverbal memoranda were in fact transformed into verbal labels and since this would be more time-consuming than processing already coded stimuli, shorter memory spans resulted.

Since the capacity for language is often regarded as one of the defining characteristics of *Homo sapiens*, it has occurred to some authors that we may have a biologically determined preference for the verbal encoding and rehearsal of all memoranda. Noting that H.M. was unable to match simple auditory and visual stimuli after only 20 seconds, a task which is readily performed by several species of primates and rodents, Iversen (1973) reasoned

that, whereas the other animals may have an efficient and direct NVM storage system, in our case, the verbal labelling/recirculating short-term memory system has replaced this more "primitive" memory machinery.

Thus, if this verbal memory system, which seems associated with the hippocampi, is eliminated, as appears to be the case in H.M., then only a residual, nonhippocampal, and much less effective, long-term storage system is left. In this view, the evolution of man toward greater verbal specialization has been achieved at the cost of greatly reduced NVM efficiency.

Sidman, Stoddard, and Mohr (1968), in their evaluation of H.M., reached a similar conclusion but with a different emphasis. They observed that he was able to rehearse and thus retain trigrams as well as normals over brief periods, but was completely unable to remember the shapes of ellipses during the same time span. Since normal subjects had all reported developing a verbal coding strategy to mediate this task, the authors concluded that the primary basis of H.M.'s amnesia was an inability to generate verbal mnemonic systems. In this schema, the hippocampi may be seen as structures which have evolved as label generators.

In summarizing this brief review of the role of

verbal factors in the processing of ostensibly nonverbal information it appears reasonable to conclude that whereas the sufficiency of verbal mediation has been amply documented, the necessity of such a hypothetical intervening stage remains an open question. The verbal-loop version of the more general linguistic relativity hypothesis has received only limited support and there is much evidence, albeit mainly indirect, suggesting that the level of retention difficulty for a memorandum is not predicted by its verbalizability. There is some indication that this conclusion holds more strongly when retention is assessed via recognition testing and that it may have to be qualified when recall/reproduction methods are employed.

From a methodological viewpoint, there are important inferences to be drawn from this work. Verbal recoding of memoranda may, in reality, occur in any supposed NVM task and a lack of information regarding the likelihood of this possibility creates a serious problem in the interpretation of performance. The most conservative strategy, in attempting to devise adequate measures of NVM, may be to assume that, wherever possible, the human subject will endeavour to convert all information received to a verbal code.

If this assumption is accepted, then no task should be considered, on a priori and intuitive grounds alone, to be a valid measure of NVM. Because of the apparent omnipresent nature of the verbal mediational response, any test purporting to assess NVM must be accompanied by evidence which is sufficiently persuasive to allow investigators to conclude that the influence of verbal factors on task performance is likely minimal. Methods of obtaining this kind of construct validity evidence are discussed in chapter 6.

"Inner Language" in Aphasic Patients

"Whenever possible, the human subject endeavours to convert meaningless patterns into meaningful, verbalized material. This is the kind of task in which the aphasic patient specifically fails." (Boller & De Renzi, 1967, p. 1057).

If verbal mediation is indeed an essential component of the "nonverbal" memory process, then patients with language disorders should be expected to show performance deficits on NVM tasks. If, on the other hand, NVM is truly language independent then there is no reason to assume that the presence of aphasia, by itself, should cause a patient to perform any differently from normal subjects on NVM measures. At the very least, aphasic patients should be expected to obtain scores no worse than non-aphasic brain-damaged patients on these tasks, if verbal mediation is not a factor in NVM.

The question of NVM deficits in aphasics has been investigated most extensively by the Milan group. De Renzi (e.g., 1968) in particular, has argued repeatedly that man is the verbal animal and that we normally attempt to use our extremely versatile semantic processing system to recode all sensory information. Support for this contention has been garnered from studies in

which large groups of left- and right-hemisphere-damaged patients are compared as to their performance levels on some measure designated as a NVM task. Typically, the data are then reanalyzed, entering the presence of aphasia as a covariate, and any change in the pattern of the results is taken as evidence regarding the role of linguistic intervention in NVM.

In spite of De Renzi's assertion, the evidence from these aphasia studies has not been consistently in favour of the verbal mediation hypothesis. In one of the earliest reports in this series, for example, De Renzi and Spinnler (1966a) found that, among left-hemisphere-damaged patients only, performance on a facial recognition task was not affected by the presence of aphasia.

Later, Boller and Spinnler (1967) discovered that performance on a task measuring memory for "non-verbalizable" colours was unaffected by degree of impairment on several oral language tests. Even though left-hemisphere patients were significantly poorer than right-hemisphere patients on this measure, the authors argued that it is unlikely that verbal mediation was a crucial factor in determining the performance asymmetry. They concluded instead that the left hemisphere may make a greater contribution, than the right, to NVM independent

of its dominance for language.

Evidence in support of the verbal mediation position was also presented in the early studies, however. In one investigation, Boller and De Renzi (1967) found that aphasic patients were much more impaired, than nonaphasic patients, on a paired-associate test using originally designed "meaningless" figures.

In the next report from the Milan group, De Renzi (1968) described a previously unpublished study by Faglioni and Spinnler involving the use of a different set of "meaningless" figures, which appeared to be more complex than those devised by Boller and De Renzi (1967). When these more difficult memoranda were presented in a sequential recognition procedure, no reliable relationship was found between scores obtained on this NVM task and those obtained on tests of object naming or sentence completion in large groups of left- and right-brain-damaged patients.

Further support for the contention that verbal mediation plays an important role in NVM was reported by Bisiach and Faglioni (1974), however. These workers found the delayed recognition of random shapes to be markedly impaired by the presence of an aphasic disorder.

In the following year, De Renzi and Nichelli (1975)

determined that performance on a block-tapping test was independent of language disorder generally and also unrelated to diagnostic type (Broca's, Wernicke's, or global) of aphasia.

The conflicting pattern of results obtained in this series of studies from the Milan group may be partly a function of the differing ways in which the term "aphasia" has been defined. In the earlier studies (e.g., De Renzi & Spinnler, 1966a), unspecified "routine tests" were used to determine the presence of a language disorder. In later investigations (e.g., Boller & Spinnler, 1967), patients were classified as aphasic or nonaphasic on the basis of scores from tests involving object naming and sentence comprehension. Other reports employed the Token Test (e.g., Bisiach & Faglioni, 1974) and/or an unspecified "comprehensive aphasia battery" (e.g., De Renzi & Nichelli, 1975) as indicators of language disorder.

Clearly, there is much variability here in terms of sophistication of assessment and in type of behaviour sampled. Most strikingly, some of these tasks tap only language production, others are concerned solely with receptive functions, and some appear to be measures of both. Although it would be appealing to try to draw

some general conclusions regarding the status of NVM performance in aphasics generally, it is probably inappropriate to lump together studies which have defined language disorders in such variable ways. It could be, for example, that only some kinds of aphasic deficits interfere with NVM.

The possibility that a finer-grained diagnostic analysis may yield more meaningful results is attested to in a recent study by Gainotti, Caltagirone and Miceli (1978). These investigators first found that impairment in memory for several designs from the Raven - Matrices was associated with the presence of a language disorder as measured by their aphasia battery. Further analyses indicated, however, that no relationship existed between this ostensibly NVM deficit and diagnostic category (Broca's, Wernicke's or "amnesic" aphasia ), where classification was based on expressive language capability only. On the contrary, impaired performance on the NVM task was reliably predicted by poor scores on a test of auditory language comprehension. The authors attributed the memory disorder to an impairment of "inner language" which, they felt, rendered the aphasic patients unable to verbally code the distinctive features of the figural memoranda.

In recent years, the question of NVM deficits in aphasics has been addressed by several non-Italian investigators. Rather than resolving the issue, however, these newer reports, mainly from American and German workers, have instead added further complexities to be considered.

In one of the more straightforward studies, Benton, Hannay and Varney (1975) presented single-line memoranda which varied in orientation and then, after a 2-second delay interval, required patients to select the previously shown slant from a multiple-choice array. They found that aphasic patients were no more impaired on this task than nonaphasic patients but their sample sizes were quite small.

In one of the few studies in which the verbalizability of the memoranda has been systematically manipulated, Levin, Grossman and Kelly (1976) presented random shapes, at three levels of association value, and required head-injured patients to recognize each again immediately from a multiple-choice array. On this task, patients with aphasic deficits were found to be reliably more impaired than those without, across all kinds of memoranda, thus apparently suggesting that verbal mediation plays a significant role in the retention of these materials. On

the other hand, the association-value factor had no effect on the recognition performance of either group of patients. Since high association-value shapes were considered to be most amenable to verbal encoding or covert rehearsal and since aphasics were expected to be most impaired in the ability to use verbal mediational strategies, it was predicted that language-disordered patients would show relatively more impairment on high- rather than low-association-value shapes. The finding that the performance of aphasic patients did not vary as a function of association value was thus taken by the authors as evidence that memory for any of these random shapes is not likely mediated by verbal encoding.

A similar conclusion was reached by Ammon (1973) who compared the performance of normals and aphasics and found that in neither group was there a significant correlation between the ability to verbalize or verbally encode a "senseless" visual stimulus and the ability to correctly choose this memorandum again in a delayed recognition test. Ammon interpreted his results as evidence against Glanzer and Clark's (1962) verbal-loop hypothesis and as support for the existence of unmediated short-term NVM.

If language-disabled patients do poorly on some task, which supposedly measures NVM, and the inference is drawn

that this task is thus, in fact, verbally mediated, the implicit assumption made is that aphasics are deficient in their ability to employ verbal mediation as an aid to memory. Although the status of covert symbolic processes in aphasia has been a long-standing controversy, the few recent reports in which the question has been asked in relation to NVM performance have suggested that the assumption of impaired verbal mediational abilities in aphasia is a reasonable one.

In one of the most direct approaches to this problem, Goodglass, Denes and Calderon (1974) first devised original nonsense figures and presented these in a span procedure (2, 3, or 4 at a time) to aphasic patients who were then required to recognize the same figures again from a multiple-choice array containing all the possibilities. The data indicated that the language-impaired subjects averaged only half as many correct recognitions as normal controls. This result suggested the usual interpretation that the ability to verbally encode these "nonsense" figures may be an important factor in the superior recognition performance of normal subjects.

Goodglass, et al., next selected a group of non-aphasic brain-damaged patients (most of whom had bilateral or right-hemisphere lesions) who had equally

poor scores on the nonsense figures test. All patients were then given the same procedure twice again, but this time different sets of object pictures were used as memoranda. One set of pictures included many pairs of homophones (e.g., cat, bat), with one of the pair in a different list from the other. The second set of pictures contained no sound-alike objects. As expected, the non-aphasic patients fared much better in remembering the object pictures, regardless of the set used, than in retaining the nonsense figures and their performance approached normal levels on this task (presumably because they were able to verbally encode the pictorial stimuli). Although the aphasic patients improved somewhat when the object pictures were used, they were still grossly impaired on this task, suggesting that they were not able to benefit from the apparent increase in verbalizability of the memoranda.

The most interesting results came from the comparison of the two types of pictures, however. When sound-alike objects were used as memoranda, the performance of the nonaphasic patients deteriorated significantly from the level which they achieved with unrelated stimuli. This decrement was also found in the normal control group and in previous studies using this method reported by Conrad

(1964, 1971). Inferior performance on the acoustically similar set was regarded by the authors as evidence that, for these subjects, covert verbal mediation played an important role in performing the visual memory task. The aphasic patients, however, showed no decline at all in performance when the homophonic pictures were used instead of the unrelated set. Goodglass, et al., regarded this finding as a demonstration of the absence of covert verbal mediation in aphasia.

In the same way that poor performance on NVM tasks has been claimed to be a function of diagnostic type of aphasia, so it has been suggested that the inability to use verbal mediational strategies is dependent upon type of language loss as well. In one relevant study, for example, Kelter, Cohen, Engel, List and Strohner (1977) used a delayed-matching procedure involving the presentation of a memorandum, a variable delay interval, and then the presentation of a comparison stimulus for an identity judgment. The memoranda employed were photos of single snowflakes, "considered extremely difficulty to code verbally, although easy to discriminate visually" (p. 53), and sets of three simple object drawings. The results of this experiment revealed that, as a group, aphasic patients performed no differently from nonaphasic brain-damaged

controls on both kinds of memoranda. When diagnostic categories were considered separately, however, fluent aphasics were found to be impaired, as compared to controls, with both snowflakes and object drawings, while nonfluent aphasic patients did poorly only with the designated nonverbal memoranda. This result suggests that while the fluent aphasics may have had a more general memory disorder, the nonfluent group's mnemonic difficulties may have been more specifically nonverbal.

When Kelter, et al., introduced a distractor task (sorting playing cards) during the delay interval, the performance of normal subjects decreased significantly, regardless of type of memoranda. A similar but non-significant trend was seen for nonfluent aphasics whereas the performance of fluent aphasics actually improved significantly with the addition of the distractor task. The authors regarded these findings as evidence that the three groups thus exhibited decreasing degrees of dependence on verbal mediation. More specifically, the normals and nonfluent aphasics were seen as successfully employing a verbal-encoding strategy even for the difficult-to-encode snowflakes. The poor performance of the fluent group in the free rehearsal was interpreted as due to their use of incorrect verbal labels. The

reason they improved when the distractor task was introduced, according to the authors, is that this activity suppressed their misleading "rehearsal" activities.

Other investigators have also produced data which suggest that the existence of expressive language difficulties per se, may not be a reliable predictor of NVM deficits. Cermak and Tarlow (1978), for example, assessed the retentive capacities of nonfluent aphasics only, by using a sequential recognition procedure which did not require a verbal response. In their method, a subject was presented with a list of items, one at a time, and required to indicate by raising his/her hand when any item was repeated. Only one item was, in fact, repeated in each list (the length of which varied) and the number of intervening canards was either one, two, or three. The memoranda used were spoken words, written words, object pictures, and random shapes.

Cermak and Tarlow found that their aphasics had extreme difficulty in recognizing either auditorially or visually presented words and scored far below even Korsakoff patients, whose performance was similar to normals and alcoholic controls, with these verbal materials. When object pictures were used, however, the

pattern of results was reversed, with the aphasic patients performing close to normal levels and the Korsakoff patients being grossly impaired. (Results from the use of random shapes were inconclusive since all groups appeared to be performing at about chance levels.)

From these findings, Cermak and Tarlow concluded that aphasics have normal NVM and that their memory disorders can be shown to be specific to verbal materials, provided the appropriate testing procedure is used. The authors suggested that aphasic patients have difficulty in remembering words probably because they do not have a covert (verbal) rehearsal mechanism available to them. Cermak and Tarlow argued that when pictures are used as memoranda, however, the aphasic patients are able to rely on their ability to use imagery, which is likely mediated by their intact hemisphere.

Virtually all studies of aphasia and NVM have been cross-sectional in design. A recent communication from Zubrick and Smith (Note 3), however, has added evidence from a longitudinal study. These investigators reported that BVRT scores improved significantly, along with measures of language functions, in a group of aphasics who had received intensive speech therapy. These gains were in contrast to negligible changes seen in WAIS PIQ's,

Raven scores and all other "nonverbal" measures sampled. The authors concluded that the concordance between language recovery and BVRT improvement suggests that Benton's visual memory task is highly susceptible to verbal mediation.

In summary, it appears that the original question of the status of NVM disorders in aphasia must now be considered in terms of several qualifying considerations. First of all, it seems apparent that not all types of language-deficient patients are likely to show equal degrees of impairment on NVM tasks. As yet, there are insufficient data available to justify any conclusions regarding which kind(s) of aphasic symptom patterns may be associated with the greatest NVM deficits, but it is clear that any future investigation of the aphasia/NVM issue should include an analysis of this factor.

Secondly, some studies reviewed in this section have suggested that even though a patient may be considered aphasic, this does not necessarily justify the assumption that (s)he is unable to employ verbal mediational aids to memory. If the results from language-disordered patients are to be used as evidence regarding verbal mediational interference in NVM, it would seem essential for future investigators to provide some demonstration that the

aphasic patients they are studying are, in fact, deficient in their use of "inner language". Several of the later studies surveyed here have suggested ways in which this may be accomplished.

Finally, it is clear that the question of whether or not aphasics have a NVM disorder depends a great deal on the type of task used to assess NVM. In the reports considered in this section, at least some kind of language-disability patients have been found to be reliably impaired in the capacity to remember such memoranda as simple "meaningless" figures (Boller & De Renzi, 1967), random shapes (Bisiach & Faglioni, 1974), "nonsense" figures (Goodglass, et al., 1974), Raven figures (Gainotti, et al., 1978), and BVRT figures (Zubrick & Smith, Note 3).

On the other hand, aphasics have been shown to perform no differently from control subjects on tasks involving memory for faces (De Renzi & Spinnler, 1966), "non-verbalizable" colours (Boller & Spinnler, 1967), complex "meaningless" figures (De Renzi, 1968), block-tapping sequences (De Renzi & Nichelli, 1975), line slants (Benton, et al., 1975), random shapes (Levin, et al., 1976) and snowflake figures (Kelter, et al., 1977).

While unqualified interpretations of this pattern of

results are hazardous, there is some suggestion here that aphasics tend to fail (and by extension verbal mediation may be most useful) in tasks involving the simpler figural memoranda. How to characterize the kind of memoranda that they succeed with (and thus presumably for which verbal mediation is not effective) is more difficult. Any simple conclusions based on general type of material alone must be tempered, however, by the observation that some types of materials, such as random shapes and "meaningless" figures, appear in both lists. In explaining these inconsistencies, it is necessary to consider differences between sets of similar kinds of memoranda as well as to examine procedural variations.

Instead of attempting to resolve such a general issue as the status of NVM deficits in aphasics, perhaps a more fruitful way to design studies of this type would be to use the performance of language-impaired patients as a criterion for the development of better NVM tasks. As Benton (1962) first suggested, "A possible method of [nonverbal] test selection would be to choose those tests on which aphasic patients do as well as nonaphasic patients. One might come up with some surprising results" (p.261).

### The Importance of Nonverbal Memory

One of the major purposes of this review has been to document the assertion that NVM is a salient and meaningful cognitive process. To this end, it has been argued that the concept of NVM is intuitively compelling, has a long history as an explanatory construct in psychology, and is intimately involved in many current theoretical controversies. In this section, the question, "Why study NVM?" is considered further and several cogent reasons offered. In addition, more detailed consideration is given to the need for better ways to measure NVM.

Perhaps the most obvious contribution of the study of NVM would be to the development of a truly general theory of memory. If NVM is, in fact, a separate function which is independent of the storage and retrieval of verbal materials, then no model of memory can be complete without an explanation of both kinds of information processing. Moreover, the importance of understanding the characteristics of NVM is magnified because of the long period of neglect of NVM in favour of the more easily investigated verbal memory system.

In one sense at least, the study of NVM may offer a better paradigm for the development of general memory theory than that provided when verbal memoranda are used.

Norman (1976, p. 102), for example, has argued that studies of NVM may offer data which are more truly representative of what we generally mean by the term "memory". He suggests that since many investigations of NVM use materials which are unique and unfamiliar to the subject, such as unknown faces or novel shapes, the task is one of pure recognition (i.e., it is a measure of whether the subject can remember seeing the test stimulus before, at any previous time). By contrast, the alphanumeric memoranda employed in verbal memory studies are generally all very familiar to the subject and the test query, "Have you seen this stimulus before?" cannot legitimately be asked.

According to Norman, the task in all verbal memory situations becomes one of recency discrimination only. In these instances the subject is actually being called upon to remember when or where (s)he has last seen this particular stimulus (i.e., "Was this one of the words in the list which was previously shown to you?") Thus, in Tulving's (1972) terms, the subject is called upon to demonstrate "episodic" memory whenever verbal memoranda are used. It may be, as Huppert and Piercy (1976) have suggested, that this distinction between "pure" memory and contextual memory is also extremely important in understanding the memory disorders of amnesic patients who, according to

these investigators, are impaired only in the latter ability.

Although Norman's distinction is an interesting one, the relevant dimension here may be better defined by the complexity of the memorandum rather than by its verbal/nonverbal attributes. Many measures of NVM have indeed used complex and unique memoranda and certainly, for these kinds of materials, it is reasonable to assume that "pure" recognition is being evaluated unaffected by any previous contact with the stimuli. If, however, simple nonverbal materials are used, such as a shade of red, the slant of a line, or the position of a dot, these memoranda would likely have been experienced many times before by the subject and the task here also would become one of recency discrimination. Similarly, if sufficiently unusual or complex verbal materials are used, such as nonsense syllables, paragraphs, or matrices of numbers, it is reasonable to assume that these specific memoranda are novel to the subject and the question, "Have you ever seen this before?" can properly be asked.

Besides being essential for the development of a truly general model of normal memory, the study of NVM is important also in furthering our understanding of memory disorders. The status of NVM in severely amnesic

patients, such as those with Korsakoff diagnoses, has been a matter of some theoretical interest in recent years.

One of the issues here is to determine if NVM is impaired, or at least deficient in the same way or to the same degree, as verbal memory is. Evidence bearing on this issue may then be used to evaluate various theories of amnesia.

Warrington and Weiskrantz (1973), for example, have concluded that for amnesic patients, short-term forgetting of nonverbal memoranda is within the normal range, as is the short-term forgetting of verbal materials. For these authors the NVM data is important as a further source of confirmation for their contention that short-term and long-term memory disorders can occur independently.

As another example, Butters and Cermak (e.g., 1975) have proposed that the fundamental deficit explaining the poor memory performance of Korsakoff patients is an inability to use verbal coding adequately. Semantic encoding is seen as the deepest level of information processing and proficiency at this skill is regarded as the reason why normal memory is so efficient. Clinical observations which suggest that amnesic patients may have extreme difficulty in remembering nonverbal materials as well, however, pose problems for the Butters and Cermak theory. Thus, to these authors, it has been important to establish

that Korsakoff patients have normal memory for nonverbal materials. Whereas some of their earlier results appeared to demonstrate this, recent studies have yielded more equivocal results. While Butters, et al., (1973) showed that retention of nonverbal materials was superior to the retention of verbal materials following a distractor task, this effect was later shown (Butters & Cermak, 1976) to be a function of the verbal distractor task used. In reviewing this work, Piercy (1977) concluded that if amnesic patients have an encoding deficit it is a general one and involves the processing of nonverbal as well as verbal materials. Thus, here again, the determination of nonverbal memory disorders has taken on some significance in attempts to develop a general theory of amnesia.

In addition to its theoretical significance, the concept of NVM has considerable potential importance for applied work with amnesic patients. Both the assessment and treatment of memory disorders will be inadequate until methods of measuring and facilitating NVM are developed. These activities have also been characterized by a pervasive lack of concern and naiveté regarding NVM. In the only review of memory assessment methods which has been published in recent years, Erickson and Scott (1977) included only a very brief section on NVM measures and

devoted this almost entirely to a survey of the Graham-Kendall MFD Test and the BVRT. In their discussion, no consideration at all was given to the fact that many of the memoranda designs can be easily coded verbally and that these measures are thus among the poorest of those available to evaluate NVM. The only other "nonverbal" memory tests even mentioned in Erickson and Scott's review were the Rey-Davis Pegboard (Zangwill, 1946), Fowler's (1969) Object Paired-Associate Test, and some miscellaneous tasks, involving objects, colours, and patterns, reported by Lewinsohn, et al., (1972).

The importance of including a thorough evaluation of the NVM function during clinical assessment has been repeatedly stressed by Milner (e.g., Milner & Teuber, 1968, p. 330). She noted that a patient may complain of a poor memory because the patient is very conscious of not being able to remember people's names or what (s)he reads in the newspaper and yet the patient may have completely normal memory for faces, locations, melodies, or other nonverbal materials. Even though the patient's deficits may be severe, to describe her/him as a global amnesic would be misleading. In spite of the obvious importance of examining all facets of memory before making any general statements, this is rarely done and in virtually

all routine evaluations of memory, NVM processes are considered in a very cursory fashion, if at all.

Conversely, a patient may appear to have a quite adequate memory if only the conventional (i.e., verbal) memory tests are used. The patient may, however, be markedly impaired with regard to NVM and this fact will go unnoticed during the evaluation unless procedures are used which are specifically designed to tap memory for faces, complex forms, location in space, etc.

Although there has been considerable recent interest in attempts to develop effective rehabilitation strategies for memory-disordered patients (e.g., see Poon & Arenberg, Note 4; Lewinsohn, Note 5), these efforts have so far been confined to the remediation of verbal memory deficits only. Some authors, such as Strauss and Butler (1978) and Erickson (Note 6) have alluded to the importance of devising treatment approaches for nonverbal memory disorders as well, but this remains a virtually unexplored topic. If NVM training is to be adequately evaluated, it is obvious that better measures of the process will have to be developed.

The striking double dissociation of verbal and non-verbal memory functions in relation to hemispheric laterality suggests that there may be new and important ways

available here to resolve some old questions regarding brain function. Specifically, more intensive study of NVM may help us to better define what it is that the right hemisphere does. If we are able to specify the effective factors of NVM tasks we may be able to replace the right hemisphere's negative descriptors (i.e., nonverbal, non-dominant) with something more positive as we define more precisely what "nonverbal" stimuli actually are.

The further study of NVM may allow for the more adequate evaluation and use of certain medical procedures in which memory assessment is important. ECT administration and Amytal testing for the purpose of lateralized excisions are two instances where better NVM measurement is greatly needed.

Since many studies have illustrated that unilateral ECT applied only to the nondominant hemisphere has little or no effect on memory functions, as measured by most standardized clinical tests of memory, UND-ECT has become the treatment of choice. The problem here is, of course, that almost all widely used memory tests tap only verbal memory functions. According to Iversen's (1977) interpretation, more recent work has begun to illustrate that if appropriate and sensitive tests are used it can be shown that significant and pervasive nonverbal memory

disorders are, in fact, produced by UND-ECT. Since we know so little about how to measure NVM adequately and about how important NVM really is in everyday activities, we cannot yet adequately estimate the risks to patients in administering UND-ECT. As verbal memory disorders are so obvious following UD-ECT and as so much of human memory performance appears to depend on verbal information processing, UD-ECT is justifiably avoided in favour of the supposedly less devastating alternative. The assumption that UND-ECT is, in fact, less detrimental clearly needs to be evaluated more carefully before being accepted.

A similar rationale can be developed for the more adequate measurement of NVM during amobarbital testing of retention. Here, the surgeon risks producing an inadvertent bilateral impairment in the patient if left-sided excisions are performed without first ensuring that right-temporal lobe functions are, indeed, adequate.

One of the great embarrassments in the field of memory research has been the poor payoff obtained from studies of infrahuman species. In spite of the enormous amount of time and effort invested in work with animals, very little of consequence to the understanding of human memory has resulted. (See Norman, 1973, for an extensive discussion of this point.) From another perspective,

Ervin and Anders observe:

The attempts to prepare animal models for anterograde amnesia have been disappointing to date. In spite of the consistency of the neuropathological data for man, many careful lesion studies in animals of various species have failed to produce a behavioural effect that all observers would define as a memory impairment. (p. 173)

One reason for the discontinuity between the animal and the human data is that fundamentally different processes may be involved in each case. Thus, while human memory has been conceived of in verbal terms, almost exclusively in some cases, animal memory is (we assume) strictly nonverbal. It may be that as we come to better understand the NVM system in humans, the animal data will make more sense and consequently may reflect back fruitful insights into human memory after all. In addition, a better understanding of NVM in the human subject may allow us to comprehend more clearly how other species remember. Since so much of our thinking about memory is cast in terms of verbal processes, we may not be using appropriate methods to study animal memory.

Since all humans (apparently) develop a NVM system before learning to use the complexities of verbal coding,

the further exploration of NVM may prove useful in understanding the way in which a verbal organization is created from a nonverbal foundation. If we can increase our knowledge of the NVM function we may be able to better determine how preverbal infants are able to remember. The years before the young child is able to use verbal processing skillfully are a time during which learning about the environment may be greater than at any other period in life. Yet, paradoxically, we have an extremely poor memory for this early period. The reason for this inconsistency may be simply that events experienced prior to the development of language competency are stored in nonverbal codes only. The study of the NVM system holds the promise, at least, that a way may be found to unlock this "forgotten" storage system.

The study of NVM in older children may be of importance also. Even though school-age children are quite capable of using verbal coding, it may be that they are still much more dependent on the NVM system than adults are. Investigations with children across various ages may thus yield important insights into the functioning of the NVM system through the use of subjects who are increasingly more skilled at, and/or prone to, the use of verbal encoding. The status of NVM in children remains almost completely

unknown at present, however, as there appears to have been few studies reported on this topic.

Virtually all of the work with NVM has been nomothetic in that the intent has been to discover general principles without regard to variations in ability between subjects. Only a few writers have even mentioned the idiographic alternative. Bartlett (1932) briefly noted that individual differences in NVM may be an important factor in understanding why some people remember better than others and Zangwill (1976) has provided a more contemporary version of this idea. It may be that there is a considerable range of ability to use NVM within the normal population. At present, this question is completely unexplored as well and would appear to offer intriguing possibilities for further work if appropriate measurement methods can be devised.

If the further study of NVM is considered to be important, then one of the first priorities must be the development of assessment procedures which will enable us to measure NVM more adequately. The most pervasive difficulty in interpreting NVM studies is the lack of any agreement as to what kinds of tasks actually tap the construct in a meaningful way. A great variety of materials and procedures have been used so far but there

is little consensus as to what methods are appropriate or even as to what validity criteria should be employed.

For some tasks which have been used as indices of NVM, the possibilities for verbal mediation appear too great to offer much confidence in the method as being a useful measure. Other tasks appear, *prima facie* at least, to be much more impressive as measures of NVM. Much investigation, therefore, needs to be undertaken to determine what factors are critical in producing a good test of NVM. Additionally, new tasks need to be developed to explore the range of possibilities that may be included as a part of the general concept of NVM and ways to validate these methods must be devised.

Many of those who have worked most closely with the construct have stressed the need for better assessment of NVM. Milner (Milner & Teuber, 1968), for example, urged that the precise quantitative methods used in the field of verbal learning should be applied to patients with verbal memory impairment and,

At the same time, it is essential that some non-verbal techniques of equal precision be invented. It is here that the clinical findings have outstripped research with normal subjects. As they stand, the designations of left and right

temporal-lobe syndromes as verbal and nonverbal respectively, are clearly provisional, and a wider range of tasks is needed if we are to go beyond the purely negative description of right temporal-lobe symptoms as nonverbal. (p. 358)

Milner (e.g., 1968b) has also pointed out that unless better tests are created nonverbal memory disorders may go unnoticed during a clinical assessment. She comments that this problem is particularly acute with right-hemisphere patients who may become quite adept at devising verbal strategies for encoding even abstract or "meaningless" stimuli as a way of compensating for their deficiencies in retaining a detailed visual impression directly. According to Milner, skill at this kind of countervailing activity can effectively mask a nonverbal memory disorder unless tasks are carefully created so as to minimize the chances of successful performance via verbal labelling.

A good example of this failure to assess NVM adequately is provided by Luria's (1976) approach to the evaluation of memory disorders. In discussing Milner's contention that nonverbal memory disorders result from right temporal-lobe lesions, he comments,

However, these defects are by no means found in every case. Recently, I have observed many

patients with right hemisphere lesions who had no difficulty with retention and recall, even after interference. (p. 160)

Luria's failure to find memory disorders in right-hemisphere patients is not surprising considering that his memory assessment methods involved verbal material almost entirely and his few tests which did not employ words as memoranda used easily verbalized items, such as object pictures. In her detailed description of Luria's battery, Christensen (1975) further points out, "It is to be remembered that the whole investigation is mainly considered to evaluate the functions of the left hemisphere" (p. 11).

Heightened skill in using verbal coding strategies on the part of right-hemisphere patients has also been noticed by other investigators. Barbizet and Cany (1969), for example, found that, on a story-recall test, their right hemisphere patients were superior even to a normal control group matched for age and education level. They suggested that:

This result can be attributed to a verbal compensation for a visual deficit. Indeed, we noted that these patients display very high motivation and sustained attention when called upon to exercise functions

they have preserved. (p. 56)

The importance of NVM and the need for better measurement methods have also been expressed by many of those writers who have reviewed various aspects of the relevant literature. White (1969), for example, emphasized the need for a better understanding of nonverbal materials as a prerequisite to progress in laterality studies:

One major difficulty in relating cerebral dominance to [lateral differences] is the certainty with which stimulus information may be ascribed the label "nonverbal". (p. 401)

In their survey of normal and pathological memory, Ervin and Anders (1970) concluded simply, "Psychologists have largely ignored the study of nonverbal memory" (p. 167).

Norman (1976) considered the evidence for theories of STM and cautioned,

We must be careful, of course, that our conclusions about memory systems do not become distorted because of the heavy predominance of studies that examine simple verbal materials. It is important that we also examine memory for pictures, for faces, for body movements, and essentially for all types of human experiences. (p. 101)

In her review of the controversy regarding STM processes in amnesics, Iversen (1977) concluded, "We do need to look at many more non-verbal tasks before coming to any definite conclusion that non-verbal memory does not involve a primary or ST memory process" (p. 158).

Robertson and Inglis (1977) evaluated the effects of ECT on memory and noted:

The distinction between verbal and nonverbal materials has received firm empirical support as an important source of variance in abnormalities of human learning and memory, but relatively little attention has been paid to the process which may underly the acquisition, retention and retrieval of these different materials.  
(p. 295)

Later they suggested,

These studies have, however, not yet advanced our understanding of the functions of the two hemispheres much beyond an intuitive classification of learning tasks into discrete verbal and nonverbal categories. A more detailed analysis of these tasks is essential for any closer understanding of cerebral asymmetry of function. (Robertson & Inglis, 1978, p. 179)

In his review of problems in clinical memory testing, Erickson (Note 6) concluded:

A better understanding of the processing of non-verbal information is needed. It is obviously inadequate to assume that nonverbal sounds, visual scenes and physical activity are transformed into verbal form for storage. Adequate verbal descriptions of music, complex motor acts, colour and faces are well beyond the capacity of the most articulate novelist, yet they are commonly stored and retrieved years later. Nevertheless, our understanding of how a person goes about processing nonverbal information is crude as compared to our understanding of how verbal information is processed. Yet it can be of critical importance to the clinician attempting to assess and rehabilitate some impaired patients.

(p. 33)

CHAPTER FIVE: THE NONVERBALNESS OF FIVE TYPES OF  
MEMORANDA

In order to construct a standardized task, which may be used for the measurement of NVM (or any memory construct for that matter), an investigator must choose a particular set of stimulus materials to use as memoranda and a particular procedure appropriate for her/his purposes. As is evident from the preceding review sections, both clinical and experimental workers have chosen a wide variety of materials and procedures in their attempts to develop valid measures of NVM. It is clear that there is no one kind of stimulus nor one specific procedural variation which is generally agreed upon as the ideal choice.

Since one of the purposes of this monograph is to assist investigators in choosing/constructing more adequate NVM tasks, the following sections offer a discussion of the problems involved in selecting and using specific kinds of stimuli as NVM memoranda. Issues concerned with procedural adequacy, for NVM measurement in general, are dealt with in chapter 7.

In this chapter, five types of commonly used NVM materials are considered as to their potential usefulness as NVM memoranda. Besides their popularity, the five kinds of stimuli have been selected for detailed evaluation because each is thought to represent a major generic type of nonverbal material and each is amenable to a quantitative analysis of construct validity, which is described in chapter 6.

For each kind of material, the typical ways in which the available stimuli have been employed in NVM tasks are reviewed. Problems with the use of the material are identified and suggestions are offered as to how stimuli of this kind can be best utilized as nonverbal memoranda. In each of the sections, particular consideration is given to those factors which may influence the degree of "nonverbalness" of the stimulus material.

### Benton Designs

The standard Visual Retention Test materials (Benton, 1955) consist of three sets of 10 designs each. Each design is composed of either a single large figure or a group of two large figures plus one small one. All of the stimuli used are outline drawings of what may be described as regular, geometric forms. These forms consist, for the most part, of basic shapes, such as circles, triangles, squares or rectangles, and more complex forms made by combining elements of each of these. Each individual figure may be located in any one of three places along the horizontal axis, while the small peripheral figure may be placed above or below the horizontal midline of the design. Adequate retention of these memoranda thus requires that the patient attend to, store, and retrieve information relating to shape, size, and location of each figure in the design.

In the most common reproduction procedure (Benton, 1974), each design is exposed for 10 seconds, removed, and then the patient is required to draw it from memory. Other recall variations include a 5-second presentation time or a 15-second (unfilled) delay interval. Norms are presented also for a copy administration. Each reproduction may be evaluated in terms of six kinds

of errors, such as rotations, misplacements, etc., and total scores can be calculated for number of errors as well as number of designs reproduced correctly, thus enhancing the diagnostic sensitivity of the test (e.g., Benton & Spreen, 1964).

Since the original description (Benton, 1945), the Benton designs have become one of the most widely available sets of memoranda (Lezak, 1976, p. 369) and have been extensively used in clinical practice as measures of "visual memory" to supplement the popular auditory-verbal memory tests. Much of the evaluative work regarding the BVRT has been summarized by Erickson and Scott (1977) in their review of clinical memory tests. These authors concluded that the test is a poor discriminant of brain damage in general and caution that perceptual and motoric factors must be controlled before it can be considered a useful measure of memory.

Evidence as to the nonverbal nature of the Benton designs has come from several sources. A few studies have explored the degree of congruence between the BVRT and various measures of verbal ability. As a group, these investigations, mainly employing patient populations, have yielded conflicting results. Heilbrun (1960), for example, found only a low ( $r = .26$ )

correlation between the test and digit span performance, while Brilliant and Gynther (1963) reported the BVRT to be essentially uncorrelated with the vocabulary subtest of the Wechsler-Bellevue. Chansky (1967), however, noted a high positive correlation between the BVRT and the verbal portion of the General Aptitude Test Battery. In a more extensive study, Breidt (1970) computed inter-correlations between the BVRT and four WAIS subtests (Block Design, Digit Symbol, Object Assembly and Digit Span). Product-moment coefficients ranged from  $+0.42$  to  $+0.62$ , with Digit Span showing the lowest correlation with the BVRT.

The inevitable comparisons of left- and right-hemisphere brain-damaged patients have been done (see Pettifor, 1967, for an example of a typical study) and this work has been summarized by Benton (1974, pp. 59-61). Although both left and right hemisphere patients appear to make consistently more errors in the contralateral field, there is no clear evidence that total error or total correct scores are reliably related to side of lesion, *per se*.

Dee (1970) evaluated performance on the copy administration and on a concurrent matching-to-sample version and determined that, in a group of unilateral brain-

damaged patients, deficits on these tasks were not related to the presence of aphasia. Further evidence regarding the possible role of verbal mediation in BVRT performance has been provided by Zubrick and Smith (Note 3). These authors found that in a large group of aphasics who showed good recovery, as indicated by improved scores on language tests, BVRT performance (Administration A) improved also. This outcome was in contrast to their performance on other nonlanguage tests, such as the Raven Matrices and WAIS PIQ, which showed negligible gains. Zubrick and Smith also found no significant differences in performance on the BVRT related to hemispheric side of lesion in a sample of tumor patients. Within the right hemisphere group, however, deficits on the BVRT were reliably associated with posterior lesions.

There have been several studies reported (e.g., Strain, Brunschwig, Duffy, Agle, Rosenbaum, & Bidder, 1968; Cronin, Bodley, Potts, Mather, Gardner, & Tobin, 1970) which have investigated the effects of unilateral ECT on memory functions as measured by the BVRT. Robertson and Inglis (1977) have reviewed this line of work and concluded that the test is quite insensitive to the effects of ECT, regardless of the side of application. They suggest that either verbal or nonverbal processing

may be sufficient to mediate successful performance on the task as it is usually given.

Benton's comments may provide the best available summary to the matter of BVRT performance and brain laterality. Noting that his own earlier studies (e.g., Benton, 1967) had indicated that only on copying performance was there a clear relationship to side of lesion, he concludes:

Thus, it would seem that the perceptual and perceptuomotor components of Visual Retention Test performance are associated with the functioning of the right hemisphere, while the memory component is not. (Benton, 1974, p. 86)

Because of concerns (e.g., Benton, 1962) that differential praxic ability levels may influence reproduction performance, multiple-choice versions of the test, using the same stimuli, were developed (Benton, 1950). Here, each memorandum design is followed by a set of four alternatives, including the memorandum again plus three similar choices, arranged randomly in a two by two array. In a later adaptation (Benton, Note 7) the 30 designs of the Revised BVRT are grouped in two sets of 15 each. The several procedures suggested for

administering the multiple-choice forms closely parallel those for the reproduction series. Since only a pointing response is required from the patient, the confounding effects of output factors are eliminated by this conversion to a recognition task.

In one multiple-choice procedure ("CR") in the 1962 manual, it is suggested that the standard copy administration be given first. When this is completed each multiple-choice array is then to be presented in turn and the patient required to select the previously drawn design. This administration allows for the evaluation of possible perceptual difficulties before confounding them with memory functions. The problem with the procedure, as suggested, is that it would likely be too difficult for most patients to remember so many complex designs. The preliminary normative data provided indicates that this is indeed the case as control patients averaged only a few correct choices above chance levels. A simple way to resolve the problem of excessive inter-item interference would be to evaluate retention for each design separately, after it has been copied and before the next design is presented.

Recently, (Benton, Hamsher & Stone, Note 8), a new set of designs has been made commercially available.

These materials consist of 16 memoranda plus a 4-choice array of alternatives for each. As with most of the earlier stimuli, each new design is composed of three separate figures, two large and one small. Again, the small figure is always located peripheral to the two large figures and may appear in any one of the four quadrants. Although each of the new designs represents a novel configuration with respect to the earlier stimuli, the 1977 materials are in fact composed of many of the same individual figures as were used in the 1955 version and the new designs do not appear to be different in any general way. No reasons for the introduction of new designs is given by the authors but it is noted that the 16 that are used were preselected from a pool of 64 items so as to represent a broad range in terms of difficulty. This selection was made on the basis of performance data from children.

One major difference in this new version of the multiple-choice test is that the canards for each memorandum have been created so as to vary in specifiable ways. Thus, each multiple-choice array includes a canard involving: (a) displacement or rotation of the peripheral figure, (b) rotation of a major figure, and (c) distortion of a major figure. The purpose of this

organization is ostensibly to permit quantitative analyses of error types, although no normative data of this kind are given by the authors.

While concern for a more precise specification of the relationship between the memorandum and its canards is generally advisable (See Williams, 1973, for a discussion of this point), in this instance, the attempt creates a curious flaw in the new test, which may be serious enough to render it unusable. Because of the systematic way in which the canards have been prepared, the memorandum can be determined in every array without any prior presentation at all! For example, if just the peripheral figure is considered, three of the representations of it are identical (to each other) in every set of four, and one is different from these three. A plausible strategy in choosing an alternative then, would be to eliminate the design that includes the anomalous figure. Similarly, by considering each of the major figures in turn, and using the same deductive logic, two more of the canards can be eliminated leaving only the correct choice.

While this procedure is somewhat awkward to describe in words, it can be done very quickly in practice and may be intuitively obvious to some patients who are

test-wise with regard to choosing among multiple-choice alternatives. Although it seems unlikely that many patients would actually discover and use this cognitive strategy, the fact that it is possible to achieve a perfect score in this way, creates an ambiguous situation for the interpretation of good performance. This problem with the new version of the multiple-choice test may be particularly critical since, as has been suggested, many patients with memory disorders for visuospatial materials may become quite adept at using verbal strategies, in NVM tasks, in order to compensate for their disability. Milner (Milner & Teuber, 1968), in particular, has emphasized that many of these patients may be even more skillful in devising and using verbal-analytical strategies than normals. This flaw in the test is especially unfortunate in that these patients with covert NVM disorders are exactly the ones that we would want the test to identify.

As presently constructed then, the new multiple-choice BVRT permits the patient to obtain a perfect score without remembering any of the memoranda designs at all. Because of the problem this possibility creates in interpreting results, and since there does not appear to be any way to circumvent it (Benton, Note 9) the

Swiss version of the test (Benton, 1961), in which it is not possible to use the elimination method, must be regarded as preferable.

Although Benton (1974) has suggested a delayed reproduction version of the BVRT (Administration D), in which a 15-second unfilled interval is interpolated between the presentation of each memorandum design and the request for drawing from memory, no norms are given for this administration and its use has not been frequently reported.

The only extensive study of the delay version appears to be that of Breidt (1970) who found that, in normals, there was a mean decrease of only 0.4 points in the number of correct reproductions made in Administration D as compared with Administration A. Moreover, a group of 109 brain-damaged patients displayed a mean decrease of only 0.7 points in the same comparison. Breidt also evaluated the effect of increasing the interval to 30 seconds and found that this modification produced only a slightly larger average decrement (approximately one point) in the number correct score of a group of 30 brain-damaged patients.

Lezak (1976, p. 373), however, reports several instances (from unpublished studies) in which patients

made fewer errors on the delayed reproduction, as compared to the immediate reproduction, condition. She suggests that this may be especially true of patients who score very poorly on the no-delay task, whereas patients who achieve adequate scores on this administration generally do slightly poorer when the delay is introduced. The paradoxical improvement in performance with a delay is attributed to the salutary effects of "consolidation" of the memory trace.

A delayed retention version (Administration O) using the earlier multiple-choice material has also been offered (Benton, Note 7). Here again, the procedure is the same for each design, with the standard 10-second exposure time being followed by a 15-second delay interval in which no attempt is made to control rehearsal or standardize mental activity. At the end of this retention period the patient is presented with the multiple-choice arrays for selection. No norms are given for this variation of the task and it is omitted entirely from the new multiple-choice manual (Benton, et al., Note 8).

Talland (1965, p. 211) has been one of the few to report data regarding the delayed reproduction performance of amnesics on the BVRT. He used an interval

of only 10 seconds between the end of inspection and the beginning of reproduction, however. Talland administered this task to a group of 20 Korsakoff patients and found their mean number correct to be only 2.4 whereas with immediate reproduction they had averaged 7.4 correct. Similarly, their error scores rose from a mean of 3.1, without a delay, to 14.4 when they were required to wait 10 seconds before beginning to draw. In general these Korsakoff patients performed at about normal levels when the task was structured as one of immediate memory and their severe retention deficits were only revealed under delay conditions. Talland's report is of further interest in that he provides data showing the increase in each type of error caused by the delay. Thus, perseveration and rotation errors increased greatly with the longer retention interval whereas distortions and misplacements showed only slight gains.

Overall, the results of studies involving delayed retention of the Benton designs have been conflicting. It does appear, however, that for some patients--possibly the more severely impaired ones--the introduction of an appreciable retention interval may be an effective way to elicit a disability which may otherwise go undetected. One way to evaluate the adequacy of retention over time

would be to systematically increase the delay interval during the course of the test. This strategy could allow for the comparison of performance under conditions of minimal and extensive holding periods.

It appears, from the most recent literature survey (Buros, 1978), that there have been no reports of the use of any multiple-choice version of the BVRT involving a delay interval. This would appear to be a particularly felicitous combination given, as discussed earlier, the advantages of the recognition over the reproduction format and the potential usefulness of incorporating a retention interval.

### Colours

Colours have been very infrequently used as truly nonverbal memoranda. Although memory for simple hues of various kinds has been investigated in several studies, involving both brain-damaged patients (e.g., De Renzi & Spinnler, 1967; Basso, Faglioni & Spinnler, 1976), and normal subjects (e.g., Banks & Barber, 1977), the procedure has typically allowed or even demanded a verbal labelling response thus reducing the task to one of memory for linguistic symbols. Concerted attempts to explore the more nonverbal attributes of colour stimuli have been exceedingly few in number.

There has been, of course, periodic interest in colour-naming disorders or "colour agnosia" (see Critchley, 1965, and Geschwind & Fusillo, 1966, for detailed reviews of these topics) but here again the concern has been with perceptual and/or word-finding difficulties rather than disorders of retention of colour information per se.

In spite of the paucity of relevant work, in terms of total output, attempts to measure the more nonverbal aspects of colour memory have had a long history. A hundred years ago, Rood (1879) studied his own ability

to perform delayed reproductions of stimuli using a colour wheel on which the mixtures could be adjusted during rotation. After briefly viewing a memorandum mixture, he found he could immediately reproduce it to within less than a 1% error rate. Further data from this pioneering study indicated a small but steady increase in reproduction error as the delay interval was lengthened to one hour and then to 24 hours.

Half a century later, Collins (1931-32) was able to gain more control over stimulus characteristics by using a spectroscope to present four monochromatic spectral bands as memoranda. Each of four subjects viewed each stimulus for 5 seconds, experienced an unfilled 15-sec. delay interval, and then attempted to reset the instrument to the colour originally seen. Collins reported that, in general, some colours such as yellow (588 nanometers) and blue (461 nm.) were reproduced quite accurately whereas others, namely red (670 nm.) and green (535 nm.) were not. Interestingly, moving some memoranda slightly from their original positions made large differences in memory performance.

Curiosity regarding colour memory began to accelerate during the 1950's and the several studies reported in this decade nicely illustrate many of the problems

which must be confronted by the investigator who wishes to devise adequate measurement methods. An early report by Hamwi and Landis (1955), for example, displays the communication problems which can occur when nonstandardized stimuli are used. These investigators employed coloured chips from a commercial Color Harmony Manual and although dominant wave length data were presented for each of their 10 memoranda, their method of specifying brightness was unorthodox and they made no mention at all of saturation, which is, of course, an essential descriptive dimension. Besides stimulus notational difficulties, their study was of limited usefulness as an NVM report because they deliberately confounded pure colour memory with verbal labeling. In their procedure, a subject was presented with one of the memoranda for 105 sec, and asked to describe it. After delay intervals of 15 min., 24 hrs., or 65 hrs., the subject was read her/his description of the memorandum colour and required to locate it from either the entire array of 670 chips arranged by hue and brightness, or from a smaller but randomized display. High rates of colour recognition accuracy were found under these conditions but because of the uncertainty regarding the specifications of the canards, it is difficult to interpret the meaning of

their results. Some indication of the variability that must have existed in the relative difficulty of the various comparisons can be surmised from the finding that one particular memorandum accounted for 80% of all errors made (!) The authors tried to estimate the magnitude of the response errors but this attempt was also rendered unconvincing by the inability to adequately specify inter-stimulus intervals.

The first line of work in which there was some substantial and sustained interest in measuring NVM for colours can be found in the early series of psycholinguistic studies which were concerned with the relationship between language and nonverbal behaviour. As one way to approach this basic problem, Lenneberg (1953) developed a general methodology for investigating how the way a colour is named is related to how well it is remembered. Several studies in this series (e.g., Brown & Lenneberg, 1954) indicated that the higher the "codability" (as determined by several measures of labelling) of a colour stimulus, the easier it is to recognize after a delay. Conclusions were always limited to the specific combinations of memoranda and canards used, however, and generalizations could not readily be made from one set of stimuli to another (cf., Lenneberg, 1961).

A study by Lantz and Stefflre (1964) best illustrates the way in which colours were employed as memoranda in the linguistic/nonverbal experiments. These authors used a set of stimuli from Farnsworth's (1943) colour discrimination test and another set from an earlier version of the Munsell (1975) series. Both sets of materials included a large number of colours, ranging over the entire spectrum. Each stimulus differed only very slightly in hue and/or saturation from its nearest compare. Their memory procedure involved the presentation of one, or four, colour(s) for a 5-second inspection period, followed by a delay interval of 5 or 30 seconds. Subjects were then required to locate the colour(s) previously shown from the total array. Lantz and Stefflre found that recognition memory performance for a colour was significantly correlated (positively) with the accuracy with which that colour could be described to another person.

The exploration of colour memory measurement procedures has also been of interest to industrial psychologists, especially those at Eastman Kodak. These workers have been concerned primarily with the practical problem of selecting personnel who are able to make accurate delayed matchings of colour samples. Burnham

and Clark's (1955) report describing the development of a test of hue memory is representative of this line of investigations. Burnham and Clark also used the stimuli from Farnsworth's (1943) colour discrimination test and constructed a "roulette" wheel apparatus which enabled the examiner to present any one of 20 memoranda and then to require the subject to select the match from memory by viewing a rotating series of 43 possibilities, one at a time, through an aperture. Since all stimuli were of nearly equal chroma (saturation) and value (brightness), errors made could be attributed to the hue of the colour stimulus only. Colours on the selection wheel were arranged so as to be approximately equally spaced visually, thus allowing for reliable scoring as to magnitude and direction of error.

In Burnham and Clark's procedure, each memorandum was presented for 5 seconds. after which it was covered and the selection wheel was spun to blend the choice colours. After a 5-sec. delay interval, the subject began to slow the wheel and attempted to locate the previously presented colour. Using this method, the authors presented a large body of normative data which indicated a fairly normal distribution of error scores with a mean of about one selection colour (about 2.2 hue

steps in the Munsell system) removed from the memorandum. Amount of previous training or experience in making colour discriminations appeared to have no effect on the memory performance of the subjects. Although hues in the reddish-yellow range were found to be the easiest to recognize and those in the yellowish-green and blue ranges to be the most difficult, there was a relatively high level of interitem difficulty across the memoranda in general. In this study, no consistent hue shifts were found at any wave lengths.

Another early report by the Rochester group investigated the measurement of colour memory via a psychophysical rather than a psychometric approach. In this study, Newhall, Burnham and Clark (1957) used only three observers who produced 1,500 simultaneous and then delayed colour-matching responses in order to compare the results of the two procedures. Twenty-five Munsell colours were used as memoranda and the matching was done by having the observer adjust the controls of a colourimeter. In their procedure, the concurrent matching-to-sample for each colour was always completed first. After a 48-sec. pause, the memorandum was shown again for 5 seconds. A 5-sec. delay interval followed and then the observer was required to again set the variable light source to match the

previously presented colour, this time from memory.

Newhall et al.'s results showed that, under these conditions, delayed matching produced approximately six times the amount of error found with simultaneous matching. This ratio included chroma and value as well as hue errors, however. When each of the tristimulus attributes was considered separately, it was found that in the successive matching condition, observers tended to reliably err in the direction of greater chroma and higher value, but there were no systematic error biases on the hue dimension.

Taking advantage of more modern advances in colourimetry technology, Nilsson and Nelson (Note 10) have recently reported the use of a highly sophisticated apparatus which permits a subject to adjust the wavelength of a light stimulus until it exactly matches that of an identically produced comparison source. Using a psychophysical paradigm, involving repeated presentations and reproduction attempts, these investigators demonstrated that highly trained observers could effect very precise delayed matches (most errors were less than one jnd) of 16 different colour memoranda. Most interestingly, no increase in size of errors was found as the delay interval was increased up to the maximum of 24

seconds. This study indicates that, under optimal conditions, colour memory can be extremely exact and the colour trace apparently does not decay at all, at least within most of the temporal range commonly associated with STM.

Colours have rarely been used for the study of NVM in brain-damaged patients. The first attempt of this kind was probably made by Prisko (1963) who used five different shades of red as memoranda in a delayed comparison task. In her procedure, which was a variation of the Konorski (1959) method, two stimuli were presented in succession, separated by a brief interval. The patient was required to indicate whether the second colour was identical to the first. Shades were chosen such that the difference between any two which were paired was clearly discriminable to the patient when one followed the other without delay. This test, even with the maximum 60-sec. delay interval and an interpolated distractor task, proved to be extremely easy for normal subjects, and contrary to expectations, both right and left temporal-lobe patients performed normally as well. Interestingly, however, H.M. was unable to bridge the brief delays successfully, and according to Milner (Milner & Teuber, 1968), his failure on this task is one of the few docu-

mented instances of impaired STM that he has displayed.

In a more systematic investigation of colour memory in brain-damaged patients, Boller and Spinnler (1967) compared two separate procedures which they intended to be quite different in terms of the relative usefulness of verbal encoding. In both tests the patient was shown a colour stimulus for 10 seconds, followed by a delay interval of 10 seconds, and was then required to choose the memorandum from among six or eight alternatives. Although no precise description of the stimulus materials was given, the canards for the "verbalizable" test were described as being of clearly different hues from the memorandum whereas those of the "nonverbalizable" test were "shades of the same fundamental colour" (p. 399). It was determined that left brain-damaged patients performed more poorly than their right-sided counterparts on both tests. Performance on both memory tasks was found to be related to the presence of visual-field defects and unrelated to performance on separate tests of oral language ability, however, leading the authors to conclude that in spite of the left-hemisphere superiority shown for colour memory, the linguistic capacity of the sinistral brain was not the responsible factor (see Brewer, 1969, however, for a re-interpretation of

Boller and Spinnler's data in terms of a verbal encoding hypothesis).

Malone and Hannay (1978) also reacted to Boller and Spinnler's conclusion that left-hemisphere superiority prevails for colour memory regardless of the "verbalizability" of the task. They conducted a series of tachistoscopic laterality experiments, with normal subjects, using colour stimuli from the Munsell (1975) series. In their general procedure, a memorandum colour was presented to one visual field and then, after a variable delay interval, a comparison stimulus was presented to the same field, signaling the subject to make an identity judgment. In some procedures, the canards differed from the memoranda in terms of hue while in others they differed in saturation. Whereas in the first experiment, the canards were of markedly different characteristics from the memorandum, in the subsequent procedures the memorandum-canard distance was progressively reduced. As expected, a significant right visual-field preference was found in the first two experiments and as the possibility of making discriminations based solely on verbal labels was minimized, this superiority disappeared and no hemispheric asymmetries were found in experiments 3 and 4.

Although Malone and Hannay were not able to produce a clear left visual-field effect for colours, in spite of their attempts to do so, this result has, in fact, been reported using similar materials but in a concurrent-matching, rather than a memory, paradigm. Davidoff (1976) used pairs of Munsell stimuli which were selected to be either very close or identical on either the hue or saturation dimensions and found that discrimination judgments were significantly more accurate when these pairs were presented directly to the right hemisphere.

In summary, the evidence relevant to the question of the "nonverbalness" of colours as memoranda is scant and ambiguous since few reports have attempted to address this matter directly. The early psycholinguistic studies (e.g., Brown & Lenneberg, 1954; Lantz & Stefflre, 1964) suggested that colours which were the easiest to name were also the easiest to remember and further indications of the importance of verbal mediational processes in colour memory were provided by Boller and Spinnler's (1967) finding of a left-hemisphere superiority even for a perceptually difficult colour memory task.

On the other hand, Malone and Hannay (1978) were able to eliminate the right visual-field advantage of their colour memory task by making the discrimination

less amenable to verbal solution and Davidoff (1976) produced a reliable left visual-field effect for the same materials. Nilsson and Nelson (Note 1) also considered their data from the point of view of semantic encoding influences and rejected this alternative, noting that there was no shift in errors toward the most easily named primary colours and that specific memoranda which were the most difficult to describe were, in fact, among the most stable in memory. Taken together, these later studies appear to indicate that there may, in fact, be a nonverbal component to memory for colours, but that this nonverbalness is an ephemeral phenomenon which depends greatly upon the materials and procedures used to define the measurement task.

Of all the various kinds of stimuli which have been used for the creation of colour memory tasks, those with the most potential for the development of a NVM test for clinical use appear to be the Munsell colour standards. These materials are based on a colour description system (Munsell, 1975) in which the location of any colour can be precisely specified on the three dimensions of hue, value and chroma. The notation of a colour on any dimension indicates its position along a scale which is constructed such that all steps are equally spaced

perceptually (Newhall, Nickerson & Judd, 1943).

In the Munsell system, the hue notation, for example, precisely locates that colour along a continuous and equal interval scale of 100 steps. The value notation indicates the degree of brightness of the colour, the scale extending from absolute black ( $V=0$ ) to absolute white ( $V=10$ ). The chroma notation describes the degree of saturation of the colour ranging from the weakest or most gray ( $C=0$ ) to the most vivid ( $C=10, 12, \text{ or } 14$ , depending on the hue).

For memory task design purposes, the Munsell system offers considerable advantages. Hundreds of precisely defined and perceptually distinguishable stimuli are available providing a large pool of standardized materials. Most importantly for the measurement of NVM, the perceptual distance between a memorandum and any comparison colour can be systematically varied along any one of three dimensions while holding the other features of the stimuli constant. This degree of quantitative control over the relationship between the memorandum and its canards is extremely difficult to obtain with any other type of stimuli and makes the Munsell colours unique and valuable as nonverbal materials.

### Faces

Faces have been one of the more popular types of memoranda used in attempts to measure NVM. Most studies have utilized photographs of people unknown to the experimental subjects. These stimuli appear, on an intuitive basis, to be quite difficult to describe adequately in words and thus have been regarded by many investigators as having a high degree of "face" validity as nonverbal materials. Also, as compared with many ostensibly nonverbal memoranda of the "meaningless" variety, faces represent a kind of visual stimulus which is highly relevant to everyday activities. Faces have had further appeal as nonverbal memoranda because of the virtually unlimited variety of examples, all unfamiliar to the subject, which may be obtained.

Faces do present problems as nonverbal materials, however. Because of their highly idiosyncratic nature, faces are probably impossible to describe precisely in terms of physical characteristics. This limitation has hampered communication about stimulus materials and it is often difficult to determine essential characteristics (such as potential for verbal mediation) of the set of faces used in any investigation unless all are

reproduced in the report. Because of the lack of objectively defined stimulus parameters there is no way to measure interitem "distance" between memoranda and canards and thus, no estimate of degree of recognition error is possible. Some of the shortcomings with the use of faces as nonverbal memoranda could be rectified if a single set of stimuli were to be developed and widely adopted for use. Such a standard set of materials would allow at least for the determination of response measures (such as degree of perceived similarity of one face to another, degree of difficulty as a memorandum, etc.) and would enable workers to precisely reference the stimulus materials they employ.

Faces have a long history of use as memoranda but it has only been in recent years that materials and procedures have been designed carefully enough to allow the investigator to state with much confidence that the task is likely nonverbal in nature. In many studies, especially the early ones, the possibility that the task could be verbally mediated appears quite high. Bartlett's (1932) experiments, which were some of the first attempts to explore facial recognition, are classic examples of how to turn faces into verbal stimuli. Each memorandum photo was clearly identifiable by nonfacial features

(pipe, cap, etc.) and Bartlett explicitly instructed his subjects to note and recall as many characteristics of each "face" as possible.

Faces were rarely used for the study of memory disorders in patients before the 1960's but Eysenck and Halstead (1945) included a measure of facial retention in their battery of 15 memory tests. Their memoranda (photos of faces from a popular magazine) were not selected so as to minimize discriminations on the basis of nonfacial cues either and their procedure required the patient to repeatedly scan the entire set, thus facilitating verbal comparisons.

Several studies in the last 15 years have investigated memory for faces in unilateral brain-damaged patients and much of this work is relevant to the question of the nonverbalness of faces as memoranda. De Renzi and Spinnler (1966), for example, used photos of men and women in both front and profile views. They commented that:

Special care was taken to make sure the faces used in the photographs were free from easily recognizable details such as a scar, mustache or glasses and from definite expressions such as smiling. Furthermore, all subjects were

covered up to mid-neck by a sheet and thus had the appearance of customers in a barber shop.

(p. 148)

In De Renzi and Spinnler's procedure, the patient was given one memorandum photo at a time for a 15-sec. study period and then, after it had been removed, was required to find it again among an array of 20 possibilities. The photos in the multiple-choice display were of five men and five women each pictured front view and in profile so the patient's task reduced to a one out of five choice once the obvious canards were eliminated. Performance on this task was found to be correlated positively with that from a nonsense figures test and deficits on both tasks were significantly related to right-hemisphere brain damage. Because poor performance was also predicted by the presence of visual-field defects, however, the authors interpreted their findings as supporting the view that the basic deficit in facial recognition is of a perceptual rather than a mnemonic nature.

De Renzi, Faglioni and Spinnler (1968) confirmed the results of the earlier study using a somewhat different task. Here, the procedure involved a delay interval of 60 secs., filled with conversation, and then the test faces were presented in a yes/no sequential

recognition format. The results indicated that only right-hemisphere brain-damaged patients with visual-field defects performed poorly on the delayed recognition measures and the authors again argued for the saliency of perceptual rather than memory determinants in explaining this hemispheric asymmetry.

In the work of De Renzi and his colleagues we see more care taken in the selection and preparation of facial stimuli than is the case in the work of earlier (and many later) investigators. The photos used were chosen specifically to reduce the possibilities for verbal coding. Firstly, cues from clothing, facial hair, etc. were eliminated, making the task more purely dependent on memory for physiognomic features. Secondly, an attempt was made to standardize facial expression and orientation thus avoiding easy discriminations on these dimensions. Finally, and for the first time, more than one view of the same person is seen, thus allowing for the possibility of determining if the patient is actually able to recognize the same face, seen in different ways, rather than just an identical picture.

Warrington and James (1967) were also among the first to investigate facial retention in patients with unilateral cerebral lesions. In their procedure, a

memorandum face was shown for a 10-sec. inspection period and then the patient was required to select this face from a sequentially presented series of eight possibilities. Right-hemisphere brain-damaged patients were found to be impaired on this task whereas left-hemisphere brain-damaged patients performed no differently from controls. Since deficient performance was most clearly associated with right parietal injuries, Warrington and James inferred that perceptual rather than memory functions were the most compromised.

Milner (1968) used college graduation photos of both males and females as test stimuli. Twelve of these were shown simultaneously for an inspection period of 45 secs. After delays of varying lengths, an array of 25 photos was presented which included the original 12 plus 13 of other students from the same series.

Besides the predicted findings of impaired performance only by right temporal-lobe patients, one unexpected result emerged. When the delay interval was eliminated and the recognition set presented immediately after the inspection set, normal subjects performed significantly more poorly than they did when tested after delays of 90 secs., with or without a distractor task. By contrast, the right temporal-lobe group per-

formed equally poorly with or without a delay period. Milner speculated that normals may use the time following presentation of complex visual materials, such as faces, for some kind of nonverbal rehearsal or recoding which improves their performance. According to her interpretation, right temporal-lobe patients seem unable to use this recirculation mechanism and thus do not profit from the delay.

Milner concluded that, in general, faces are particularly apposite stimuli for highlighting the NVM deficits found after right temporal lobectomy. She noted that this appears to be so because of the high level of visual complexity of each individual face coupled with the high degree of similarity among all members of this class of memoranda.

In a recent study (Dricker, Butters, Berman, Samuels & Carey, 1978), Milner's procedure was replicated using a new set of graduation photos. Right-hemisphere brain-damaged patients were again found to be impaired on delayed recognition, but these authors included a concurrent-matching task also and found that the right-lesioned patients were unable to accomplish this successfully. Dricker, et al.'s results suggest that Milner's patients may have had more of a perceptual

than a memory deficit and emphasize the necessity for adequate input/output controls in memory studies with patients.

In virtually all facial retention studies the test photograph of the memorandum face has been identical to the initially presented photo. In Dricker, et al.'s study, however, right-hemisphere patients and Korsakoff patients displayed great difficulty in even concurrent matching of faces when the photos to be compared showed the same person but with different facial expressions. In tasks where duplicate photos are used, the patient may be able to remember a memorandum face by verbally encoding particular aspects of the person's expression. The use of different facial poses for the presentation and test photos eliminates this mediational strategy and creates a more realistic test of "person" recognition, as well.

The state of the art of preparing nonverbal facial stimuli has been demonstrated by Benton and Van Allen (1968) who developed a set of materials with carefully controlled characteristics. Male and female university students, of approximately the same age, were photographed such that only facial features were visible, excluding even differences in hair styles, and all had

a uniform, poker-faced expression. Front, three-quarters, and profile views of each face were taken along with views under different lighting conditions. Benton and Van Allen used these photos in a perceptual paradigm only and determined that inadequate matching-to-sample was clearly associated with right-hemisphere brain damage.

The Iowa faces have since been made generally available in the Test of Facial Recognition (Benton & Van Allen, Note 11; Benton, Van Allen, Hamsher & Levin, Note 12). Because nonphysiognomic cues have been so thoroughly excluded, these stimuli represent probably the best set of faces generally available for the study of NVM. Benton, et al.'s suggested procedure involves only concurrent matching-to-sample and other investigators as well (e.g., Jones, 1969; Levin, Grossman & Kelly, 1977) have used the materials to assess perceptual adequacy only. Although these faces would appear to be ideal stimuli for use in the measurement of NVM also, as yet there have been no reports of their use in any retention paradigm.

Some evidence as to possible hemispheric specialization for facial recognition (and thus indirect evidence as to its presumed nonverbalness) may be gleaned from

clinical and experimental studies of prosopagnosia. The lesion localization data on this question have been recently summarized by Marlowe (1977, pp. 42-44) with the conclusion that the great majority of patients exhibiting this disorder have right-hemisphere injuries, but that a considerable number have some left-hemisphere damage as well.

The prosopagnosic findings are likely of even more limited value as evidence as to the nonverbalness of memory for faces since the deficit is usually defined as the loss of the capacity to recognize familiar faces as such. The ability of these patients to recognize unfamiliar faces on re-presentation is unknown in many cases but at least one study (De Renzi, Scotti & Spinnler, 1969) indicated that prosopagnosics did no more poorly on this kind of task than did right-hemisphere-lesioned patients in general.

There has been some controversy regarding the issue of whether separate and unique brain mechanisms are involved in the recognition of faces or whether essentially the same processes are used as for the recognition of any complex visual stimulus. The evidence pertaining to the specificity issue is not germane to this discussion of the nonverbalness of faces but attempts to

resolve the matter (See Ellis, 1975, for a review) have prompted the use of faces as nonverbal memoranda in novel ways. Yin (1970), for example, presented inverted faces to unilateral brain-damaged patients, in a delayed recognition task, and found that those with (non-frontal) right-hemisphere lesions actually did better than those with comparable left-hemisphere lesions. The usual finding of greater impairment in memory for faces following right-hemisphere lesions was confirmed when the photographs were presented in the normal orientation. A similar dissociation was not found when houses (upright and inverted) were substituted in the same task.

On the basis of these findings, Yin argued that there is a system in the right posterior brain which is not only face-specific but also orientation-specific. Another way of interpreting his results is that inverted faces may somehow lose their nonverbal character. Perhaps whatever it is which determines preferential processing for faces by the right hemisphere is dependent upon their normal orientation. Yin's results seem to be counter-intuitive since one would expect faces to be less meaningful when inverted.

Some additional evidence as to the cerebral laterality of memory for faces has come from ECT studies. In one representative report, D'Elia, Lorentzson, Raotma and Widepalm (1976) presented patients with an array of 30 faces as memoranda and then required them to select these again from a larger array containing the originals plus 30 novel canards. The stimuli used were achromatic photos of medical students of which half were males and half females. The authors found, as expected, that patients showed reliable performance decrements on this task after receiving unilateral nondominant ECT, whereas, those to whom dominant-hemisphere treatments were given showed no change. The usual double dissociation was completed when word pairs were substituted for faces.

In summary, the studies which have evaluated memory for faces following unilateral insults to the brain have confirmed the expected finding that right-sided damage produces the more severe impairment. Many of these investigations have strongly suggested, however, that the performance deficits seen on delayed recognition tasks, using faces as memoranda, may be due to perceptual rather than mnemonic inadequacy. The possibility that many right-brain-damaged patients may have

particular difficulties in making discriminations among faces, even without a memory load, must be taken into account by any investigator who wishes to study memory processes per se. It seems clear that the confounding of perceptual and memory factors in previous work has greatly limited the usefulness of the data obtained as evidence as to the status of NVM. Perhaps the major contribution of the unilateral studies has been to emphasize the need for adequate input-output control procedures in future work.

There have been, of course, numerous attempts to explore performance differences in various facial recognition tasks contingent upon brief presentation of the memorandum to one visual field or the other. In much of this work retention intervals have been either nonexistent or so brief as to render the data more useful for the understanding of perceptual rather than memory processes. A few visual half-field studies have been reported, using faces as memoranda, in which the retention interval has been systematically lengthened, however, and the results of these investigations provide some suggestive evidence as to lateral asymmetries in NVM.

Hilliard (1973), for example, presented a briefly exposed face photograph to one visual field or the other

and then required subjects to make a yes/no identity decision to a test face presented, at fixation, following a delay interval of either 500 msec~~s~~. or 10 secs. The recognition accuracy data revealed a left visual-field superiority for both retention intervals leading Hilliard to suggest that the preferential processing of facial stimuli by the right hemisphere is unaffected by differential storage times.

The effects of varying retention intervals on memory for schematic faces exposed briefly to only one visual field have been further explored by others such as Patterson and Bradshaw (1975) and Moscovitch, Scullion and Christie (1976). Both of these reports provided evidence of a strong left visual-field effect at longer delays (up to 5 mins. in the former and up to 1000 msec~~s~~. in the latter) suggesting that processing asymmetries seen with faces may extend beyond the initial registration stage.

Since the longer delay intervals used in this work greatly exceed callosal transfer latencies, interhemispheric communication effects cannot be ruled out. Thus, although these tachistoscopic laterality studies are interesting in suggesting that "perceptual" asymmetries can be observed even after substantial delay periods,

their relationship to the issue of the nonverbalness of memory for faces is, at best, oblique and they have been considered only briefly here (See Van Mastrigt, 1977, pp. 40-44, for a more extensive summary).

Faces have been contrasted with verbal memoranda in studies using global amnesic patients. In one investigation with interesting results, Warrington and Taylor (1973) explored memory span for faces using photos of male actors taken from a theatrical magazine. A string of 1, 2, 3 or 4 faces was presented followed by a demand to identify the ones shown from a sequence which included one canard for every memorandum. Amnesic patients displayed increasing deficits, compared with normals, as the list was lengthened but their performance was identical to that of the control group when surnames were substituted for faces.

In a second experiment, described in the same report, minimal delay recognition was compared with that of a 30-sec. delay interval using three faces at a time as memoranda. Although amnesic patients were substantially more inaccurate than normals, neither group showed any degree of forgetting over the retention period. By contrast, both groups showed the usual decay function over time when surnames were substituted.

The results from both of Warrington and Taylor's experiments were taken to support the contention that memory for faces and memory for surnames exhibit quite different properties. The authors further argued that faces are processed exclusively by the LTM system and that no STM component is involved.

In a later study, using similar stimuli, Warrington (1974) presented 50 faces in succession at the rate of one every 3 secs. In the retention phase, every memorandum was presented again, each paired with a novel canard selected from the same pool of faces, the patient being required to indicate the one which had been seen before. Warrington found her sample of four amnesic patients performed at no better than chance levels on this task and were grossly inferior to normal controls who averaged only a few errors. Similar results were found, however, when words or representational paintings were used as memoranda in the same procedure, and, this time, Warrington interpreted her findings as evidence against material-specific memory disorders in amnesic patients. Alternatively, the procedure used in this study may have created a task which was too difficult for any material-specific differences to be seen in amnesic patients.

A large number of other studies have compared memory for faces with that for verbal memoranda using either normals or variously impaired groups of subjects. In a recent report, for example, Holmes and McKeever (1979) found dyslexics to have adequate recency discrimination when faces were used as memoranda but to be markedly deficient when words (they could read) were substituted in the same task.

Numerous other investigations have suggested that faces are processed differently from the way in which verbal materials are handled but many studies revealing no differences between the two kinds of materials have also been reported. The most general statement which can be made is that there appears to be an interaction between faces versus verbal materials and the type of procedure used. Since few studies have been designed carefully enough to ensure equivalent levels of difficulty for each type of memoranda and to avoid ceiling effects, etc., the question of the uniqueness of the facial memory process remains unresolved in spite of the vast amount of work published.

Several studies (e.g., Warrington & James, 1967) have employed well-known faces, such as those of popular entertainers or political figures, as memoranda. It seems likely that this kind of stimulus would be quickly translated into a verbal code and thus not be suitable for use in the measure of NVM. Evidence in support of this interpretation has been presented by Marzi, Brizzolara, Rizzolatti, Umilta and Berlucchi (1974) who found a right visual-field superiority for the recognition of famous faces. These investigators reported also that the visual-field superiority for unknown faces can switch from left to right if the subject is given practice in associating a name with each anonymous face. It seems clear that if faces are to be used as memoranda for the study of NVM, only unfamiliar ones should be employed and care should be taken to ensure that these are not shown so extensively, during the presentation phase, that the patient is able to develop associative labels for each.

Because of the complexities inherent in faces as visual stimuli, virtually all attempts to devise procedures to measure memory for faces have structured the task as one of recognition or delayed matching in some way. There have been a few efforts to explore

procedures for assessing recall of faces, however.

Tasks in which subjects were required to reproduce previously seen faces by drawing them have not appeared feasible due to the difficulties in controlling for variations in artistic ability or in scoring the productions. Other methods, using schematic faces, have offered promise, though.

Smith and Nielsen (1970), for example, used drawings of faces which were prepared such that each of five features was varied as to size. After a brief presentation and a variable delay interval, the subjects were given the name of a feature and asked to recall whether it was small, medium or large. It seems likely that a task demand of this kind would predispose the subject to process the face drawings in a verbal manner, however.

In an extensive series of studies, McKelvie (1976) explored the effects of verbal labelling upon the subsequent recognition of schematic faces. Memory for these stimuli was found to be better when subjects were given pretraining involving the association of a descriptive name to each memorandum but this result only held for those faces which were difficult to label. McKelvie concluded that verbal labels can be useful both in the encoding and retrieval stages of retention but that

their effectiveness depends entirely on the task characteristics.

Although endeavours to explore recall and recognition of schematic faces are interesting, the extent to which these artificial configurations can be considered similar to real faces is unclear. Also, because they are composed of separately identifiable components, schematic faces seem more likely to allow, or even promote, verbal encoding. It may be that the recall of faces operates quite differently from recognition processes for the same stimuli but this question cannot be addressed until an appropriate method for the evaluation of reproductions of real faces becomes available. Ellis, Shepherd and Davies (1975) have suggested a potentially feasible possibility, however, using the Photo-fit technique to reconstruct photographs of faces.

Intuitively, memory for faces seems to depend on visual imagery rather than linguistic processing of the information. Many workers have, in fact, expressed the opinion that faces are truly nonverbal stimuli and that the likelihood that they are encoded verbally is remote. In his review of factors affecting the process of facial recognition, Ellis (1975), for example, concluded that recognition of faces seems to be almost entirely a

visual process and that attempts to explore the role of verbal coding have been unsuccessful in showing evidence of such mediation.

In one of these efforts, Goldstein and Chance (1970) showed 14 faces, taken from a university yearbook, to a group of students and asked them to write a word or phrase describing what each reminded them of, or looked like. If the stimulus had no associative meaning the subjects were instructed to write, "no". As expected, responses to faces were more frequent than to the other nonverbal stimuli (ink blots and snow crystals) to which the same procedure was applied. Although faces were also found to be easier to remember, as a group, than the other types of memoranda, Goldstein and Chance determined the relationship between association value and degree of difficulty as a memorandum for each face and found all correlations to be negligible or negative. They therefore concluded that their results did not support a mediational interpretation of facial recognition.

The question of verbal mediation in facial recognition was further explored by Malpass, Laviguer and Weldon (1973) who gave subjects extensive training (8 hrs.) in generating and using verbal descriptions of faces as an aid to memory. Although subjects showed marked

improvement in their ability to communicate about faces, no subsequent gains were found in their ability to remember them. On the other hand, a brief training session, emphasizing visual practice only, produced significant increments in delayed recognition performance. This result led the authors to conclude that verbalizations are likely ineffective mediators of memory for faces.

Because of the obvious practical importance of memory for faces in normal subjects, this topic has received considerable attention from researchers and an extensive body of literature has accumulated. Some of the information from these investigations (e.g., Laughery, Alexander & Lane, 1971) provides useful normative data for the construction of a facial recognition task. One extensive and up-to-date survey of the stimulus and subject factors influencing memory for faces has been provided by Goldstein (Note 13). The consensus of this and other reviews (e.g., Ellis, 1975) appears to be that there are few, if any, factors which have been shown to yield consistent and robust effects. Thus, there are data suggesting that females are better at facial recognition, data which indicate that males are better, and still other findings which point to

interactions of both kinds with the sex of the memorandum face. The same pattern of conflicting results appears to be the case with other stimulus and subject factors, such as race, age, etc. Moreover, this indeterminacy extends to procedural variables as well. There is no agreement, for example, that more time spent viewing the memorandum produces better recognition performance, or that a longer retention interval decreases performance levels.

Most disturbing of all perhaps, Goldstein finds that there is a very wide range of differences in "memorability" across individual faces used in recognition studies. Some faces appear to be readily recognized (correctly) by almost all subjects, whereas other memoranda faces have hit rates which are reliably much lower. Similarly, some faces used as canards have false positive rates as high as 12 times those for others which are rarely chosen (incorrectly) as having been seen before. This discrepancy is found in spite of the fact that the highly popular canard faces do not seem, on an intuitive basis at least, to resemble the memoranda faces more than the other canards. It appears that at present, we have no way of specifying degree of similarity among faces and no way to account for why some should be

more "memorable" (correctly or incorrectly) than others. Again, these are problems which could be at least partly alleviated by the development of a standardized set of faces, with known response measures, which all investigators could communicate accurately about.

Until such time as universally referenced facial stimuli become available, investigators who wish to measure NVM for faces must either prepare a set of novel faces for which the possibility of making discriminations based on verbal cues appears remote, or select for use a collection of commercially available stimuli, such as the Benton and Van Allen photos, which have been carefully created so as to minimize verbal encoding.

In all but a very few studies (e.g., Tzavaras, Hecaen & Le Bras, 1970; Galper & Hochberg, 1971), the "target" photos used in the test series have been identical reproductions of the memoranda photos. This way of preparing the materials reduces the task to one of picture recognition rather than true memory for faces, however. In everyday experience, faces are commonly recognized in spite of continual changes in expression or angle of viewing. If the

results of a test of facial memory are to be generalized beyond the laboratory situation, the procedure should require the subject to recognize the same (memorandum) face from photos which show this face from different camera angles and with different expressions.

In one study in which these factors were systematically varied, Patterson and Baddeley (1977) found that normals were able to recognize faces changed moderately in pose and expression about as well as faces which were identical at presentation and test. As would be expected, recognition rates dropped, however, when the memoranda faces were re-presented in profile view or with any major change in appearance, such as with the addition of glasses. Since the use of different poses and expressions, for the same memorandum face, would also serve to eliminate these factors as verbal cues, this strategy appears ideal for the measurement of NVM and has been incorporated into the facial recognition materials described in the next chapter.

### Nonsense Figures

In 1963, Kimura first described the use of a set of "unfamiliar stimuli" which have, since that time, gained some measure of popularity as nonverbal materials. Her stimuli are of two types. One set is composed of basic geometric figures, made up mainly of straight lines and arcs of circles, which have the appearance of being drawn with the aid of simple drafting equipment. The other set consists of irregular, amorphous figures, made by meandering, open-ended and overlapping lines. These latter stimuli have the appearance of being aimless scribbles drawn in a freehand style, and were referred to by Kimura as "nonsense figures". Both kinds of stimuli are complex in the sense of having many points of inflection, and both were considered "meaningless" in that they were not intended to be representations of nameable objects.

Kimura used a continuous recognition procedure to structure her task. A sequence of 160 stimuli was prepared, using both geometric and nonsense figures, interspersed in a random fashion. The figures in this sequence were arranged, however, such that 8 of them occurred 8 times each, 4 geometric figures and 4 nonsense figures appearing once each at random locations through-

out each block of 20 figures. Each of the remaining 96 figures was unique.

In Kimura's procedure, the figures in the sequence were presented one at a time and for each the patient was required to indicate whether or not (s)he had seen the figure before. Thus, for the first block of 20 stimuli all figures would be novel to the patient, whereas in the remaining 7 blocks of 20 stimuli, the 8 memoranda figures were expected to become more familiar with repeated presentations. This continuous recognition task was designed as a nonverbal analogue of Hebb's (e.g., 1961) recurring digits test.

In evaluating a patient's performance, Kimura calculated a net score, defined as the number of correct recognitions of the memoranda figures minus the number of false positive choices. She found that this corrected score reliably differentiated between left and right temporal-lobe resection patients. Further inspection revealed that the two groups did not differ in terms of total number correct and that the separation of the two types of patients was due entirely to the very high false positive rate of the right lobectomy cases. Also of interest was the finding that the geometric figures alone were relatively poor in discriminating between the

two groups while the nonsense figures alone showed a highly significant intergroup difference.

Milner and Kimura (cited in Milner, 1967) next replicated this study using a new sample of patients which included parietal lobectomy cases. The right temporal-lobectomy patients were again found to be significantly impaired, in contrast not only to the left temporal-lobectomy group but also to the left and right parietal-lobectomy patients, all of whom performed similarly to normal controls. This time, the right temporal group showed a clear impairment on the total score measure (false positive plus false negative responses) and no analysis was reported by type of error.

In order to determine if the deficit shown was, in fact, material-specific, Milner and Kimura (cited in Milner & Teuber, 1968, p. 346) also administered an analogous task, using words, nonsense syllables and 3-digit numbers, to their temporal lobectomy patients. As expected, it was the left temporal-lobectomy patients who were impaired when these verbal memoranda were used while the right temporal-lobectomy group's performance did not differ from that of normal controls. In this comparison, the incidence of false positive responses varied greatly across patients for both the verbal and

nonverbal tasks, suggesting that this measure is not necessarily a defining characteristic of deficient performance when the continuous recognition procedure is used.

In spite of uncertainties regarding which measure of performance to use, Kimura's demonstration of a clear double dissociation suggested rather strongly that right hemisphere and/or nonverbal processes were essential to the retention of these "unfamiliar" figures. This relationship was seen most strikingly when the nonsense figures rather than the geometric figures were used and since performance was most impaired when anterior rather than posterior lesions were involved, mnemonic rather than perceptual deficiencies appeared to be implicated.

In a further report from the Montreal group, Barbara Miller (1973) used Kimura's recurring figures to investigate the effects of unilateral nondominant- versus bilateral-ECT. The memoranda were presented to the patients before treatment and a recognition test administered afterwards. No significant difference was found between the two groups, suggesting that the involvement of the left hemisphere may be irrelevant to the level of performance seen in the retention of these materials. This study was important because (according to Robertson

& Inglis, 1977) no other investigation has compared the retrograde effects of the two ECT treatments on material which could not readily be verbalized.

The materials and instructions for the "Recurring Figures Test" have since been made available (Kimura, Note 14) to other investigators. The figures are drawn in black on white cards (.08m by .13m) and it is recommended that each be presented for three seconds. The only normative information given by Kimura is that from a group of 11 normals who obtained a mean net score (correct identifications minus false positives) of 38.9 out of the 56 points possible.

Newcombe (1969, p. 84) administered the Recurring Figures Test to groups of patients who had incurred missile wounds to the brain some 20 years previously. Although performance differences between left- and right-hemisphere groups did not reach significance, the trend was clearly in the direction of a right-hemisphere deficit on this task. Right-temporal and right-parietal groups were particularly impaired as compared with their left-lobular counterparts. Overall, however, the net scores for all patients were not reliably different from those for a normal control group ( $N = 28$ ,  $\bar{X} = 28.5$ ). It was suggested that most of the patients had apparently

made a complete recovery and this fact likely accounted for the failure to find consistent hemispheric differences. The scores of Newcomb's control sample were markedly lower than those obtained by Kimura's normals, however. Since the former groups was much older than the latter, this result suggests that the task may be sensitive to the effects of aging.

This question has been pursued by E. Miller and Lewis (1977) who used the Recurring Figures Test to study NVM in three groups of elderly subjects. A significant feature of their analysis was the use of signal detection measures to separate mnemonic processes from decision strategy. When they considered the relationship between hit rates and false positive rates, the authors were able to find reliable differences among depressives, demented and normals by dissociating memory efficiency from willingness to guess. Thus, while the controls made the highest number of correct recognitions, their false positive rate was also higher than the depressed patients, who adopted the most conservative response strategy of all groups. E. Miller and Lewis suggested that, even though both groups performed poorly, the Recurring Figures Test could be used to aid in the differential diagnosis of depression and dementia via this process of

error analysis.

In an earlier study, Brooks (1974b) administered the Recurring Figures Test to 34 severely head-injured patients and found that the net score (total correct minus false positives) significantly differentiated the patients from normal controls. Further analysis indicated that the two groups did not differ in terms of false positive errors, but that the head-injury patients made significantly more false negative responses. In an attempt to explore possible material-specific memory disorders within the test, Brooks also compared the performance of aphasic with nonaphasic patients and found that these groups did not differ in their responses to the geometric figures, nor to the nonsense figures when each of these stimuli were considered separately.

The data from Brooks (1974b) study were further subjected to a signal detection analysis and the results formed the basis for a second report (Brooks, 1974a). The author's general conclusion here was that head-injury patients are impaired in their "true" memory efficiency when this is evaluated with measures which ostensibly permit the examiner to make corrections for differential rates of guessing. In addition, Brooks concluded that head-injured patients adopt a

significantly more cautious (and inappropriate) strategy in responding to the stimuli of the Recurring Figures Test, thus making very few misidentifications, but at the cost of missing many "signals".

In a recent comment, Richardson (1979) has criticized Brooks' (1974a) arguments for the use of signal detection analysis with the Recurring Figures Test and has drawn quite different conclusions from the same data. Richardson points out that several assumptions, essential to the appropriate use of signal detection measures, are not met within the context of simple recognition tests, such as Kimura's and that the validity of the parameters of signal detection theory, as indices of sensitivity and response bias, are thus highly questionable in Brooks' analysis. He further suggests that, when the theory is applied in an appropriate manner, Brooks' data indicate a memory disorder but no concurrent change in response bias for head-injury patients. The same conclusions are shown to hold when theory-neutral or nonparametric, procedures are used.

In general then, it appears that although several ways of coping with the problem of response bias in the Recurring Figures Test have been attempted, none have been wholly successful. Kimura's early attempts to

correct for differential guessing rates and later signal detection analyses have both been criticized as inadequate. Since the problem of differential strategy is unavoidable in yes/no recognition tasks, it may be that the best approach is simply to examine the false negative and false positive scores separately and avoid correction procedures or theory-dependent analyses.

Additional sets of "nonsense figures", similar to Kimura's have been prepared by other investigators. De Renzi (1968), for example, reported the use of two such sets. Stimuli from the first group had the appearance of brief but continuous scrawls. When these were presented in a paired-associate procedure, it was found that left hemisphere brain-damaged patients were not able to remember them as well as right hemisphere brain-damaged patients. A second set of stimuli were then constructed which were also continuous scrawls but which were more complex in that the continuous lines were longer and created much more convoluted figures. When these were administered in a continuous recognition procedure, Kimura's original findings were supported. The results showed that this time the right-hemisphere patients did significantly poorer than the left hemisphere patients but that virtually all of this difference

was accounted for by those right-hemisphere patients with visual-field defects. De Renzi attributed the reversal of effect in the first study to the use of the paired-associate procedure rather than to the simplicity of the figures.

Several other workers (e.g., Samuels, Butters, Goodglass and Brody, 1971; Goodglass, Denes & Calderone, 1974; Umilta, Bagnara & Simion, 1978; Bevilacqua, Capitani, Luzzatti & Spinnler, 1979) have prepared original sets of "nonsense figures" similar to those first devised by Kimura. None of these more recent stimuli have been shown to be right-hemisphere specific or to be "nonverbal" in any way and none have gained the degree of familiarity, among research workers at least, attained by the originals.

On the basis of the evidence relating them to right-hemisphere processing, the stimuli devised by Kimura appear to offer potential for further evaluation as nonverbal memoranda. The nonsense figures in particular may be the most useful, as they seem to be more difficult to encode verbally than the geometric figures and, according to Kimura's analysis, are greatly superior in sensitivity to right temporal-lobe lesions. The fact that left-hemisphere insults do not appear to

significantly impair the retention of these figures is consistent with the assumption that they may be regarded as nonverbal memoranda.

### Random Shapes

Many attempts have been made to produce "meaningless" configural materials for which the stimulus properties could still be quantitatively expressed (see Michels & Zusne, 1965, and Brown & Owen, 1967, for reviews of the earlier work on this topic). Of all the various possibilities suggested, the methods described by Attneave and Arnoult (1956) have been by far the most widely used to create nonverbal memoranda. These authors described how populations of two-dimensional shapes could be constructed by following a set of decision rules (as to number of sides, size of angles, etc.) and by choosing the particular values for each point from a table of random numbers. Different sets of shapes could be specified by varying the decision rule parameters and within each set, an almost unlimited number of specific stimuli could be obtained by varying the locations of the reference points.

For the creation of any single stimulus, Attneave and Arnoult's method entails selecting a number of random co-ordinates on a large matrix and then connecting these points to form an irregular, multi-sided figure. The stimulus thus produced typically appears as a solid black polygon with straight-line contours. By

using their method these authors were able to create a very large number of shapes, each being unique, but all from each set being equivalent in terms of stimulus properties.

Attneave and Arnoult's method was part of a general line of work in which an attempt was being made to define subjective factors, such as complexity, solely in terms of stimulus properties. Thus, a shape with 12 points of inflection could be regarded as more complex (and thus more difficult to remember) than one with only six points since the former requires that more information be processed.

Complexity is not the only dimension relevant to the processing of configural material, however. Other factors, such as meaningfulness, may be highly important also. Even though created by a random process, a particular 12-point shape may be seen by a subject as resembling some common object and therefore may be "meaningful" as such. If a particular 6-point shape does not elicit a comparable association, it may be more difficult to remember in spite of the fact that it is less objectively "complex". Within a particular set of randomly constructed shapes, all of the same objective complexity level, there may be wide variations in

meaningfulness which in turn could greatly influence the difficulty of each shape as a memorandum.

One attempt to gain some control over the meaningfulness dimension was reported by Vanderplas and Garvin (1959a). This study became a classic reference which provided a point of departure for virtually all succeeding work with random shapes. Vanderplas and Garvin constructed 180 shapes following one method described by Attneave and Arnoult. This total was composed of six sets of 30 shapes, each having 4, 6, 8, 12, 16, and 24 points of inflection. All stimuli were shown one at a time for 3 seconds each to a group of 50 university students. For each shape, the subject indicated whether or not it reminded her/him of anything, and if so, what. An association value, the percentage of subjects making positive responses, was then calculated for each shape. As expected, there was an inverse relationship found between complexity, as defined by number of points, and association value. No shape invariably evoked an association (the highest value was 62%) and there were many association responses given even to the most "meaningless" shapes (the lowest value was 20%).

Vanderplas and Garvin presented the association

values for each of the 180 shapes and their method thus provided a standardized set of configural materials each having a stimulus-defined level of complexity and a response-determined level of meaningfulness. Their report is important also because it appears to be the first attempt to objectively measure the potential for verbal mediation in nonverbal materials.

In a companion article, Vanderplas and Garvin (1959b) studied the memorability of their shapes using a paired-associate learning procedure in which subjects attempted to link a nonsense syllable to each polygon. Subsequent recognition testing using only the shapes revealed that the more complex stimuli were the more difficult to recognize and that neither the number of previous exposures (during the paired-associate pretraining) nor the association value of the shape influenced retention scores.

In a more extensive study (Vanderplas, Sanderson & Vanderplas, 1965), association values were determined for 1,100 random shapes using a response method similar to that employed in the original investigation, but here subjects were tested in small groups and gave written responses. The study yielded a set of 100 random shapes at each of 11 levels of complexity, from 4 through 24

points of inflection. Within each set of equal complexity, the shapes could then be rank ordered in terms of potential for verbal labelling.

Because of the time required for the construction of each stimulus and the mechanical nature of the entire procedure, more recent workers have developed computer programs which will rapidly generate large numbers of random shapes having stimulus characteristics as desired. Brown and Owen (1967) have reported one such program and presented a set of sample shapes which have also been popular in current work (e.g., Hines, 1978a; 1978b). Knoll and Stenson (1968) have also produced a program to generate random shapes, their system following another of Attneave and Arnoult's methods which employs arcs of a circle as well as straight lines. One disadvantage of these newer stimuli is that they lack the association value indices and the body of normative data which has been accumulated for the more popular Vanderplas and Garvin series.

For the study of recognition memory, a potential advantage of the computer production of random shapes is the ease with which sets of canards could be constructed, each varying in shape from the memorandum by a specifiable amount. In Vanderplas and Garvin's (1959b) recognition study, for example, canards were prepared (by

hand) in which each point of the memorandum was moved in one of the four co-ordinate directions by a small amount. The canard shapes thus varied only slightly from the memorandum making the discrimination more difficult (and seemingly more nonverbal). With computer-generated shapes, it may be possible to develop canards which are scaled in terms of degree of difference from the memorandum thus allowing for some estimate of the magnitude of the recognition error.

Random shapes (especially those from Vanderplas and Garvin's 1959a series) have likely been the most commonly used nonverbal stimuli. Besides having the appearance of being difficult to encode verbally, they are one of the very few types of nonverbal materials which offer some evidence as to the probability of verbal labelling, at least. These attributes plus the availability of a range of objectively specified complexity levels has made them extremely popular in memory studies (with both normals and with patients) in which it is desired to minimize the effects of verbal mediation.

Popularity, of course, does not guarantee effectiveness. As yet there have been no direct attempts to determine if random shapes do, in fact, function

adequately as nonverbal memoranda. Much indirect evidence is available, however, from studies in which random shapes have been compared with verbal materials. If subjects perform differently in some way when random shapes, rather than verbal memoranda are used then the conclusion is strengthened that random shapes are different in kind from verbal materials. The polygons offer the additional possibility that verbalizability levels within the set of shapes may be specified and compared.

Comparisons of random shapes with verbal materials may be found among three kinds of studies. Random shapes have been contrasted to verbal memoranda in studies of the selective deficits of unilateral brain-damaged patients and in visual half-field experiments with normal subjects. In both of these kinds of investigations, the finding of a clear right hemisphere specialization for random shapes could be taken to support the hypothesis that the shapes are in fact processed non-verbally. In a third kind of study, patients with diffuse brain damage have been given memory tasks using random shapes and similar tasks involving verbal materials. Performance discrepancies between the two types of materials may then be taken to support the

contention that memory for random shapes operates in some fundamentally different way from memory for verbal materials.

Random shapes have been very widely used as "non-verbal" memoranda in tachistoscopic laterality studies, especially with normal subjects, and there is a large literature here. A report by Fontenot (1973) illustrates the prototypic design. In this investigation, 6-point and 12-point shapes from Vanderplas and Garvin's series were used as memoranda. New association values were obtained for all shapes and used to form high and low meaningfulness subgroups of 8 shapes each from each complexity level. After a brief presentation of the memorandum, the subject was required to select the same shape from a multiple-choice array of 30 possibilities.

The results revealed an interesting interaction. While low-complexity shapes were recognized with equal accuracy in either visual field, there was a clear left visual-field superiority for the recognition of high-complexity shapes. Overall, low-complexity shapes were remembered better than high-complexity shapes, and the same superiority was seen for high association-value shapes over low association-value shapes. Since no interaction between association value and visual field

was found, Fontenot's study may be interpreted as indicating that objectively defined stimulus factors may be more important than subjectively defined associative responses in determining right hemisphere processing. Extending this reasoning a bit further, the results suggest that it is complexity rather than meaningfulness which imparts "nonverbalness" to a stimulus.

In further studies reported by the Iowa group, Dee and Fontenot (1973) replicated the previous findings of a left visual-field superiority for 12-point shapes (but of low association value only this time) and showed that the strength of this effect increased as the delay interval was lengthened. Dee and Hannay (1973) again reported a left visual-field superiority for 12-point shapes of low association value and attempted to rule out attentional biases as a cause of the effect. Hannay, Rogers and Durant (1976), however, used exactly the same stimuli and found a strong right visual-field effect.

The set of possible outcomes was completed by Birkett (1978) who also used 12-point shapes (of unspecified association value) and found no significant visual-field differences. Nonsignificant results were also reported by Hines (1978b) who used 8-, 16-, and 20-point shapes.

Taken as a group, the studies which have employed random shapes as tachistoscopically presented memoranda have not produced results consistently supporting the belief that these are truly nonverbal stimuli, if right hemisphere superiority in processing is taken as an index of "nonverbalness". Both left visual-field and right visual-field superiorities, as well as no differences, have been frequently observed at several levels of complexity and association value and there appears to be little stability in the pattern of results. Moreover, conflicting outcomes have been obtained from study to study even when identical sets of shapes have been used. The phenomenon of a reliable left visual-field effect appears to be as elusive with random shapes as it has been with other kinds of "nonverbal" stimuli.

In NVM studies employing unilateral brain-damaged patients, the polygons have usually been presented in free vision and for considerably longer periods of time than in the tachistoscopic work. A report by Bisiach and Faglioni (1974) is illustrative of investigations of this type. These authors chose shapes from Clark and Knoll's (1969) series, defining 4- and 6-point shapes as low in complexity and 16- and 24-point shapes as high. Half of the shapes from each of these sets were chosen

to be of high association value ( $\bar{X} = 45.2\%$ ) and half of low association value ( $\bar{X} = 35.2\%$ ). In their memory procedure, each memorandum shape was presented for a 5-second inspection period and then removed. After an unfilled delay interval of another five seconds the patient was shown a multiple-choice display consisting of ten random shapes arranged in a vertical column. Each display contained the memorandum shape again plus 9 canards, all chosen from the same subset as the memorandum (e.g., all of high complexity and low association value). In addition to the memory administration, the same procedure was repeated leaving the memorandum in view, thus making a concurrent matching-to-sample administration.

Bisiach and Faglioni found that, contrary to expectations, left-hemisphere patients performed more poorly than right-hemisphere patients and that this difference was most pronounced with low association-value shapes. In addition, the more complex shapes were found to be remembered better by the right-hemisphere patients. Both of these results were surprising and appear to be at variance with most of the evidence linking right hemisphere brain damage to impairments in the processing of complex configural materials.

Other lateralized lesion data has come from studies

of patients undergoing subcortical stimulation. Ojemann (1971), for example, has used 16- and 24-point shapes with association values of 36 or less in a sequential recognition procedure. He found that right thalamic tract stimulation significantly disrupted task performance when the memoranda were random shapes, whereas identical stimulation had no effect on performance when easily named object pictures were used instead. Similar results have been reported by Fedio and Van Buren (1975).

Evidence pertaining to right hemisphere specialization for the processing of random shapes has come also from studies of patients being treated with lateralized ECT. Robertson and Inglis (1978), for example, prepared a novel set of shapes, following Attneave and Arnoult's (1956) method, and selected the most meaningless of these from a preliminary rating study. Robertson and Inglis' procedure involved the serial presentation of 20 shapes followed by an immediate test of recognition for 10 of these, a 20-minute delay filled with other testing, and then a recognition test of the other 10 memoranda. Patients who received unilateral nondominant ECT showed a significant decrease in performance on this task as compared to pretreatment levels. Furthermore, this deficit was not seen when any of four other types of

memoranda (high-imagery nouns, low-imagery nouns, object pictures, and geometric designs) were used in the same procedure.

In summary, studies of patients suffering from unilateral insults to the brain have not consistently supported the hypothesis that memory for random shapes is primarily a right-hemisphere function. Again, the pattern of results is conflicting and the data from these experiments do not provide compelling support for the view that the polygons are truly nonverbal, if this attribute is defined as preferential processing by the right hemisphere.

Random shapes have been compared with various verbal memoranda in studies of patients with diagnoses of diffuse cerebral pathology. The results from these investigations make it possible to evaluate the claim that memory for random shapes may be selectively spared, or impaired, and thus that these configurations are substantially different in kind from verbal materials.

In the first of a series of studies of Korsakoff patients by the Boston group, Butters, Lewis, Cermak and Goodglass (1973) used 45 computer-generated random shapes as memoranda but no information was given as to complexity levels or association values for these stimuli. On each trial, a single memorandum shape was

presented for one second to the patient followed by either an immediate or a delayed recognition test involving a same or different judgment. Delays of 9- and 18-seconds were used during which the patients were required to count backwards by twos. The results revealed no significant differences, regardless of delay length, between the Korsakoff patients and matched groups of normals and alcoholic controls. Reliable discrepancies were found, however, when trigrams were used in place of the random shapes and the authors used these results to argue that the memory disorder of Korsakoff patients is specific to verbal materials.

In a follow-up study, however, De Luca, Cermak and Butters (1975) used a similar memory procedure but varied the type of distractor task and found, contrary to the previous results, that Korsakoff patients were impaired in their memory for random shapes (again unspecified) regardless of how, or if, the delay interval was filled. More recently, Cermak and Tarlow (1978) used apparently the same set of random shapes in a sequential recognition procedure and found no differences between Korsakoff patients and controls, although a floor effect here may have obscured potential inter-group differences.

Considering a different population, Levin, Grossman

and Kelly (1976) used random shapes to assess NVM in patients with head injuries of varying severity. They compared 20 shapes of high, medium and low association values which were all of the same (unspecified) complexity level. In their procedure, the memorandum was presented for 10 seconds, followed by an unfilled delay interval, also of 10 seconds, and then a 4-choice display was presented for recognition testing. Although performance deficits were related to severity of head injury, association value was not found to be predictive of memory performance in either the controls or the head-injured group. In addition, there was no interaction between association values and the presence of aphasia in head-injury patients. In light of these findings, the authors concluded that the random shapes used were not likely encoded verbally.

In a later study, Peters and Levin (1977) presented data indicating that injections of physostigmine selectively enhanced memory for random shapes in a single encephalitic patient, whereas no such salutary effect was seen with verbal memoranda.

Studies of patients with bilateral brain damage have, in general, thus also failed to offer consistent support for the contention that random shapes are

processed in some fundamentally different way from verbal memoranda. Taken together, the evidence on this point from various sources appears to be inconclusive at best and is likely of limited value. The studies which have been reported so far have not been designed to determine the degree of nonverbalness of random shapes and this question can best be resolved by conducting investigations in which it is addressed more directly.

In spite of the lack of consistent support for the nonverbal nature of random shapes, these materials appear to offer potential for use as memoranda in NVM tasks. They are one of the few kinds of stimuli which have objectively defined physical properties and thus can be precisely described and referenced. This feature makes it possible to develop a standardized set of memoranda about which all investigators can communicate accurately. The achievement of standardized measurement materials appears to be a necessary prerequisite for advancement in any scientific study.

Regardless of their great popularity among research workers, there apparently has not been, as yet, any attempt to employ these materials in the development of a clinical test for the assessment of NVM functioning in the individual patient. Since these polygons offer

the unique advantage of being rank-ordered in terms of both stimulus and response characteristics and since they now have a considerable body of normative data associated with them, they would seem to be ideal for use as NVM test memoranda. Besides their high level of familiarity to research workers, the fact that these stimuli are now commercially available (Note 15) should enhance the acceptability of any well-designed random shapes test which other memory investigators could easily duplicate.

In the large number of studies using random shapes which have been reported in the general-experimental literature, the polygons have, to some extent, been adopted as nonverbal analogues of nonsense syllables for the parametric study of memory in normal subjects. While most of these investigations are not of direct concern in evaluating the usefulness of random shapes as nonverbal memoranda, they do provide somewhat of a body of normative data as to the performance level expected of normal subjects when various procedural options are used. These experimental studies are thus helpful in guiding attempts to develop a feasible procedure for a useful clinical test.

If random shapes are to be used to produce the

most nonverbal test possible, clearly those stimuli with the lowest association values would be the most desirable as memoranda. The large pool of shapes available from the Vanderplas and Garvin series would permit the selection of memoranda of low and equal "meaningfulness" at each of several levels of complexity.

Any NVM test using random shapes should probably involve a recognition rather than a reproduction demand. Although there have been attempts to have subjects draw these kinds of stimuli from memory (e.g., Botwinick & Storandt, 1974, p. 121), no one as yet has suggested a compelling way to resolve the rather formidable scoring problems this method raises.

Several studies (e.g., Vanderplas & Garvin, 1959b) have suggested that even normal subjects may have great difficulty remembering random shapes if the retention interval is more than a few seconds or if several shapes must be retained concurrently. If a clinical test is to be useful in separating the very impaired from the not so impaired patient, then it must not be so difficult that all patients with any degree of memory disorder fail. For these reasons, and to promote better patient cooperation in working with these "meaningless" materials, the best procedure to use with random shapes appears to be to

present only one memorandum at a time for recognition testing and to use only brief retention intervals.

As the tachistoscopic studies have indicated, presentation times need not be lengthy in order to ensure adequate registration. Hines (1978a), for example, found that recognition accuracy averaged about 80% even for presentation times as brief as 75 msc. Patients will need more viewing time probably, but the studies with clinical populations have suggested that only a few seconds of presentation is needed even for the most complex shapes.

Random shapes as memoranda appear to be very vulnerable to interference from some kinds of distractor items. Hines (Hines & Smith, 1977; Hines, 1978a) determined that memory performance was greatly reduced when other random shapes were used as distractor stimuli and that this result could not be explained by a simple masking effect (i.e., disruption of retention could begin and extend much beyond the brief retention interval regarded as the maximum length of iconic memory). Paradoxically, other "nonverbal" distractor items, such as faces and complex pictures, were not effective in reducing memory for random shapes but tasks involving the manipulation of

digits were. Because of the uncertainty regarding the effects of extra-item interference with random shape memoranda, distractor tasks should probably be avoided in the development of a simple clinical test.

In some studies (e.g., Dee & Fontenot, 1973), stimuli have been prerated as to similarity and an attempt made to select those canards which are most like the memorandum they are presented with in the recognition test. This tactic would be expected to produce a more difficult test than if canards were chosen randomly for each memorandum. Other investigations (e.g., Cermak & Tarlow, 1978), however, have suggested that discriminating among these shapes from memory may already be a very difficult task, especially for patients. Since the information load, particularly with the more complex shapes, is quite high, care must be taken to avoid making the memory task too difficult or the intersubject range may be truncated.

CHAPTER SIX: EMPIRICALLY VALIDATING THE  
CONSTRUCT OF NONVERBAL MEMORY

The spatial tasks we give our patients should be as "pure" as possible, in the sense that the requirements for symbolic activity should be minimal . . . . I know of no easy way to determine whether a task requires implicit verbalization or not. (Benton, 1962, p.261)

Of course there are compelling reasons to hold that the nervous system can code visual information on a more or less permanent basis without the necessity of verbal labels. . . . The experimental psychologist, however, has been somewhat reluctant to accept this form of storage in man because it is difficult to provide a paradigm in which one can be sure that the retention is visual and not dependent upon a verbal recoding. (Posner, 1969, p.186)

Our understanding of the verbal-nonverbal distinction remains largely intuitive. (Robertson & Inglis, 1977, p.298)

Attempts to Operationally Define Nonverbal Memory

In chapter 4, the verbal mediation question was discussed at some length. The major conclusion reached was that tasks purporting to be measures of NVM must have some empirical way to document their nonverbalness. If this kind of evidence is not available, the objection that the memoranda are just recoded and retained in verbal form cannot be refuted. Virtually all of the multitude of tasks which have been suggested in the literature as measures of NVM were created and accepted on an intuitive basis only, however. Materials and procedures were selected which the authors believed would likely tap NVM. Many of these materials have subsequently garnered some construct validity in indirect ways, such as being associated with a right-hemisphere processing superiority. The sources of indirect data supporting the nonverbalness of five of the most popular types of nonverbal memoranda were reviewed in chapter 5 and recommendations were made as to how to select the materials most likely to be nonverbal in character.

Since the primary mode of validating the nonverbalness of NVM tasks has been to show preferential processing by the right hemisphere, much attention has already been paid to studies of this type. Evidence

as to hemispheric specialization for NVM has been reviewed by type of lesion in chapter 3. No further consideration of the lateralization data will be presented here except to note that the finding of even a strong right-hemisphere superiority for any task is, at best, only circumstantial evidence as to the degree of nonverbalness of that task. There is no consensus, for example, that even the isolated right hemisphere is completely devoid of "inner language" (cf., Zaidel, 1978).

Another related way in which investigators have attempted to bolster the claim that a particular task is truly a measure of NVM has been to show that only nonaphasic brain-damaged patients are impaired on the task whereas aphasic patients perform no differently from normal controls. The problems of inference in these kinds of attempts have been explored in some detail in chapter 4. Again, the general conclusion is that this is a weak method of validation fraught with methodological difficulties.

There have also been some attempts, particularly by the Milan group (e.g., Bisiach & Faglioni, 1974), to equate stimulus complexity with

nonverbalness. Although possibly a useful validity criterion for some kinds of memoranda, the complexity dimension is just not relevant to many kinds of nonverbal materials, such as colours or position in space. In addition, the relationship between complexity and other attributes of nonverbalness, such as meaningfulness, is not at all straightforward. Stimulus complexity does not predict association value in random shapes, for example, (Battig, 1962).

A venerable strategy in memory research is to explore the characteristics of some task by determining what interferes with it. Thus, if a task were truly a measure of NVM, it might be expected that it would be most disrupted by a nonverbal distractor task whereas a verbal distractor task would be relatively ineffective in impairing retention. Only a few investigators have attempted to use type of interference as a validation criterion for NVM, however. The Boston group, for example, have reported several studies of this type, but their results have not been consistent. (These and other related attempts to operationally define NVM by demonstrating that it has different characteristics from verbal memory have been reviewed in chapter 2.

In general, problems in determining the nonverbalness of distractor tasks themselves and uncertainties regarding "rehearsal" of nonverbal memoranda limit the usefulness of the interference method of validating NVM tasks.

Although it has long been recognized that so-called "meaningless" stimuli may actually have some degree of meaningfulness associated with them, it has only been in recent years that attempts have been made to compare various nonverbal memoranda on this dimension. The primary approach here has been the use of the association-value measure, pioneered by Glaze (1928) with nonsense syllables. Esper (1933) appears to have been the first to apply this method to nonverbal materials. He used it to select, for memoranda, those Chinese characters to which less than a third of his respondents were able to give associative responses. It was not until the seminal work of Vanderplas and Garvin (1959) however, that this method of indexing the degree of nonverbalness of a particular memorandum became widely adopted.

As has been previously discussed (See section of chapter 5 titled "Random Shapes"), the usefulness of the association value measure is not at all clear. It appears unrelated to the physical

characteristics of the stimulus (Clark & Knoll, 1969), does not necessarily predict memorability (Price & Hill, 1968), is uncorrelated with side of lesion (Bisiach & Faglioni, 1974) or presence of aphasia (Levin, Grossman & Kelly, 1976), and perhaps most importantly for present purposes, does not seem to be related to the kind of verbal encoding responses that subjects report when asked to remember a perceptually complex memorandum.

Goldstein and Chance (1970) explored the latter point by comparing associative responses with those of another group of subjects who were asked, ". . . to write something about the picture that would help you recognize it were you to see it again later on" (p.240). When instructed to "associate", responses to all stimuli (faces, inkblots and snowflakes) tended to be short, unitary and affective. When instructed to code for memory, however, responses tended to be long and conjunctive, with more than one cue for each stimulus, and there were fewer instances of being unable to respond. The authors also reported that, within an individual subject, the associative responses tended to be invariant (e.g. "inkblot" for all in this series). Since interitem discriminations could not possibly be made on the basis of these minimal descript-

ions, Goldstein and Chance were led to question whether the associative technique yields information which is relevant to what actually happens in attempts to verbally encode perceptually difficult stimuli. In their view, verbal responses may be readily generated for any kind of nonverbal memorandum, but the subject may not necessarily make use of these cues in the memory process. At the very least, Goldstein and Chance's work demonstrates the importance of instructional set in attempting to obtain measures of verbalizability.

In addition to the above difficulties, the association-value measure has been shown to be quite unreliable. Eisenman (1966), for example, replicated Vanderplas and Garvin's original study and showed that the association values obtained for each shape could be markedly altered depending on the demand characteristics of the task. There were many changes in the rank-order position of individual shapes and much higher association-value percentages overall were obtained, for example, when responses were given in a "relaxed" setting with unlimited time. Goldstein (1961) also found association values (to the same shapes) which were quite discrepant from

those reported by Vanderplas and Garvin (1959).

Although almost all association-value studies have followed Glaze's (1928) example in collecting yes/no responses to each stimulus, Lewis and Boehnert (1965) have explored the use of other methods of obtaining meaningfulness data. Random shapes were characterized in terms of (a) the total number of associations that each elicited, (b) the heterogeneity of responses, and (c) the judged appropriateness of the associations given. The last measure was represented by the authors as a "connotative strength" index, and the best available measure of what the ambiguous stimulus means to the subject. It is not clear, however, that any of these methods resolve the difficulties, discussed above, with the general notion of association values as validating measures for nonverbal materials.

If a particular stimulus is given the same associative "name" by a large number of the subjects responding to it, the conclusion may be reached that this stimulus readily evokes a verbal descriptor and thus would be most amenable to verbal mediation. On the other hand, a stimulus for which a wide variety of names is given might be considered more difficult

to label and thus more nonverbal. This kind of reasoning was initially proposed by Brown and Lenneberg (1954) who used both inter- and intra-subject naming agreement as measures of the codability of nonlinguistic stimuli. They demonstrated that, for Munsell colours, recognition accuracy was directly predicted by naming agreement.

A similar conclusion was reached by Frijda and Van De Geer (1961) using 30 facial expressions as memoranda. Here, one group of subjects was asked to choose three terms which best described a particular expression. Another group of subjects was shown an expression for 20 seconds and then asked to locate it, from memory, in an array of 60 possibilities. The authors found good agreement between several measures of naming (including reaction time, number of responses given and heterogeneity of responses), and several measures of recognition. They concluded that expressions which tend to be verbally coded with a high degree of inter-observer agreement are more easily discriminated from other expressions.

Not all investigators have corroborated the early impression that naming agreement is predictive

of recognition accuracy. Lantz and Stefflre (1964), for example, found that naming agreement was not significantly correlated with delayed recognition of the Munsell colours.

Even if naming agreement can be shown to reliably predict recognition accuracy, this result would bear only obliquely on the question on whether naming disagreement is a valid criterion for determining the nonverbalness of a memorandum. In order to justify the use of the measure as a test of the construct, some way must be found to defend the basic assumption that a lack of consensus among observers in labelling a memorandum implies that this memorandum is not likely to be encoded verbally by the individual subject. So far, no one has advanced a persuasive argument in support of this supposition and the use of the naming-agreement criterion remains a very indirect way of attempting to validate the nonverbalness of stimulus materials. Items which elicit very heterogeneous naming responses may possibly be viewed as more complex but are not necessarily, by this definition alone, more nonverbal. What is needed is an evaluative procedure which provides a more appropriate and convincing metaphor for the actual process of verbal mediation.

Communication Accuracy as a Measure  
of Nonverbalness

None of the methods discussed so far have been very compelling as ways to validate the construct of NVM. This is hardly surprising since all were initially developed for other purposes and their application to the problem of operationally defining nonverbalness is somewhat forced. None of the methods appear, on an intuitive basis at least, to offer a way of capturing the essence of what is typically meant when it is claimed that a particular memorandum is nonverbal. What is needed is a way to quantify the likelihood that a specific NVM task could be accomplished successfully by translating the memoranda into verbal codes. Although it too was developed for other purposes and has not been used this way previously, the communication accuracy method would seem to offer potential for obtaining this kind of information.

Perhaps the first reference to the basic idea of communication accuracy is contained in a study of memory for colours by Hamwi and Landis (1955). These workers presented colour chips to subjects and for each memorandum, asked them to, "label the colour components

and give a name to the colour" (p.185). These verbalizations were recorded and after delays of 15 minutes, 24 hours or 2½ days, each subject was read her/his description and after hearing it, attempted to locate the same chip again from a large array. A wide range in difficulty was found across the colours used. Some were relatively easy to describe well enough to mediate retention even after the longest delays; others proved to be very difficult to distinguish from the canards, at any of the retention intervals, in spite of the overt assistance from verbal encoding cues. Although Hamwi and Landis did not draw the conclusion, it would be possible to argue that the latter stimuli are more nonverbal than the former.

The original presentation of the method in its two-person form appears to have been by Lantz and Stefflre (1964) in an extension of the psycholinguistic work on the codability of colours. In order to obtain a ranking of the stimuli in terms of ease of description, these authors showed each colour to a group of subjects with instructions to, "describe this item in such a way that another person will be able to pick it out" (p.473). The entire selection

of colours was then shown to another group of subjects and the statements from the first group read aloud to them. For each verbalization read, the subjects in the second group were requested to choose the item they thought it was a description of. It was therefore possible to calculate for each colour the percentage of times it was identified correctly on the basis of verbal description alone. Lantz and Stefflre were primarily concerned with demonstrating that the communication accuracy score for each item directly predicted that item's difficulty level as a memorandum. The communication accuracy measure was further shown to be a better predictor of recognition performance than was either naming agreement or Glanzer and Clark's (1962) brevity-of-description index and this superiority held for two different sets of colours.

In a follow-up report, Stefflre, Vales and Morley (1966) replicated these findings and extended their generality to other languages. Again, Munsell colour chips served as stimuli and separate groups of encoders and decoders were used to calculate communication accuracy scores for each item. Although this codability index again correlated highly with the degree of difficulty as a memorandum, the set of

colours found easiest to describe (and remember) by Spanish speakers was quite different from the set found to have the same characteristics for speakers of a Mayan Indian language. This result suggests that the nonverbalness of a particular stimulus may be somewhat culturally dependent.

In the same year, Koen (1966) adapted the communication accuracy method to the codability of facial expressions. Here, the stimuli used were 24 photographs, taken from Hulin and Katz (1935) of the same person portraying different emotions. Each photo was shown to an encoding subject with the instructions to describe the expression in writing, ". . . so someone else could identify the picture from your description" (p.437). In the decoding phase, each description was read by other subjects who attempted to locate the referred-to item in an array of 72 possibilities. Again, this method permitted the rank ordering of all stimuli as to the relative ease with which each could be described accurately, in words, to another person. As before, the accuracy score used was the percentage of times a particular item was chosen correctly from among similar canards on the basis of verbal

description alone.

Koen found that verbal communication accuracy was reliably more effective than a control condition in which the encoding subject tried to mimic the facial expressions and the decoder tried to make selections solely on the basis of observing the first subject's face. As in previous studies, expressions with low communication accuracy rates (both verbal and enactive) were found to be the hardest to remember when simple recognition was tested.

In an earlier study, Glanzer and Clark (1964) had asked subjects to look at complex geometric figures, taken from Fehrer's (1935) series, and to write a description of each from which it would be possible to recreate the figure. They showed that the more words that were used to describe a figure, the harder it was to later reproduce accurately from memory. No attempt was made to assess communication accuracy for the figures, however.

Cohen and Granstrom (1968) used eight of the same figures employed by Glanzer and Clark and extended their task to include drawing of the figures, by another group of subjects, from the written descriptions alone. Cohen and Granstrom found,

contrary to previous work, that those figures which were described the poorest (by the communication accuracy criterion) were remembered the best. When subjects, instead of stimuli, were ranked, however, a significant positive correlation was found between the ability to describe the figures and the ability to memorize them.

In a somewhat different application of this method, Cohen and Granstrom (1970) used multiple sets of figures, each consisting of a basic prototype plus several elaborations. The subject was shown one of the variations, as a memorandum, and asked to write a statement describing how it differed from the standard. This description was then judged as to accuracy by determining how many of the other possibilities it would apply to. As before, a positive correlation was found between the ability to describe a figure and the ability to reproduce it. This relationship did not obtain, however, when recognition testing was used in place of reproduction.

The communication accuracy method has been used primarily by workers interested in demonstrating the importance of linguistic processes in memory. Ironically, the method may turn out to be the most useful as a tool for constructing and validating NVM

tasks. The key to its usefulness lies in its credibility as an analogue to the verbal mediation process. To be a valid analogy, the communication accuracy test must be designed such that it is a believable external representation of unobservable verbal events.

If, as many have argued (e.g., Paivio, 1971), humans endeavour to encode all stimuli both verbally and nonverbally wherever possible then, the investigator who wishes to study NVM only must find a way to demonstrate that the possibilities for retention via verbal mediation are negligible in the tasks (s)he is using. To date, no one has succeeded (few have tried) in offering a convincing way to estimate the extent of verbal processing which may occur in any ostensibly nonverbal memory task. The credibility of currently used NVM tasks rests entirely on inferences drawn from indirect sources of evidence. Judicious application of the method of communication accuracy as a measuring instrument may provide the first direct index of construct validity both for NVM tasks as units and for particular items within a test series.

The question of the extent of verbal mediation in any memory task may be approached from two perspectives. If one asks, "How much verbal processing does, in fact,

occur?", the answer may be quite variable, due to individual and situational differences, and thus not too meaningful. If one asks instead, "How much verbal mediation is maximally possible in this task?", then an upper boundary to this process can be estimated. If the boundary is low enough, it can be argued that it is unlikely that any appreciable amount of verbal mediation could, in fact, occur. The best strategy in attempting to develop NVM tasks would seem to be to show that it is just not possible to process the information successfully by verbal means and thus, by deduction, those who succeed on it must be using nonverbal processes.

The ideal way to validate a NVM task would be to (a) present the memorandum to the subject, (b) require the subject to attempt to describe the memorandum in words adequate enough to mediate later retention, (c) remove the memorandum, (d) erase all memory of it from the subjects awareness, and (e) present the subject with her/his own verbal description of the memorandum and ask the subject to recognize or reproduce the memorandum from this information. Clearly, if the subject could recognize or reproduce the memorandum using only her/his own description, it is possible to

accomplish the task by verbal mediation. Conversely, failure on this hypothetical task would provide strong support for the contention that verbal processing will not suffice.

Because step (d) in the preceding sequence is impossible, two subjects must be used in order to accomplish the aim of this idealised experiment. Once the first subject (hereafter called the encoder) has seen the memorandum (s)he can no longer be used in a retention test, based on verbal cues alone, since her/his retention choices would be influenced by prior visual impressions. Verbal description of the memorandum can, however, be transmitted from the encoder to a second subject (the decoder) who has never seen the memorandum. If the decoder can successfully locate the memorandum in an array of possibilities then memory through verbalizations is at least possible. If the decoder is not able to make a correct choice, given that both encoder and decoder are motivated to accomplish this end, then the possibility of using verbal strategies to process this kind of information would appear to be remote.

The validity of the communication accuracy test depends upon its believability as a veridical

representation of what likely happens when a subject is asked to try to remember some "nonverbal" stimulus. In effect, the subject may be seen as attempting to describe the memorandum in words to her/himself and to later retrieve these verbalizations as aides de memoire. The communication accuracy method should offer a reasonable metaphor for this internal process and one which should be applicable to all but a few instances.

One exception to the generality of the method would be found in those cases in which the encoder and decoder do not share common referents. For example, an encoder might privately describe a face as looking like her uncle, and this cue could be very effective in mediating successful delayed recognition for her. This information would not allow the decoder to choose correctly, however, unless the uncle was known to the decoder also. Situations such as this, in which idiosyncratic verbalizations are used to encode memoranda, limit the goodness of fit between the communication accuracy measure and the unobservable events it attempts to model. Although it seems likely that, in general, the amount of mediational content which would not be useful to transmit would be small, estimates of the extent of this discordance would be useful for future work.

In spite of the problem of private referents, the communication accuracy method may prove to be extremely useful as an instrument to assess the verbal codability of putative NVM tasks. In order to further explore the value of this approach, the following experiment was conducted. In this study, the primary intent was that of item analysis. The communication accuracy method was used to collect data which would allow an investigator to choose, from a large pool of possibilities, those items which appeared to be the least amenable to verbal mediation. An item was defined as a memorandum stimulus plus a recognition array, composed of another representation of the memorandum and three canards (false alternatives) which were each very similar to the memorandum. It was anticipated that items selected in this manner could then be used in the construction of NVM tasks. It was further expected that for each of these new tasks, the degree of construct validity, (i.e. as a measure of NVM) could then be directly estimated by the communication accuracy (CA) scores of the items used.

In this experiment, one subject, the decoder (D), attempted to locate the memorandum in a 4-choice array with nothing to guide the choice but his/her

memory of a verbal description of the memorandum provided by another subject, the encoder (E). Overall, 20 D subjects made one response each to 20 items each of five types of stimulus materials. For each item then, a CA score could be defined as the total number of correct choices made.

Because the task offered a one-in-four possibility of choosing correctly purely by chance, 25% of the D subjects would be expected to produce correct responses to a particular item in this manner alone. Thus, for any item, a CA score which was reliably greater than chance would have to occur in order to argue that verbal communications significantly affected the D subjects' responses. On the other hand, a CA score no greater than the level expected by chance would appear to offer strong support for the contention that performance on this item was unaffected by verbalizations.

More formally, it was proposed that a null hypothesis,  $H_0$ , be evaluated and a decision regarding acceptance or rejection be made.  $H_0$  was defined as the expectation that the D subjects' responses would be produced by chance factors alone and thus these data will be distributed binomially ( $N=20, p=.25$ )

around a mean of five correct choices for each item. If, for any item, the data appeared to be drawn from a distribution with a mean significantly greater than five then it was proposed that  $H_0$  should be considered unlikely in that case.

Rejection of  $H_0$  would imply support for the view that the accuracy of the D subjects' responses was reliably improved by the verbal information they received. Rejection would thus require the conclusion that, for this item in this situation, it is possible at least to generate verbal cues which can be used to markedly aid performance on the discrimination test. Conversely, acceptance of  $H_0$  would imply that it was not possible, under these experimental circumstances, for the E subjects to generate verbal messages which were effective in mediating the discrimination task.

Since all items within each set of 20 were constructed to be as nonverbal as possible, and therefore were considered to be equally difficult to mediate verbally, there was no basis for predicting the CA scores of each. Similarly, there was no compelling a priori basis for hypothesizing the order of the types of materials, in terms of average CA scores, nor any good reason to expect a sex difference or an interaction between sex and type of material.

## Method

Subjects. Undergraduate volunteers (20 males and 20 females) were obtained from the Psychology Dept. subject pool at the University of Victoria. Subjects were selected randomly, the only constraint being that anyone who was not a native speaker of English was rejected.

Test materials. Five sets of 20 items each were evaluated as nonverbal materials. Each of these 100 possibilities consisted of a memorandum and three canards which were similar in appearance to the memorandum. The stimulus pools from which these materials were drawn have already been described in some detail in chapter 5. For this study, the specific selections were made as follows:

1. Each of the designs from the population developed by Benton (1955) for the Visual Retention Test was considered and the 20 judged, on a subjective basis, to be the least amenable to verbal encoding were selected to be further evaluated as nonverbal memoranda. All designs chosen included two major figures and one minor figure. For each of the 20 memoranda (C4,C6,C7,C8,C9,C10,D3,D5,D6,D7,D8,D9, D10,E3,E4,E5,E7,E8,E9 and E10) the appropriate 4-choice set, prepared by Benton (1961), was used

as the recognition array. The figures comprising the canard designs involved errors of misplacement and rotation primarily but some errors of distortion and omission were also offered as false alternatives. All designs appeared as black line drawings on white backgrounds and all were printed on .12m x .32m stimulus cards. The memoranda figures were approximately .05m in diameter while the multiple-choice figures were reduced to half this size.

2. Twenty precise hues (two from each of the ten major groupings of the Munsell standards) were evaluated as memoranda. For each one, a 4-choice array was constructed consisting of a duplicate of the memorandum plus canards at  $\pm 5$ ,  $\pm 7.5$  and  $\pm 10$  steps removed (along the hue continuum) from the memorandum. The specific stimuli used are presented in Table 1. All materials were identical in brightness and saturation (value = 6 and chroma = 8 in Munsell notation), all had a matte finish and all were presented against a white background. The memoranda appeared as .03m x .05m solid colour swatches; all multiple choice stimuli appeared as .015m x .022m solid colour chips.

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 Location of Each Hue in Each Colour Recognition Array
 

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(-2) <u>5Y</u> 10YR ① 5YR 2.5GY (-4) (+3)	(+3) 2.5RP <u>5P</u> ② 10PB 5PB (-2) (-4)	(-2) (+3) 10RP 2.5YR ③ <u>5R</u> 5RP (-4)	(-2) (+3) 10GY 2.5BG ④ 5GY <u>5G</u> (-4)
(-2) <u>5B</u> 10BG ⑤ 2.5PB 5BG (+3) (-4)	(+3) 2.5B <u>5BG</u> ⑥ 10G 5G (-2) (-4)	(-4) (+3) 5P 2.5R ⑦ <u>5RP</u> 10P (-2)	(-4) (-2) 5B 10B ⑧ 2.5P <u>5PB</u> (+3)
(-4) <u>5GY</u> 5Y ⑨ 10Y 2.5G (-2) (+3)	(-2) 10R <u>5YR</u> ⑩ 2.5Y 5R (+3) (-4)	(+4) (-3) 7.5B 10G ⑪ <u>7.5BG</u> 2.5B (+2)	(-3) (+2) 10B 2.5P ⑫ 7.5P <u>7.5PB</u> (+4)
(+4) <u>7.5RP</u> 7.5R ⑬ 10P 2.5R (-3) (+2)	(+2) 2.5G <u>7.5GY</u> ⑭ 7.5G 10Y (+4) (-3)	(+4) (+2) 7.5Y 2.5Y ⑮ <u>7.5YR</u> 10R (-3)	(-3) (+4) 10PB 7.5RP ⑯ 2.5RP <u>7.5P</u> (+2)
(-3) <u>7.5Y</u> 10YR ⑰ 7.5GY 2.5GY (+4) (+2)	(+4) 7.5PB <u>7.5B</u> ⑱ 10BG 2.5PB (-3) (+2)	(+2) (+4) 2.5YR 7.5YR ⑲ <u>7.5R</u> 10RP (-3)	(-3) (+4) 10GY 7.5BG ⑳ 2.5BG <u>7.5G</u> (+2)

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Note. Item number is circled. Underlining indicates the memorandum. Each number in parentheses indicates the number of Munsell steps (divided by 2.5) that canard is removed from the memorandum.

3. Graduation photos of 10 female and 10 male students were chosen (from the classes of 1978 and 1979 at the University of Victoria) to be evaluated as nonverbal memoranda. The 20 faces which were selected, from the large pool available, were judged to be, on a subjective basis, among the most difficult to describe in words. For each memorandum face, photos of three other same-sex faces were selected such that each appeared, subjectively, to be maximally similar to the memorandum face. Since all subjects were wearing identical gowns, no discriminative information was available below the neck. Since the photos showed the subjects without caps, an attempt was made to match the canard faces to a memorandum face on the basis of hair characteristics. Where the memorandum subject was wearing discriminanda, such as glasses or a moustache, these appeared on the associated canard faces as well. All materials were presented as .09m x .11m matte-finish prints, in colour, showing either a front or  $3/4$  view of the subject. Recognition arrays were constructed using a second and different photo of the memorandum subject, plus the three similarly appearing canard faces. The second photo of the memorandum

subject often showed a different facial expression and camera angle from that of the first photo.

4. The set of nonsense figures prepared by Kimura (Note 1) was considered and 20 of these were selected for further evaluation as nonverbal memoranda. The 20 chosen were judged, on a subjective basis, to be the most difficult to describe adequately in words. For each memorandum, three additional figures were selected such that each appeared, subjectively, to be maximally similar to the memorandum figure. Table 2 presents the stimuli used to construct each of the 20 4-choice arrays. All figures were approximately .04m in width and height and each appeared as a cluster of curving and irregular black lines on a white background.

5. The four random shapes with the lowest association values at each of the 6-, 8-, 12-, 16- and 24-point levels from Vanderplas and Garvin's (1959a) series were chosen to be evaluated as nonverbal memoranda. For each memorandum, a 4-choice array was constructed consisting of a duplicate of the memorandum plus those three (same complexity-level) shapes which were judged, subjectively, to be the most similar in appearance to the memorandum. The

## Location of Each Nonsense Figure in Each Recognition Array

$\begin{array}{cc} \underline{4} & 74 \\ & \textcircled{1} \\ 107I & 114 \end{array}$	$\begin{array}{cc} 23 & \underline{11} \\ & \textcircled{2} \\ 49 & 123 \end{array}$	$\begin{array}{cc} 6 & 65 \\ & \textcircled{3} \\ \underline{10} & 151 \end{array}$	$\begin{array}{cc} 18I & 49I \\ & \textcircled{4} \\ 89 & \underline{8} \end{array}$
$\begin{array}{cc} \underline{31} & 18 \\ & \textcircled{5} \\ 126I & 149 \end{array}$	$\begin{array}{cc} 57I & \underline{20} \\ & \textcircled{6} \\ 123I & 143I \end{array}$	$\begin{array}{cc} 14I & 117 \\ & \textcircled{7} \\ \underline{21} & 120I \end{array}$	$\begin{array}{cc} 47I & 53I \\ & \textcircled{8} \\ 135I & \underline{16I} \end{array}$
$\begin{array}{cc} \underline{68} & 46 \\ & \textcircled{9} \\ 84I & 95 \end{array}$	$\begin{array}{cc} 3 & \underline{73} \\ & \textcircled{10} \\ 126 & 148I \end{array}$	$\begin{array}{cc} 6I & 151I \\ & \textcircled{11} \\ \underline{61} & 65I \end{array}$	$\begin{array}{cc} 26I & 42 \\ & \textcircled{12} \\ 117I & \underline{76} \end{array}$
$\begin{array}{cc} \underline{97I} & 46I \\ & \textcircled{13} \\ 47 & 107 \end{array}$	$\begin{array}{cc} 74I & \underline{99} \\ & \textcircled{14} \\ 84 & 114I \end{array}$	$\begin{array}{cc} 26 & 36I \\ & \textcircled{15} \\ \underline{102} & 143 \end{array}$	$\begin{array}{cc} 95I & 131I \\ & \textcircled{16} \\ 145 & \underline{85} \end{array}$
$\begin{array}{cc} \underline{138} & 23I \\ & \textcircled{17} \\ 36 & 120 \end{array}$	$\begin{array}{cc} 53 & \underline{128} \\ & \textcircled{18} \\ 131 & 135 \end{array}$	$\begin{array}{cc} 34I & 149I \\ & \textcircled{19} \\ \underline{112} & 148 \end{array}$	$\begin{array}{cc} 14 & 34 \\ & \textcircled{20} \\ 57 & \underline{146} \end{array}$

Note. Item number is circled. Memorandum is underlined. I indicates figure was inverted.

## Location of Each Random Shape in Each Recognition Array

Number  
of  
sides

6:	<table border="1"> <tr><td><u>30</u></td><td>15</td></tr> <tr><td>26I</td><td>22</td></tr> <tr><td>①</td><td></td></tr> </table>	<u>30</u>	15	26I	22	①		<table border="1"> <tr><td>19</td><td><u>28</u></td></tr> <tr><td>24I</td><td>25I</td></tr> <tr><td></td><td>②</td></tr> </table>	19	<u>28</u>	24I	25I		②	<table border="1"> <tr><td>18</td><td>17I</td></tr> <tr><td><u>27</u></td><td>16</td></tr> <tr><td></td><td>③</td></tr> </table>	18	17I	<u>27</u>	16		③	<table border="1"> <tr><td>21I</td><td>23</td></tr> <tr><td>20</td><td><u>29</u></td></tr> <tr><td></td><td>④</td></tr> </table>	21I	23	20	<u>29</u>		④
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Note. Item number is circled. Memorandum is underlined. I indicates shape was inverted.

specific stimuli selected for each array are listed in Table 3. Each of the 100 shapes employed was photographed, enlarged and printed on .10m x .13m matte paper with the stimuli appearing as solid black polygons against a white background.

Each memorandum was mounted on a separate presentation board. Each of the arrays was also mounted on cardboard and the choices were labelled  $\begin{matrix} A & B \\ C & D \end{matrix}$ . The position of the memorandum in each matrix was determined randomly with the constraint that, overall, it appeared in each of the locations an equal number of times. Each memorandum and its corresponding array was arbitrarily assigned one of the numbers from 1 to 20.

Procedure. All subjects were run in same-sex pairs. Female and male pairs were run in alternating order until ten pairs of each completed the task.

For each memorandum, one subject acted as the encoder (E) of information and the other as the decoder (D) of the message transmitted. One of the subjects was arbitrarily chosen to perform the encoding task for the first memorandum. Thereafter, the subjects exchanged roles at every new memorandum.

The two subjects were seated across a table from each other and a partition in the middle of the table was used to prevent each subject from viewing the materials presented to the other. The general purpose of the experiment and the task requirements for the E and D roles were explained to both subjects. (Complete instructions read to the subjects are presented in Appendix A.)

When both subjects indicated that they understood what was required of them, the first memorandum of the first set of materials was presented to the E subject. The E subject was requested to try to describe the memorandum, in words, to the D subject. It was stressed that the description should be accurate enough to permit the D subject to be able to select the memorandum from among alternatives which are very similar in appearance to the memorandum. The E subject was given 20 seconds to complete the description during which time the D subject was instructed to listen carefully and to try to remember what the E subject said.

At the end of the time limit, the memorandum was removed from view. The D subject was then presented with the 4-choice array for that

memorandum and asked to choose the one which the E subject just described. The D subject's choice was recorded.

Throughout the procedure, communication always flowed only from the E subject to the D subject (i.e., the D subject was required to remain mute and no questions to the E subject were permitted).

Once the D subject made her/his selection, the 4-choice array was presented to the E subject who was also asked to choose the stimulus that (s)he had just described. Recording of this response and removing the array completed the procedure for the first item.

The second memorandum in the first set of materials was then presented to the subject who was the decoder for the first memorandum and the same procedure was repeated with the subjects taking the opposite roles. The remainder of the memoranda for the first set and all of the memoranda for the other four sets were presented following the above steps with the subjects reversing roles at each new item. Brief rest periods were given between sets.

During the experiment, subjects were encouraged to perform their roles to the best of

their abilities. An attempt was made to motivate the highest possible level of performance by offering a small monetary prize for the team of subjects that obtained the best score on each set of materials.

The time taken to complete each type of material was noted for each subject pair. The descriptions produced by the E subjects were tape recorded to allow content analyses to be done at some later time.

To equate practice and fatigue effects across items, the order of presentation for each subject pair was counterbalanced using the Latin square shown in Table 4. This series of 20 presentation orders was constructed following the method devised by Williams (1949) for making "balanced" arrangements. In a sequence of this kind, every memorandum precedes and follows every other memorandum once only. The square shown in Table 4 was assembled by using Williams' method to construct a standard (balanced) square and then the order of the rows was randomized. The square thus produced may be considered to be randomly chosen from the set of all possible balanced arrangements of this kind with 20 levels.

Similarly, the presentation order for each type of material was counterbalanced, to equate for

Table 4

## Order of Presentation of Each Memorandum to Each Subject Pair

Subject pair	Presentation order																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	12	13	11	14	10	15	9	16	8	17	7	18	6	19	5	20	4	1	3	2
2	14	15	13	16	12	17	11	18	10	19	9	20	8	1	7	2	6	3	5	4
3	7	8	6	9	5	10	4	11	3	12	2	13	1	14	20	15	19	16	18	17
4	6	7	5	8	4	9	3	10	2	11	2	12	20	13	19	14	18	15	17	16
5	2	3	1	4	20	5	19	6	18	7	17	8	16	9	15	10	14	11	13	12
6	5	6	4	7	3	8	2	9	1	10	20	11	19	12	18	13	17	14	16	15
7	15	16	14	17	13	18	12	19	11	20	10	1	9	2	8	3	7	4	6	5
8	16	17	15	18	14	19	13	20	12	1	11	2	10	3	9	4	8	5	7	6
9	10	11	9	12	8	13	7	14	6	15	5	16	4	17	3	18	2	19	1	20
10	1	2	20	3	19	4	18	5	17	6	16	7	15	8	14	9	13	10	12	11
11	8	9	7	10	6	11	5	12	4	13	3	14	2	15	1	16	20	17	19	18
12	13	14	12	15	11	16	10	17	9	18	8	19	7	20	6	1	5	2	4	3
13	9	10	8	11	7	12	6	13	5	14	4	15	3	16	2	17	1	18	20	19
14	3	4	2	5	1	6	20	7	19	8	18	9	17	10	16	11	15	12	14	13
15	17	18	16	19	15	20	14	1	13	2	12	3	11	4	10	5	9	6	8	7
16	11	12	10	13	9	14	8	15	7	16	6	17	5	18	4	19	3	20	2	1
17	4	5	3	6	2	7	1	8	20	9	19	10	18	11	17	12	16	13	15	14
18	18	19	17	20	16	1	15	2	14	3	13	4	12	5	11	6	10	7	9	8
19	20	1	19	2	18	3	17	4	16	5	15	6	14	7	13	8	12	9	11	10
20	19	20	18	1	17	2	16	3	15	4	14	5	13	6	12	7	11	8	10	9

Note. Table entries indicate memorandum numbers.

practice/fatigue effects, using the arrangement shown in Table 5. Here, two 5 x 5 Latin squares were selected from Edwards' (1960) series (two complementary squares are needed to achieve balance when there is an odd number of levels) and this set of ten sequences was used twice to provide for 20 subject pairs. Within each set of ten, the order of the rows was randomized. In the design illustrated in Table 5, each type of material appeared an equal number of times at each presentation position and each type preceded and followed every other type exactly four times.

Table 5  
 Order of Presentation of Each Type of Material  
 to Each Subject Pair

Subject pair	Presentation order				
	1	2	3	4	5
<u>Females</u>					
1	C	N	B	F	R
3	B	C	R	N	F
5	R	B	F	C	N
7	C	B	N	R	F
9	N	F	C	R	B
11	R	F	B	N	C
13	F	N	R	C	B
15	F	R	N	B	C
17	N	C	F	B	R
19	B	R	C	F	N
<u>Males</u>					
2	R	B	F	C	N
4	N	F	C	R	B
6	C	B	N	R	F
8	F	N	R	C	B
10	B	R	C	F	N
12	R	F	B	N	C
14	C	N	B	F	R
16	F	R	N	B	C
18	N	C	F	B	R
20	B	C	R	N	F

Note. B = Benton designs, C = colours,  
 F = faces, N = nonsense figures, R = random shapes.

## Results

The CA score obtained for each item is presented in Table 6.

From the binomial distribution (e.g., Owen, 1962, p.269), it may be predicted that if there is a 25% probability of choosing correctly solely by chance and if 20 independent choices are made then 95.91 percent of the time the total number of correct choices will be no greater than eight. Alternatively, for this situation, there is a 4.09% possibility of the total number correct being nine or more if, in fact, the responses are determined randomly. Thus, where nine or more correct responses are made to an item by the D subjects it may be argued that  $H_0$  should be rejected since it appears very improbable that the data for this item have been sampled from a binomially distributed population ( $N=20, p=.25$ ) with a mean of five.

Because of the large number of statistical tests made, it could be argued that some adjustment of the significance level is necessary, however. With alpha set at approximately 4%, on the average about four of the 100 CA scores would be expected to be above the critical value, purely by chance, even if  $H_0$  were true. In order to minimize the possibility

Table 6

Total CA Score for Each Item of Each Type of Material

Type of material	Item number																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Benton designs	15	16	18	9	16	18	17	17	19	15	19	17	15	16	20	17	18	19	18	14
Colours	11	12	12	<u>7</u>	11	13	13	<u>6</u>	11	<u>8</u>	13	<u>8</u>	11	11	16	<u>5</u>	11	11	15	<u>6</u>
Faces	<u>8</u>	11	17	16	14	13	11	12	20	14	14	13	12	18	<u>7</u>	11	12	15	16	14
Nonsense figures	14	14	14	14	19	19	15	19	18	16	14	17	19	18	17	17	16	14	16	15
Random shapes	14	10	17	17	17	13	14	15	18	11	12	13	19	15	15	18	18	12	14	9

Note. Underlining indicates those scores which are not significantly greater than chance ( $p < .04$ ).

of accepting spurious results such as these as valid tests of the hypothesis, the rejection region could have been more narrowly defined.

If, for example, it had been decided to reject  $H_0$  only where the 20 D subjects were able to make 10 or more correct choices for any item, then the probability of falsely rejecting  $H_0$ , if in fact it is true, would have been reduced to .0139. With alpha set at this value, only about one misleading result of this kind would normally be expected from a series of 100 such statistical tests.

Reduction of the probability of making a Type I error results in an increase in the probability of making a Type II error, however, and, in effect, reduces the ability of the test to guard against accepting  $H_0$  when it is, in fact, false. Since the main purpose of the study was to select items for which it can be argued convincingly that verbal mediation is unsuccessful, it was deemed appropriate to keep alpha at .0409.

This strategy requires accepting the disadvantage that a few items may be judged, in error, to be verbalizable but minimizes the number which will likely be judged, in error, to be nonverbalizable.

By choosing a more moderate alpha level, and thus reducing the Type II error rate, the net effect was to employ a lower cut-off score and thus require the items selected to meet a more stringent criterion of nonverbalness.

The total CA score of each subject pair for each type of material is listed in Table 7. These scores are also summarized graphically in Figure 1. One appropriate method for the analysis of these data is offered by the model for repeated-measures analysis of variance (e.g., Winer, 1971, pp.518-539). Table 8 specifies the computations performed for this analysis and a summary of the results is presented in Table 9. Clearly, there is no interaction and no sex effect but reliable differences among types of materials are present in these data.

In order to explore these differences further, Duncan's (1955) Multiple Range Test was used to make multiple comparisons. (Duncan's test was chosen on the basis of evidence, such as that reviewed by Thomas, 1974, that the other commonly used tests for making pairwise comparisons exhibit higher Type I error rates and lower power.) Table 10 portrays the computations necessary for Duncan's test

Table 7  
Total CA Score of Each Subject Pair for  
Each Type of Material

Subject pair	Type of material					Totals
	Benton designs	Colours	Faces	Nonsense figures	Random shapes	
<u>Females</u>						
1	20	12	13	19	13	77
3	14	11	15	15	14	69
5	16	11	14	17	13	71
7	16	10	16	12	14	68
9	16	8	16	12	16	68
11	18	14	14	15	13	74
13	12	11	17	17	13	70
15	17	13	5	15	12	62
17	17	10	16	18	19	80
19	18	11	15	19	16	79
	164	111	141	159	143	718
<u>Males</u>						
2	18	11	17	17	16	79
4	19	7	14	17	18	75
6	18	10	10	17	17	72
8	17	15	17	19	13	81
10	17	9	10	16	10	62
12	20	13	10	17	13	73
14	17	10	13	16	14	70
16	20	11	13	16	17	77
18	11	4	12	15	14	56
20	12	10	11	16	16	65
	169	100	127	166	148	710

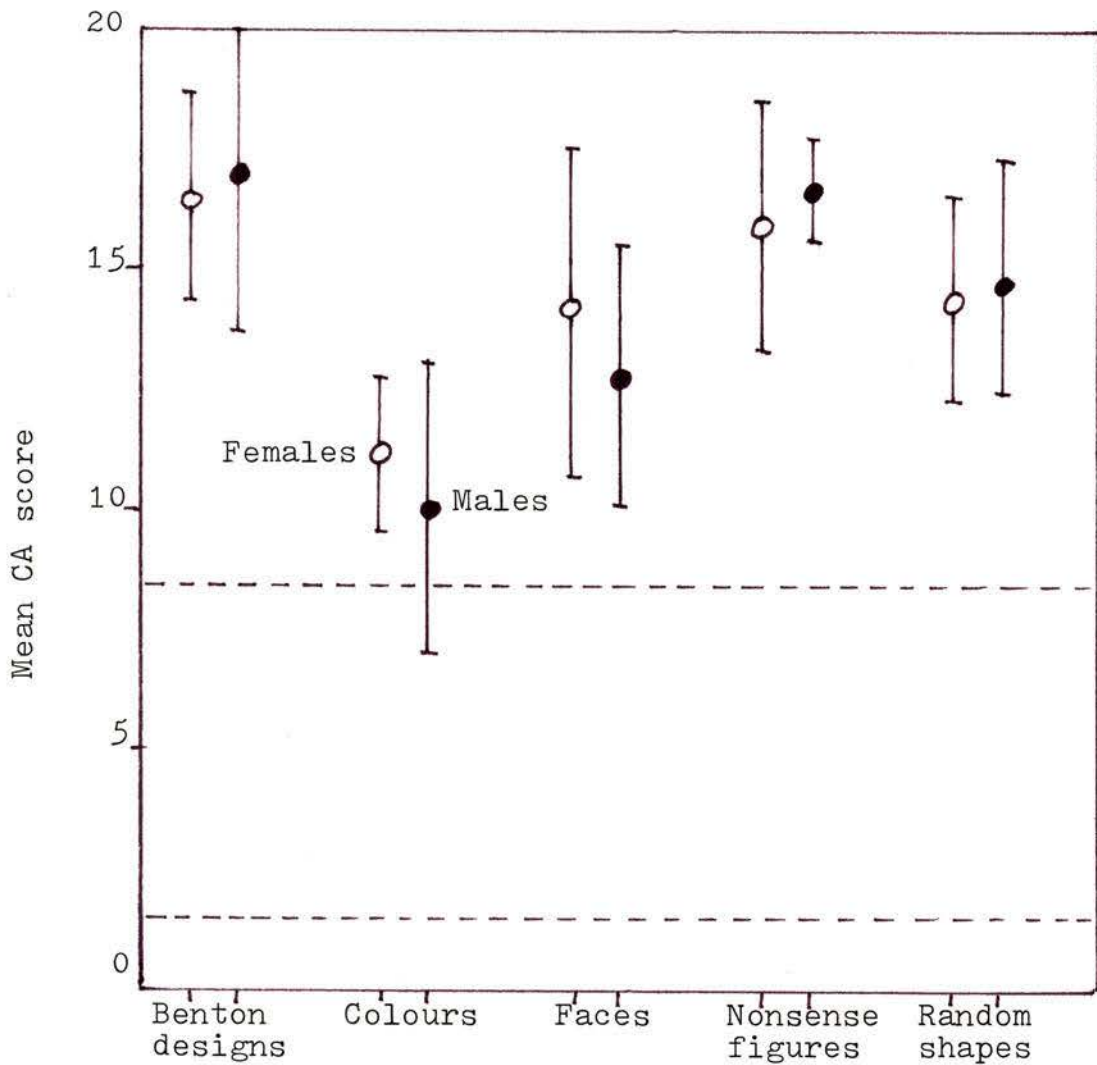


Figure 1. Mean CA score per subject pair for each sex on each type of material. (Dashed lines indicate range of responses not significantly different from chance.)  $\bar{\quad}$  =  $\pm$  one standard deviation.

Table 8

## Computations for Repeated Measures Analysis of Variance

Source	df	SS	MS	F	critical values	
					.95	.99
Between subjects	$an-1$	$(6)-(1)$				
A	$a-1$	$(3)-(1)$	$\frac{SS_A}{df_A}$	$\frac{MS_A}{MS_{\underline{S}wg}}$	4.41	8.29
<u>Ss</u> within groups	$a(n-1)$	$(6)-(3)$	$\frac{SS_{\underline{S}wg}}{df_{\underline{S}wg}}$			
Within subjects	$an(b-1)$	$(2)-(6)$				
B	$b-1$	$(4)-(1)$	$\frac{SS_B}{df_B}$	$\frac{MS_B}{MS_{B \times \underline{S}wg}}$	2.53	3.65
A x B	$(a-1)(b-1)$	$(5)-(3)-(4)+(1)$	$\frac{SS_{A \times B}}{df_{A \times B}}$	$\frac{MS_{A \times B}}{MS_{B \times \underline{S}wg}}$	2.53	3.65
B x <u>S</u> wg	$a(n-1)(b-1)$	$(2)-(5)-(6)+(3)$	$\frac{SS_{B \times \underline{S}wg}}{df_{B \times \underline{S}wg}}$			

(continued next page)

Table 8 (continued)

Where (1) =  $G^2/abn$ , (2) =  $\sum X^2$ , (3) =  $(\sum A^2)/bn$ , (4) =  $(\sum B^2)/an$ ,  
 (5) =  $[\sum (AB)^2]/n$ , (6) =  $(\sum S^2)/b$ .

Note. For all analyses,  $a = 2$ ,  $b = 5$ ,  $n = 10$ .

For the CA data in Table 7:

$$\begin{aligned} G^2 &= 1428^2, \\ \sum X^2 &= 20^2 + 12^2 + \dots + 16^2 + 16^2, \\ \sum A^2 &= 718^2 + 710^2, \\ \sum B^2 &= 333^2 + 211^2 + \dots + 291^2, \\ \sum (AB)^2 &= 164^2 + 111^2 + \dots + 148^2, \\ \sum S^2 &= 77^2 + 69^2 + \dots + 65^2, \end{aligned}$$

Table 9  
 Summary of Analysis of Variance of CA Scores  
 for Each Type of Material

Source	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>	<u>p</u> <
Between subjects					
Sex	1	.64	.64	.07	.80
<u>Ss</u> within groups	18	170.32	9.46		
Within subjects					
Materials	4	485.16	121.29	21.95	.01
Sex x materials	4	20.16	5.04	.91	.46
Materials x <u>Ss.w.g.</u>	72	397.88	5.53		
Total	99	1074.16	10.85		

Table 10  
 Computations for Duncan's Multiple Range Test

$$\begin{aligned} \text{DMR Critical Value } r &= \sqrt{\frac{MS_{B \times S, w.g.}}{na}} \times q_{1-\alpha} (r, df_{B \times S, w.g.}) \\ &= \sqrt{\frac{5.5261}{10 \times 2}} \times q_{1-\alpha} (r, 72) \\ &= .53 \quad \times \quad " \quad " \end{aligned}$$

$1-\alpha = .99^a$	$1-\alpha = .95^a$	$q (r, df_{B \times S, w.g.})$
4.12	3.14	$q (5, 72)$
4.03	3.08	$q (4, 72)$
3.92	2.98	$q (3, 72)$
3.76	2.83	$q (2, 72)$

	F	R	N	B	r	CV .99	CV .95
C	2.85	4.00	5.70	6.10	5	2.18	1.66
F		1.15	2.85	3.25	4	2.14	1.63
R			1.70	2.10	3	2.08	1.60
N				0.40	2	1.99	1.50

Note. C = colours, F = faces, R = random shapes, N = nonsense figures, B = Benton designs.

<sup>a</sup>Table values from Kirk (1968, p.533).

Table 11

## Multiple Comparisons of CA Means for Materials

Differences between pairs of means					
	Colours	Faces	Random shapes	Nonsense figures	Benton designs
Colours	-	2.85**	4.00**	5.70**	6.10**
Faces		-	1.15	2.85**	3.25**
Random shapes			-	1.70*	2.10**
Nonsense figures				-	0.40

Ordered means					
	Colours	Faces	Random shapes	Nonsense figures	Benton designs
	10.55	<u>13.40</u>	<u>14.55</u>	<u>16.25</u>	<u>16.65</u>

Note. Underlining indicates those means which do not differ significantly from each other.

\* $p < .05$ .

\*\* $p < .01$ .

Although the above procedure is recommended by Winer (1971, p.528), it should be noted that other authorities dispute its validity. Keppel, for example, (1973, p.420) recommends using a different MS error term for each comparison and Morrison (1967) argues that only multivariate methods may be used to calculate multiple comparisons in a repeated measures design. Because of the controversial nature of this topic, the results reported here should be regarded as tentative.

and a summary of the results is presented in Table 11. This analysis suggests that the five types of materials may be grouped into three categories on the basis of ease of verbalizability. The Benton designs and the nonsense figures, which do not differ from each other in terms of CA means, are significantly easier to encode verbally than any of the other types of material. Colours stand alone at the other extreme, being significantly more difficult to describe adequately in words than the other four stimulus varieties. Faces and random shapes are intermediate in terms of mediational possibilities and are not reliably different from each other.

Table 12 presents the CA data for faces only with sex of memorandum crossed with sex of subject pair. A chi-square test reveals no significant interaction between these two variables.

In Table 13, the total CA scores and errors for random shapes are listed by complexity level for each sex. Again the chi-square statistic indicates that, for both sexes, the proportions observed at each complexity level cannot be considered independent.

In Table 14, the total CA score for each random shape is compared with the association value for that

Table 12

Total CA Scores and Errors for Faces by Sex  
of Memorandum

---

Sex of memorandum	CA score	Errors
	Female subjects	
Female faces	74	26
Male faces	67	33
Totals:	141	59
	Male subjects	
Female faces	62	38
Male faces	65	35
Totals:	127	73

---

Note. For females,  $\chi^2(1) = 1.18, p < .28$ .  
For males,  $\chi^2(1) = .19, p < .66$ .

Table 13  
 Total CA Scores and Errors for Random Shapes  
 by Complexity Level

Number of sides	CA score	Errors
	Females	
6	28	12
8	30	10
12	27	13
16	31	9
24	27	13
Totals:	143	57
	Males	
6	30	10
8	29	11
12	27	13
16	36	4
24	26	14
Totals:	148	52

Note. For females,  $\chi^2(4) = 1.62, p < .80$ .  
 For males,  $\chi^2(4) = 7.95, p < .09$ .

Table 14  
Correlation Between CA Score and Association Value for  
Random Shapes

Item no.	Association value	CA score
1	26	14
2	26	10
3	26	17
4	26	17
5	26	17
6	22	13
7	26	14
8	20	15
9	26	18
10	26	11
11	20	12
12	26	13
13	24	19
14	22	15
15	26	15
16	30	18
17	22	18
18	28	12
19	24	14
20	28	9

Note.  $r = -.05$

shape from Vanderplas and Garvin's (1959a) original study. For these two variables,  $r = -.05$  indicating that they are not related (in a linear way, at least).

Table 15 presents the total CA scores for each subject pair arranged in the order in which the data were collected. Latin square analyses were conducted, to estimate the magnitude of the error contributed by practice/fatigue effects, and a summary of these results appear in Table 16. It is evident that there is much variability among subjects, with two blocks showing a significant position effect and two blocks yielding a nonsignificant effect. These results are thus inconclusive as to the role of practice/fatigue factors in influencing the CA data.

The changes in total CA scores, as a function of presentation position, are plotted in Figure 2 for each type of material separately. Inspection of this figure reveals no consistent upward or downward trend for any of the five types of material. On the basis of these findings it is reasonable to conclude that the performance of subject pairs neither improved nor declined substantially over the course of their exposure to the successive types of material.

Table 15  
 Total CA Scores of Each Subject Pair for  
 Each Presentation Position

Subject pair	Presentation position				
	1	2	3	4	5
<u>Females</u>					
1	12	19	20	13	13
3	14	11	14	15	15
5	13	16	14	11	17
7	10	16	12	14	16
9	12	16	8	16	16
11	13	14	18	15	14
13	17	17	13	11	12
15	5	12	15	17	13
17	18	10	16	17	19
19	18	16	11	15	19
	132	147	141	144	154
<u>Males</u>					
2	16	18	17	11	17
4	17	14	7	18	19
6	10	18	17	17	10
8	17	19	13	15	17
10	17	10	9	10	16
12	13	10	20	17	13
14	10	16	17	13	14
16	13	17	16	20	11
18	15	4	12	11	14
20	12	10	16	16	11
	140	136	144	148	142
Position totals:	272	283	285	292	296

Table 16

## Summary of Latin Square Analyses of CA Data

Subject pairs:		1,3,5,7,9			11,13,15,17,19		
Source	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
Subjects	4	11.44	2.86	1.21	43.20	10.80	1.05
Materials	4	101.44	25.36	10.75**	86.80	21.70	2.10
Positions	4	39.44	9.86	4.18*	8.00	2.00	.19
Residual	12	28.32	2.36		124.00	10.33	
Total	24	180.64			262.00		

Subject pairs:		2,4,6,8,10			12,14,16,18,20		
Source	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
Subjects	4	44.56	11.14	2.55	52.56	13.14	77.29**
Materials	4	177.76	44.44	10.16**	160.96	40.24	236.70**
Positions	4	37.76	9.44	2.16	84.16	21.04	123.76**
Residual	12	52.48	4.37		2.08	.17	
Total	24	312.56			299.76		

\* $p < .05$ .\*\* $p < .01$ .

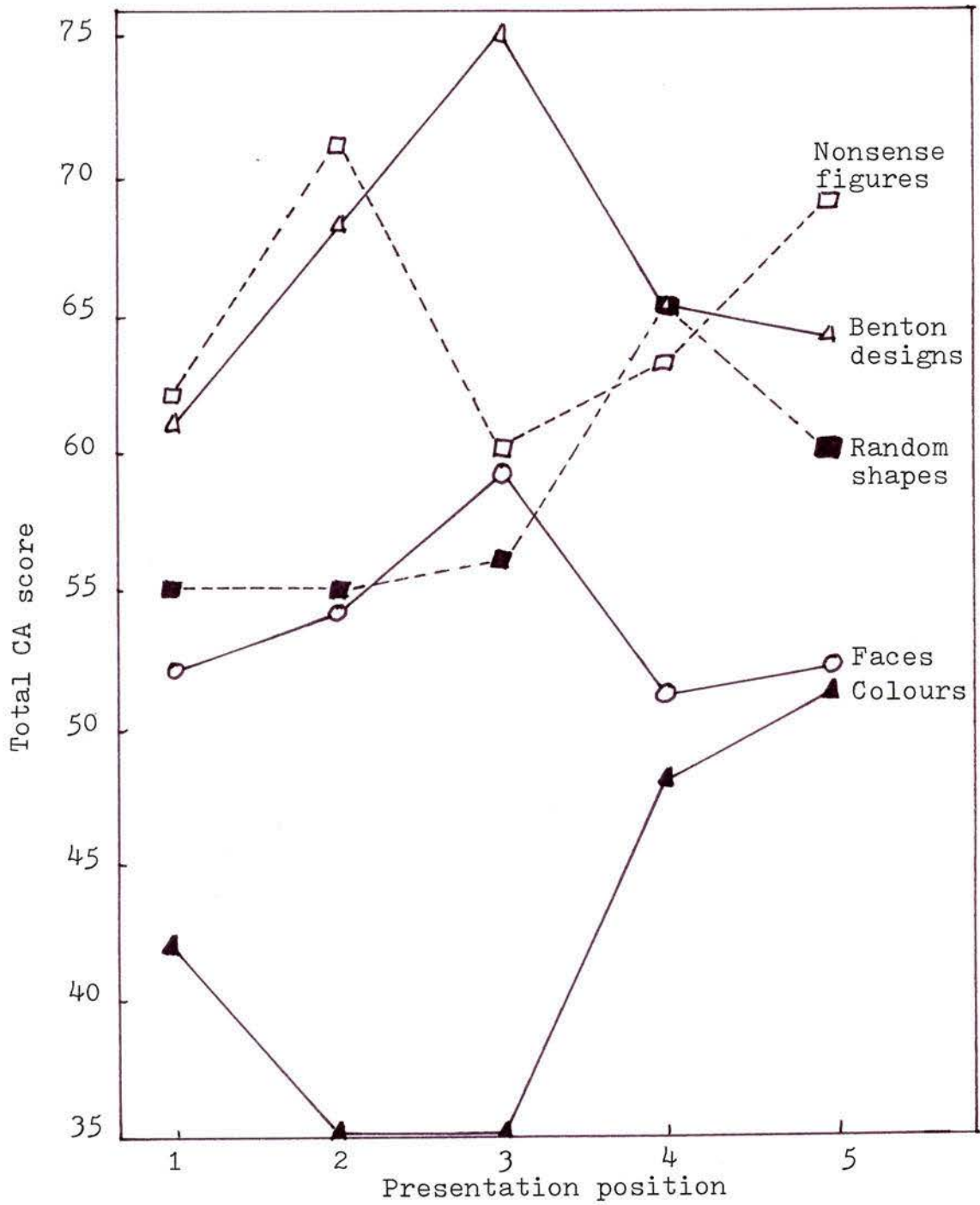


Figure 2. Changes in total CA score as a function of presentation position for each type of material.

In any analysis of variance model, homogeneity of variance and covariance is assumed. In independent-groups designs there is normally little reason to question this assumption. In designs where each subject is used as her/his own control, however, there is a high probability of significant practice/fatigue effects and these may operate to produce unequal variances and covariances. Because of this risk, it was considered necessary to assess the degree of homoscedasticity. This was accomplished by comparing the observed values in the variance/covariance matrix with the overall average values for these parameters. A chi-square test used for this comparison confirmed that the variances within cells and the covariances between cells were approximately equal for both sets of CA summary scores (for materials,  $\chi^2(13) = 15.07, p < .30$ ; for position,  $\chi^2(13) = 17.03, p < .20$ ). The conclusion was therefore drawn that the repeated-measures analysis of variance model is appropriate for these data.

The analyses reported to this point conclude those which were planned in designing the study. In the following pages, several post-hoc analyses are described. These were conducted to explore relationships which appeared to be of interest after the data were collected.

The time score recorded for each subject pair on each type of material is listed in Table 17. The analysis of variance for these data (following the model specified in Table 8) is summarized in Table 18. Again there was no reliable interaction and no sex effect but significant differences were present among the types of material. A check on the uniformity assumption revealed that the data did not exhibit homogeneity of covariance ( $\chi^2(13)=30.81, p < .01$ ). Substitution of Greenhouse and Geisser's (1959) conservative test did not alter the pattern of the results, however. (For the materials factor,  $F(1,18)=12.50, p < .01$ ). It was thus concluded that the time-score differences, among the types of material, were reliable ones.

The pattern of these differences was explored using Duncan's Multiple Range Test in the manner illustrated in Table 10. Table 19 summarizes the results of these multiple comparisons. Subject pairs responded significantly faster to the Benton designs than to any other type of material. When the remaining four types of material are ordered by time-score means, each is not reliably different from the type above or below it.

In order to examine within-set variability,

Table 17  
 Time Taken by Each Subject Pair for  
 Each Type of Material

Subject pair	Type of material					Totals
	Benton designs	Colours	Faces	Nonsense figures	Random shapes	
<u>Females</u>						
1	17	18	18	19	18	90
3	18	20	20	20	20	98
5	16	17	21	16	18	88
7	17	18	18	18	18	89
9	18	18	20	19	18	93
11	17	15	17	18	17	84
13	18	17	22	20	21	98
15	15	16	17	18	17	83
17	15	18	23	18	19	93
19	16	16	17	16	17	82
	167	173	193	182	183	898
<u>Males</u>						
2	19	19	22	18	22	100
4	21	26	28	23	28	126
6	18	19	22	19	19	97
8	17	18	18	19	18	90
10	19	19	19	19	19	95
12	17	17	18	17	20	89
14	14	17	22	19	19	91
16	15	16	15	17	16	79
18	19	19	19	18	20	95
20	17	18	20	20	19	94
	176	188	203	189	200	956

Note. Table entries are rounded to the nearest minute.

Table 18  
 Summary of Analysis of Variance for Time Scores

Source	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Between subjects					
Sex	1	33.64	33.64	1.87	.19
<u>Ss</u> within groups	18	324.00	18.00		
Within subjects					
Materials	4	82.64	20.66	12.50	.01
Sex x materials	4	3.56	.89	.54	.71
Materials x <u>Ss.w.g.</u>	72	119.00	1.65		
Total	99	562.84	5.69		

Table 19  
Multiple Comparisons of Time Score Means

Differences between pairs of means				
	Colours	Nonsense figures	Random shapes	Faces
Benton Designs	.90*	1.40**	2.00**	2.65**
Colours	-	.50	1.10*	1.75**
Nonsense figures		-	.60	1.25**
Random shapes			-	.65

Ordered means				
Benton designs	Colours	Nonsense figures	Random shapes	Faces
17.15	<u>18.05</u>	<u>18.55</u>	<u>19.15</u>	19.80

Note. Underlining indicates those means which do not differ significantly from each other.

\* $p < .05$ .

\*\* $p < .01$ .

one type of material, colours, was chosen arbitrarily and the decoder responses to these items were subjected to a Latin-square analysis. The data, arranged by item number, are presented in Table 20 and appear also in Table 21, arranged by presentation position.

The Latin-square computations are specified in Table 22 while Table 23 summarizes this analysis. The  $F$  tests indicate that there are reliable differences among the colour items in terms of the accuracy of the D responses. Individual differences among subject pairs and position effects do not, however, contribute significantly to the variance in these data.

Table 24 lists the total correct choices of the encoder subjects for each type of material. The E choices are also illustrated, on a per item basis, in Figure 3. It is apparent that the only type of material showing any appreciable variability in E responses is colours. For these stimuli, females do not make significantly more correct choices on the memory task than do males [ $F(1,18) = 3.42, p < .08$ ].

For each of the colour items, the total correct

choices made by the D subjects and the E subjects are presented in Table 25. For these two variables,  $r = .45$  and for this value,  $t(18) = 2.14, p < .01$ . Those hues which were difficult to describe adequately in words tended to be the same ones that were hardest to remember correctly.

In order to illustrate the descriptive responses made by the E subjects, typical examples of verbalizations are presented in Appendix E.

Table 20

## Decoder Responses to Colour Items Arranged by Item Number

Subject pair	Item number																				Totals
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
<u>Females</u>																					
1	1	0	1	0	0	1	1	0	0	1	1	0	1	1	1	0	1	1	1	0	12
3	0	0	1	0	1	0	1	0	0	1	1	0	0	1	1	1	1	0	1	1	11
5	1	1	1	0	0	1	1	1	0	1	0	0	1	0	1	0	0	1	1	0	11
7	1	0	0	0	1	0	0	0	1	1	1	1	1	0	1	0	0	0	1	1	10
9	0	0	1	0	0	0	0	1	1	0	0	0	1	1	1	0	1	0	1	0	8
11	1	1	1	1	1	1	1	0	1	1	0	0	0	0	1	1	1	1	1	0	14
13	1	1	1	1	0	1	1	0	0	0	0	1	1	0	1	0	1	0	1	0	11
15	1	0	1	1	1	1	1	0	1	0	1	1	1	1	1	0	0	0	1	0	13
17	1	0	1	1	1	0	0	0	0	1	1	0	1	0	1	1	0	0	1	0	10
19	1	1	0	0	0	1	1	1	0	0	1	1	0	0	1	1	0	1	1	0	11
	8	4	8	4	5	6	7	3	5	5	6	4	7	4	10	4	5	4	10	2	111
<u>Males</u>																					
2	0	0	0	0	1	1	0	1	1	1	1	1	0	1	0	0	1	1	1	0	11
4	0	1	0	0	1	0	0	0	1	0	1	0	1	1	0	0	0	0	1	0	7
6	0	1	0	0	0	1	1	0	0	0	1	0	1	1	1	0	1	1	0	1	10
8	1	1	0	0	1	1	1	0	1	1	1	1	0	1	1	0	1	1	1	1	15
10	0	1	1	1	0	1	0	1	1	0	0	0	1	0	0	0	0	1	1	0	9
12	1	1	1	0	1	0	1	1	1	0	0	1	0	1	1	0	1	1	1	0	13
14	0	1	0	0	0	1	1	0	0	0	1	0	1	1	1	0	1	1	0	1	10
16	0	0	0	1	1	1	1	0	1	0	1	1	0	0	1	1	1	0	0	1	11
18	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
20	1	1	1	0	1	1	0	0	0	1	1	0	0	1	1	0	0	1	0	0	10
	3	8	4	3	6	7	6	3	6	3	7	4	4	7	6	1	6	7	5	4	100
Item totals:	11	12	12	7	11	13	13	6	11	8	13	8	11	11	16	5	11	11	15	6	211

Note. 1 = correct response, 0 = incorrect response.

Table 21

## Decoder Responses to Colour Items Arranged by Presentation Position

Subject pair	Presentation position																				Totals
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
<u>Females</u>																					
1	0	1	1	1	0	1	1	0	0	1	1	1	1	1	0	0	0	1	1	0	12
3	1	0	0	0	1	1	0	1	1	0	0	0	0	1	1	1	1	1	0	1	11
5	1	1	1	0	0	0	1	1	1	1	0	1	0	0	1	1	0	0	1	0	11
7	1	0	0	0	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	1	10
9	0	0	1	0	1	1	0	1	0	1	0	0	0	1	1	0	0	1	0	0	8
11	0	1	1	1	1	0	1	0	1	0	1	0	1	1	1	1	0	1	1	1	14
13	0	0	0	0	1	1	1	1	0	0	1	1	1	0	0	0	1	0	0	1	11
15	0	0	0	1	1	0	1	1	1	0	1	1	1	1	0	1	1	1	0	1	13
17	1	1	1	0	0	0	1	0	0	0	1	1	0	1	0	0	1	1	1	0	10
19	0	1	1	1	1	0	0	0	1	0	1	1	0	1	0	1	1	0	1	0	11
	4	5	6	4	7	4	7	6	6	4	7	7	5	7	5	6	5	6	5	5	111
<u>Males</u>																					
2	1	0	0	0	1	1	1	1	1	1	1	0	1	0	0	0	1	0	1	0	11
4	0	0	1	0	0	1	0	0	1	1	0	0	0	1	1	1	0	0	0	0	7
6	0	1	0	1	0	0	1	0	0	0	1	1	0	0	1	1	1	1	0	1	10
8	0	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	0	1	1	1	15
10	0	1	0	1	1	1	1	0	0	1	0	0	0	1	0	1	1	0	0	0	9
12	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	1	1	1	0	1	13
14	0	0	1	0	0	1	1	1	0	0	1	0	1	0	0	1	1	0	1	1	10
16	1	1	0	0	1	0	0	1	1	1	1	1	1	0	1	0	0	1	0	0	11
18	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	4
20	0	0	1	1	0	1	0	1	1	0	1	1	0	1	0	0	1	0	1	0	10
Position	2	5	5	5	4	6	4	7	6	7	7	6	5	3	4	5	6	5	4	4	100
totals:	6	10	11	9	11	10	11	13	12	11	14	13	10	10	9	11	11	11	9	9	211

Note. 1 = correct response, 0 = incorrect response.

Table 22

Computations for Latin Square Analysis of Decoder Responses to Colour Items

Source	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>	.95 <sup>a</sup>	.99 <sup>a</sup>
Mean	1	$T^2/n^2$				
Subjects	n-1	$\sum S^2/n - T^2/n^2$	$SS_S/df_S$	$MS_S/MS_R$	1.61	1.95
Items	n-1	$\sum I^2/n - T^2/n^2$	$SS_I/df_I$	$MS_I/MS_R$	"	"
Position	n-1	$\sum P^2/n - T^2/n^2$	$SS_P/df_P$	$MS_P/MS_R$	"	"
Residual	(n-1)(n-2)	$X^2 - T^2/n^2 - SS_S - SS_I - SS_P$	$SS_R/df_R$			
Total	$n^2$	$\sum X^2$				

Note. For the data in Tables 20 and 21:

$$\sum S^2 = 12^2 + 11^2 + \dots + 4^2 + 10^2,$$

$$\sum I^2 = 11^2 + 12^2 + \dots + 15^2 + 6^2,$$

$$\sum P^2 = 6^2 + 10^2 + \dots + 9^2 + 9^2,$$

$$\sum X^2 = 0^2 + 1^2 + \dots + 1^2 + 0^2,$$

$$T^2 = 211^2,$$

$$n = 20$$

<sup>a</sup>Critical values for F(19,342) from Winer, 1971, p.869.

Table 23  
 Summary of Latin Square Analysis of  
 Decoder Responses to Colour Items

Source	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
Mean	1	111.30		
Subjects	19	5.65	.30	1.25
Items	19	8.55	.45	1.88*
Position	19	2.95	.16	.67
Residual	342	82.55	.24	
Total	400	211.00		

\*  $p < .05$ .

Table 24  
Total Correct Choices by Encoder Subjects for

Subject pair	Each Type of Material					Totals
	Benton designs	Colours	Faces	Nonsense figures	Random shapes	
<u>Females</u>						
1	20	17	20	20	20	97
3	20	18	20	20	20	98
5	20	18	20	20	20	98
7	19	18	20	20	20	97
9	20	13	20	20	20	93
11	20	19	20	20	20	99
13	20	16	20	20	20	96
15	20	20	20	20	20	100
17	19	18	20	20	20	97
19	19	18	20	20	20	97
	197	175	200	200	200	972
<u>Males</u>						
2	20	16	20	20	20	96
4	20	13	20	20	20	93
6	20	15	20	20	20	95
8	20	18	20	20	20	98
10	19	14	20	20	20	93
12	19	19	20	20	20	98
14	20	18	20	20	20	98
16	20	16	20	20	20	96
18	20	14	20	20	20	94
20	17	16	19	20	20	92
	195	159	199	200	200	953

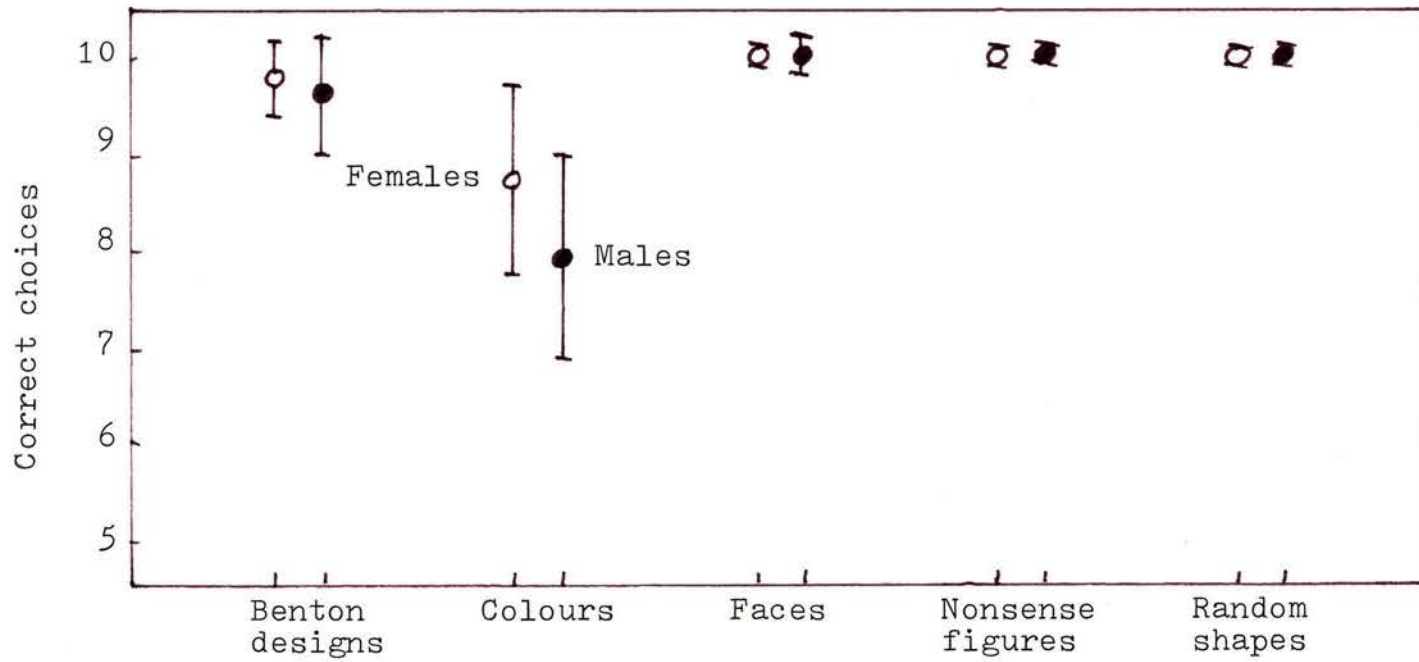


Figure 3. Mean number of correct Encoder choices per item for each sex on each type of material.  $\bar{\pm}$  =  $\pm$  one standard deviation.

Table 25

CA Score and Total Correct Choices by Encoders for Each Colour Item

Score	Colour item number																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Correct encoder choices	18	18	16	15	19	17	16	12	17	18	16	18	18	16	17	17	16	17	19	14
CA score	11	12	12	7	11	13	13	6	11	8	13	8	11	11	16	5	11	11	15	6

$r = .45$

Note. For  $r = .45$ ,  $t(18) = 2.14$ ,  $p < .01$ .

## Discussion

Of the 100 items evaluated by the CA method, only six colours and two faces met the predetermined criterion of nonverbalness. For the remaining 92 items, it must be concluded that a substantial number of people would be able to successfully employ verbal mediational cues if they so desired. In developing tasks to serve as measures of NVM, colour items 4,8,10,12,16 and 20 and face items 1 and 15 offer the investigator an acceptable level of construct validity whereas use of any of the others would have to be considered less than ideal. For those few items with CA scores  $\leq 8$ , it is reasonable to assume that it is just not possible to encode, transmit and retrieve information, in a verbal form only, which is sufficient to mediate successful discrimination of the memorandum from its canards.

The five sets of material were chosen for evaluation by the CA method because they represent the most popular kinds of nonverbal stimuli and because it was expected that some of them at least, would be useful as sources of items for future work in developing measures of NVM. Within each set of material, the particular items assessed were

carefully selected, on an a priori and subjective basis, to be those most likely to be nonverbalizable. Memoranda were chosen to be as free from easily identifiable verbal cues as possible and canards were closely matched to each memorandum to make the discrimination task difficult to accomplish verbally. In spite of these methodical attempts to produce the most nonverbal items possible, subjects were still able to find ways to translate their visual impressions into verbal codes and thus to improve their performance on virtually all items to levels significantly above that expected by chance.

Since all the items in each set were selected/constructed to be equally (i.e., maximally) nonverbal, there was no basis for anticipating which of them would, or would not, meet the validity criterion. Moreover, a post hoc examination of the eight successful items revealed no obvious reasons for their refractoriness to linguistic analysis. The CA method thus appears to be a way to determine stimulus attributes which are not otherwise recognizable.

One major conclusion to be drawn from the CA study is that many kinds of items, which have been

commonly regarded by investigators as suitable to tap the nonverbal aspects of memory, are really not nonverbal at all, at least in the fundamental sense of being completely unverbalizable. The CA results demonstrate that if a subject tries to process these items verbally, most of the time (s)he will be successful. If items such as those having CA scores  $\geq 9$  are to be used in tasks purporting to measure NVM, the investigator must rest her/his argument for construct validity on the rather weak assumption that, given the choice, subjects will choose not to use their extremely versatile verbal processing system .

In spite of the negative results for 92% of the items, it is still conceivable that some (or even all) of these would, in fact, be processed nonverbally by some (or even all) subjects in a memory task. Given an organism which likely attempts to dually encode all stimuli wherever possible (cf., Paivio, 1971), however, we have no way to estimate what percentage of the memory process is accomplished verbally, or nonverbally, when both are possible. For the investigator who wishes to measure NVM only, the most reasonable way to proceed would seem to be to

select items for which the probability of verbal interference is as low as possible. The CA method appears to offer a way to estimate the extent of verbal confounding of nonverbal items and may allow for the eventual dissociation of verbal and NVM on an empirical basis.

Even those items which shared some significant degree of verbalizability may be useful in constructing NVM tasks, however. Consideration of an extreme example will illustrate the concept involved. If a particular item was entirely verbal in nature, say a subspan string of digits, then the CA score for this item should be 20. Where an item has a CA score greater than the critical value, but less than 20, it may be concluded that memory for this item may entail some degree of verbal mediation (i.e., it cannot be considered a completely verbal-free item) but not enough to regard it as a consistently verbally encodable item.

It may further be argued that, for these ambiguous items, the CA score is a reasonably good index of the degree of nonverbalness. Thus, an item with a CA score of 15 could be considered more verbalizable than one with a CA score of 10. From

this logic, it follows directly that the items from any set of material could simply be rank ordered by CA score and the requisite number of items needed for any memory task could be obtained by using those with the lowest scores. Although a task created in this manner could not be considered a "pure" measure of NVM, it could still have some substantial claim to construct validity. Perhaps more importantly, the extent of verbal confounding could be expressed quantitatively and thus be directly compared with other instruments purporting to measure the same thing.

The fundamental assumption underlying all of the item analyses is that (for CA scores  $>5$ ) the closer the score is to the level expected by chance, the more difficult it would appear to be to transmit essential information about that item, verbally, to another person. By extension, it may be reasoned that the lower the CA score, the more difficult it would be to transmit information to oneself in the sense of encoding linguistically, rehearsing by recycling the verbal information, and choosing among similar alternatives by retrieving the stored symbols.

No male/female differences were revealed in any of the CA data analyses, nor were there any

significant interactions between sex of subject pair and type of material (including sex of memorandum face or complexity level for random shapes) or presentation position. The sex component did not emerge, either as a significant main effect or as part of a significant interaction, in any of the analyses of the time scores or the E responses. These results indicate that all the data may be collapsed across this variable without any loss of information and suggest that the sex factor may be given less importance in future studies of this type.

The comparisons among the types of material signify that, overall, Benton design and nonsense figures provide rather poor quality items for the measurement of NVM. This outcome calls into question the statements regarding NVM made by the many authors who have claimed to be measuring the construct by using tasks involving these kinds of stimuli. The results of this study suggest that, for those subjects who wish to do so, Benton designs and nonsense figures can be readily translated into verbal representations. On the average, more than 80% of the subject pairs responding to these materials in the CA task were able to make the correct choices.

Thus, a substantial proportion of the general population may be able to process these items verbally and for these people, the designs and figures could be functionally equivalent to stimuli composed of letters or words.

Random shapes and faces appear to offer significantly better possibilities as stimuli for NVM tasks. For the items used in the CA study, subjects averaged about a 30% error rate over both shapes and faces. Although they were able, through the use of verbal descriptions, to improve their performance significantly above the level expected by chance, their gains were only about half of what would be expected if these stimuli had been completely verbalizable. Several items in particular appeared to offer substantial transmission difficulty. It is possible that if more effective canards had been selected for these items, many more may have achieved CA scores below the cut-off point.

Those shape and face items with the lowest CA scores might be improved by examining the error data and discarding those canards which were infrequently chosen. New canards could be selected,

either subjectively again, or on the basis of objective similarity ratings. The CA method could then be reapplied to determine if the new alternatives were effective in lowering the CA scores of these items. Through a trial-and-error process such as this it may be possible to develop a larger set of truly nonverbal items.

In selecting facial items for further development, photos of either males or females may be used since sex of memorandum face does not appear to be a factor in determining verbalizability whether measured for male or female respondents.

For random shapes, complexity level does not seem to influence codability. A memorandum shape with a low CA score may be one with any number of sides. Similarly, association value apparently does not predict CA score. The test of this latter relationship was a poor one, however, since the only memoranda used were those with the lowest association values. It is possible that had stimuli with a wider range of association values been evaluated, a positive relationship would have emerged between these two ostensible measures of potential for verbal mediation.

Colours are clearly the best of the five types of material, in terms of their resistance to verbal description, and these stimuli may represent the best items currently available for the measurement of NVM. Subjects experienced considerable difficulty in attempting to communicate discriminative information about the hues. Contrary to the situation observed with all the other kinds of material, where the common complaint was insufficient time, the subjects who attempted to encode the colour memoranda often were at a loss for words and were silent for much of the 20-sec. period.

For many workers, the concept of nonverbalness has been primarily operationalized in terms of "spatial" tasks. While it may be that certain kinds of topographical information are processed non-verbally, it is interesting to note that the three types of configural material fared the worst when evaluated by the CA criterion. This finding suggests that for the measurement of nonverbalness per se it may be more fruitful to explore the use of stimulus materials other than those of the commonly used spatial variety.

It is important to note, however, that the CA

findings apply only to the particular materials, and indeed to the specific items, used. It is not justifiable to conclude, for example, that faces in general are more or less verbalizable than any other stimulus type on the basis of the results from this study. Faces, or any other kind of material, selected from different populations from the ones employed here, could show quite different CA scores. Furthermore, the indices of nonverbalizability obtained for the items cannot be legitimately applied to the memoranda alone. If a memorandum is paired with canards other than the specific ones used in this study, the degree of nonverbalness of the item could be quite radically different. Because each CA score is valid only for the particular item, defined as a unit of one specific memorandum and three specific canards, it would be inappropriate to attempt to generalize the findings of the CA evaluation to other kinds of stimuli. The advantage of the highly specific CA measure, however, is that it provides construct validation at the item level.

The results of the presentation position analyses indicated that there was no learning effect

across types of material. Subjects evidently were not able to use their experience with one type of stimulus to improve their performance on the next. It is therefore reasonable to conclude that the CA task is not encumbered with a general learning component and hence the value of the method, as a validity criterion, is strengthened. The same conclusion appears to hold also on an item-by-item basis. For colours, the one type of material for which the data were examined at the within-set level, no position effects were found across the 20 items, suggesting again that the CA scores obtained are each independent estimates of verbalizability. One practical outcome of this finding is that less elaborate counterbalancing procedures may be used in future studies.

Since all other aspects of the procedure were relatively invariant in terms of the number of seconds taken to complete, the average time scores for each type of material reflect primarily the hesitation of the decoder subjects in making their choices. Although there is some significant variability in these data, the pattern of the results cannot easily be related to the magnitude of the

CA score for each type of material (or to any other variable for that matter). It thus appears that CA scores are not a function of decision making time or an uncertainty lag effect. It may simply be that the time scores order the types of material by degree of perceptual complexity, or interest level, and thus may reflect the time spent scanning the different varieties.

The within-set variability shown by the CA scores for the colour items appears to be a reliable phenomenon and not due to chance fluctuation. It would be expected, on the basis of the Latin-square analysis of these data, that replications of this study would yield a similar pattern of item totals. The CA scores, moreover, do not appear to be significantly affected by differences among subject pairs. As anticipated, the subjects used in this study formed a rather homogeneous group in terms of their response to the CA task. It would be of interest, though, to replicate the study using a different normative group, such as hospital controls.

Each item of each type of material was designed to be as difficult as possible to succeed at in the CA task. Since one trivial way in which

this could be accomplished would be to make some, or all, of the canards so similar to the memorandum that they are perceptually indistinguishable from it, the E choices were obtained to evaluate the likelihood that some items were not possible to remember in any way. This control procedure verified that, for four out of the five types of material at least, poor performance on the CA task could not be explained by perceptual difficulty. The E data indicated that, for all types of material except colours, the delayed memorandum/canard discriminations were easy ones for subjects who were able to use both verbal and nonverbal processing systems. For the designs, faces, figures and shapes, failure on the CA task can reasonably be attributed to the insufficiency of verbal mediation.

In contrast to their almost errorless performance on the other four types of material, the E subjects misrecognized a mean of 3.3 colour memoranda. Since five subject pairs (nos. 4, 6, 9, 10 and 18) contributed almost 50% of these errors, there is a possibility that some of these individuals may not have had completely normal colour vision/perception. In future studies

involving colour items, it would appear advisable to screen subjects initially to assure adequate ability to make the requisite discriminations.

Since the memoranda from some colour items with low CA scores (viz. nos. 4,8 and 20) were forgotten by 25% or more of the E subjects, the usefulness of these items remains unclear. They may represent the special case in which a nonverbal item can be created by decreasing the perceptual distance between the memorandum and its canards down close to the level of a j.n.d. Items constructed in this way would certainly be nonverbalizable but they would also be extremely difficult to remember, either verbally or nonverbally and, in effect, would have verbalizability confounded with item difficulty. If nonverbal items were prepared by this method, it would likely be impossible to produce ones which were easy or even moderate in level of retention difficulty.

It may be that the concept of "nonverbalness", for recognition items at least, exists only in a rather narrow range along a continuum defined by the degree of similarity between the memorandum and its canards. At one extreme, the false alternatives

are so different from the memorandum that the use of a simple verbal label will allow the subject to mediate a correct recognition. At the other extreme, the canards are so alike the memorandum that discrimination is not possible. The investigator who wishes to measure NVM must find items which are far enough along the continuum from one end to rule out the potential for verbal interference and yet far enough along from the other to ensure a reasonable range of item difficulty. The use of the CA method, together with the E choice control, appears to offer a way to define the limits of the NVM range.

The significant positive correlation between the E and D responses to each of the colour items is consistent with much of the early work (e.g., Brown & Lenneberg, 1954; Lantz & Stefflre, 1964) showing a direct relationship between the recognition accuracy for a colour memorandum and its verbal codability. This result is hardly surprising, however, and would also be predicted by a dual-encoding model (e.g., Paivio, 1971). Any memorandum which can be readily processed by both the verbal and nonverbal systems would be expected to have a higher recognition rate than one for which it was possible

to use only one of these systems (cf., Robertson & Inglis, 1978). The finding of this relationship between verbalizability and recognition accuracy in no way denies the existence of NVM, however, as some linguistic relativity theorists (e.g., Whorf, 1956) have argued. Support for this position could come from the finding that verbal-free memoranda are impossible to remember but, as colours 10,12,16 and faces 1 and 15 demonstrate, items with very low CA scores can be remembered very well.

It should be noted that, when NVM tasks are used in experimental and clinical practice, the subject is usually given considerably less than 20 secs. to inspect each memorandum. Since any verbal encoding must be accomplished in this briefer presentation time, the estimates of construct validity obtained for the items in this study may be unduly pessimistic. The CA scores listed in Table 6 may reflect a kind of maximum verbalizability possible under ideal conditions. As they are generally used, the items may be much less verbalizable than the CA scores from this study would indicate.

A 20-sec. presentation time was selected (on the basis of pilot data) to provide a fairly stringent test

of nonverbalness. It was reasoned that if an item could obtain a low CA score in spite of an inspection period as lengthy as this, the investigator could be assured that this item would be genuinely nonverbal in whatever context it was used. The use of this strategy may have generated a high false-negative rate, however.

In addition to the presentation-time variable, several other aspects of the CA task could have been modified in order to make it an easier or more difficult test of nonverbalness. The CA procedure used in this study was chosen to be an analogue of a very simple memory paradigm involving no delay interval, no interpolated interference and a 3:1 recognition ratio. If any of the parameters were changed so as to make the "memory" task more difficult, CA scores would likely be lower overall. Because the CA scores are dependent on both the particular items and the task structure, the results of this study cannot be directly generalized to situations in which other procedural variations are used.

Ideally, the evaluation of construct validity in NVM tasks might proceed in two steps. Items

could first be selected by a rigorous CA procedure, such as the one used in this study. These items could then be used to construct a suitable task with a specific presentation time, retention interval, etc. Finally, an appropriate version of the general CA method could be used to evaluate the nonverbalness of the task (i.e., the items in the context of the particular procedure). Tasks achieving low CA scores could then be justifiably regarded as appropriate and valid instruments for the measurement of NVM.

CHAPTER SEVEN: SOME PRELIMINARY CONSIDERATIONS  
REGARDING THE MEASUREMENT OF MEMORY IN GENERAL

Defining Memory

In order to measure any concept adequately it is first necessary to devise a clear and unambiguous definition of exactly what is meant when the term is used. Equally important is to specify what is not included. Here, it is essential to delineate the boundaries of the concept in order to separate it from other related ideas.

In spite of the obvious importance of defining what is purportedly being measured, few authors writing about NVM (or the assessment of memory in general, for that matter) have attempted to specify what they actually mean by the term "memory". In virtually all investigations, memory is treated as a common-sense concept, the assumption being that there is a general consensus as to what kinds of tasks are, in fact, measures of memory. Even a cursory look at the range of methods used to evaluate memory will reveal the enormous variability in the way the concept has been operationalized, however. Considering the temporal dimension only, retention intervals as brief as a fraction of a second and as long as most of a lifetime have been used to evaluate "memory" disorders in patients, for example.

The great diversity of tasks used to index memory has made comparisons among studies extremely difficult. If memory is to be regarded as a useful term, there must be some agreement as to what characteristics are essential for a task to be considered a measure of memory and related concepts must be similarly defined operationally and dissociated. If consistency of usage can be achieved then it may be possible to discern some order in the confusing pattern of results that presently exists.

There is little consensus to be found regarding the definition of memory in authoritative sources, either within or external to psychology. Most dictionaries (e.g., English & English, 1958) offer vague generalizations, suggesting typically that memory is the faculty of retrieving past experience accompanied by the realization that this experience is a revival. Debate regarding the fundamental nature of memory has been a popular activity among philosophers, at least since Plato's time, but there is little current agreement in this field either, as to what memory can or cannot be considered (e.g., See Straus & Griffith, 1970.)

From a behavioural perspective memory is an inferred process. It may be studied by arranging tasks which can only be performed successfully if information is stored and retrieved. If the patient performs the tasks

adequately we may assume that memory has been demonstrated. The only remaining question, in assessing a patient at least, is whether the tasks used are sufficient to tap the full range of memory functions. In effect, when a patient performs adequately on a memory task, there is nothing to explain. In this situation, the investigator need only guard against making a Type II error, (i.e., accepting the conclusion that the patient has normal memory when in fact (s)he does not).

When the patient fails a memory task, however, the investigator is faced with a different, and usually more difficult, kind of interpretative problem. Did the patient fail because a crucial aspect of her/his memory is impaired or is the failure due to a deficit in some non-memory function which is also essential to successful performance on the task? In order to guard against a Type I error in these situations, the investigator must take care to arrange conditions such that the possibility of task failure due to nonmemory factors can be systematically and rigorously evaluated.

All clinical tests and experimental tasks require that several nonmemory functions, such as those related to gnosis and praxis, must be brought into play for successful performance to result. If any one of these critical

abilities is deficient, the task behaviour, as the final common pathway, will suffer. Seeing only the task failure, the essence of the clinical interpretation demand is to determine which of the component skills was responsible. Few of the currently available memory assessment methods offer the investigator any compelling way to rule out competing hypotheses. From a decision-theory viewpoint, memory tasks need to be redesigned to increase their power to reject the conclusion that task failure was due to nonmemory factors when, in fact, it is false.

The problem of accurately determining the status of separate ability components is especially difficult when global or "wide-net" measures are used. On these tests, several patients may be unsuccessful, but each may fail for a different reason. The trend towards the development of multifactorial tasks has been particularly prevalent in neuropsychological assessment. Measurement in clinical neuropsychology especially has been burdened by an over-concern with the search for screening tests which will allow the investigator to make brain-damaged/non-brain-damaged decisions. Since brain-damaged patients as a group show enormous variability in the kind of deficits they exhibit after cerebral injury, the more "complex" a test is, (i.e., the more functions needed for adequate

performance) the more successful the test will be as an index of nonspecific brain damage. There are indications, however, (e.g., Spreen & Benton, 1965) that these kinds of tests may have reached an asymptote of usefulness.

If the goal of patient evaluation is description rather than classification, then the tasks used should be factorially as simple as possible. The more complex a test is, the more difficult it is to interpret if the investigator's goal is assessment rather than diagnosis. In order to rigorously evaluate the status of any particular ability, such as memory, tasks must be designed such that the possibility of competing explanations of performance failures is kept to a minimum. More importantly, there must be a systematic and compelling way to evaluate the likelihood that nonmemory factors may have contributed significantly to any task failures.

If the assessment strategy is desired, tasks can be made as "pure" as possible by defining the construct to be measured in the simplest possible way that is consistent with reliable measurement. For memory, certain minimum criteria must be met for a task to be considered as a legitimate test of this ability. In order to qualify as a measure of memory, the task must include the following characteristics:

1. Some stimulus (the memorandum) must be presented to the subject.

2. The subject must demonstrate in some observable way that (s)he has adequately perceived the memorandum and is capable of making the response required in Step 4.

3. The memorandum must be removed from the subject.

4. There must be a demand for some response which can only be made accurately if the subject has retained an impression of the memorandum.

Any procedure purporting to be a test of memory must include each of these essential steps or be dismissed as being of inadequate power for assessment purposes. This simple model of how memory can best be measured permits a great deal of flexibility in terms of exploring mnemonic parameters (See section entitled, "Procedural Options"). Failure to meet any of these criteria, or elaborations on them lead to predictable difficulties in the interpretation of results. One of these increases in task complexity is discussed in the following section.

### Separating Learning From Memory

For many philosophers of science (e.g., Royce, 1978) all disciplines must take one fundamental step, in order to achieve mature status, and that is to achieve agreement among workers as to basic terminology. Until this agreement is reached, empirical studies will likely contribute little to the development of theory since data collected will not be cumulative. In psychology, cognitive constructs have often been operationally defined but rarely have these definitions achieved a level of consensus sufficient to ensure that everyone is using the same terms in the same way. Typically, anyone reading a research report must scan the description of the procedure used to determine what the author actually means by a term such as "learning" or "memory".

The confusion which surrounds the use of the terms "learning" and "memory" is a good illustration of the current immature level of development of psychology as a science. In discussions of cognitive deficits, for example, the two terms are often used synonymously and frequently, a particular test may be referred to as a learning task by one author and as a memory task by another. Moreover, each of these terms may be used to describe a range of tasks which seem to bear little

relation to each other. A similar situation exists in experimental work with normal subjects. Although it is currently more fashionable to study "memory" rather than "learning" (cf., Craik, 1977), no unambiguous distinction between these two hypothetical constructs has achieved much consensus.

While the term "memory" may be used, as a common-sense concept, to refer to any situation in which retention of information is involved, it does not appear likely that substantial progress will be made in understanding the fundamental nature of the process unless a scientific (i.e., precise and universally acceptable) definition is achieved. This definition must be one in which the essential operations needed to infer the existence of the process are specified. The set of criteria for a memory task listed in the previous section is one attempt to provide such a definition. If results among studies are to be at all comparable, the use of the term must be restricted to only those tasks which meet whatever criteria are accepted. As in other sciences, different terms must be developed and used consistently to refer to phenomena which are substantially different in form.

A simple conceptual distinction can be made between learning and memory which, if generally adopted, would

greatly enhance communication among workers. Operationally, a memory task can be defined as one in which the memorandum is presented once and only once to the subject. In this paradigm, it is then removed and not presented again before the demand to demonstrate retention is made. Per contra, another task may be similar in every way to the memory task but if the memorandum is presented more than once to the subject, it should be considered a learning rather than a memory task.

The separation of learning and memory based on the distinction between single versus multiple presentations of the memorandum is not only intuitively appealing but offers a way to classify any retention task as being of one type or the other. To date, no review of memory or any comparison across memory studies has explicitly employed this criterion. The comprehensive reviews of NVM studies (chapters 1-4) provide an example of the use of the single-presentation definition as a basis for inclusion. With a few exceptions, reports based on multiple presentation of memoranda (i.e., nonverbal learning) were omitted.

In science, setting the boundary conditions for a topic of study is basically a strategic decision, which can be defended by logical argument or by intuitive appeal but which is not open to empirical test. The worth

of a particular way of defining the limits to the phenomenon under investigation can only be determined retrospectively. If there has not been a significant gain in understanding over a reasonable period of time then the need increases to try another taxonomic system. It appears to me that in the vague area that we have been calling learning and/or memory, this need is currently very great.

Logically, memory may be seen as essential for learning and learning may be viewed as just a more complex form of memory. If data from the two domains are systematically compared it may turn out that there is no situation in which the two kinds of behaviour are significantly discontinuous (e.g., All patients with memory disorders may have learning disorders and vice versa). This is an empirical question, however, and we have no reason to assume that learning and memory are, or are not, identical processes until we measure each adequately and compare the results.

On a task-analysis basis, learning and memory may be dissociable in that the former appears to be a "higher-order" process. If memory was totally dysfunctional, learning could not logically occur. Intact learning ability is not a logical prerequisite for a successful memory performance, however. A patient may display

adequate retention of a memorandum, compared to controls, following a single presentation but not show the improvement in performance seen in normals following repeated presentations. It appears that H.M.'s amnesia may be of this type, for example. Conversely, a patient may be able to learn, at a rate similar to normals, when repeated presentations are given, but may be relatively impaired in storing and retrieving information from single exposures.

It seems likely that different neural processes may be involved in learning, as opposed to memory, tasks. Repeated presentation of the memorandum allows for feedback, probably in the form of matching the re-presented memorandum to the previously stored image, and promotes alterations of the image toward a more veridical representation. This process of successive approximation likely requires additional neural/cognitive machinery that is not necessary for the simpler task of "pure" memory. The careful study of brain-damaged patients with learning deficits and with memory deficits may determine if there are additional processes required for learning which can be selectively impaired.

The single presentation of a memorandum followed by a request for retrieval of this information appears to provide the most fundamental paradigm for the study of

retention. By using only this simple model the effects of various parametric factors such as type of material, length of retention interval, amount of interference, etc., can all be evaluated without the confounding effects of multiple presentations of the memoranda. Learning paradigms simply add another dimension to the study of memory and a separate battery of tests should be developed for these situations. The evaluation of memory functioning as defined by the single-presentation model is complex enough and it seems prudent to concentrate on this basic level before attempting to explore even more complicated phenomena.

### Input/Output Controls

In order for any task performance to be successful, many different kinds of cognitive processes must ordinarily be brought into play. To perform adequately on Graham and Kendall's (1960) Memory-For-Designs Test, for example, the patient must be able to see each figure clearly, to form a veridical percept, to retain this representation for a few seconds, and to make an accurate drawing based on the stored visual image. While failure on this test is routinely interpreted as indicative of a memory disorder, it is clear that an impairment in vision, perception, or motor control could produce the same result. Usually, the clinician relies on her/his observations of the patient's input/output (I/O) functions from other situations to make a judgment regarding their adequacy for the memory test. When attempting to interpret the data from studies using memory tasks, such as the MFD, we have no way of knowing, however, if the examiner did in fact guess correctly. What is needed here is a systematic way to determine the adequacy of I/O functions that is compelling enough to persuade others that any task failure must be due to memory impairment.

Memory studies using groups of clinical patients almost invariably lack proper I/O controls also, yet their

authors freely attribute poor task performance to memory problems only. If the question of perceptual-motor adequacy is addressed at all, the usual approach (e.g., Warrington & Rabin, 1970a, 1970b) is to present data from other nonmemory tasks. The strategy here is to suggest by inference that these patients appear to be able to meet the I/O task demands, at least for similar kinds of materials, when memory is not required. Although of some value, this is still a very weak way to guard against misattribution errors. Data from other tasks done at other times using other materials and procedures do not offer convincing evidence that the subjects were actually able to meet the gnostic and praxic demands of the specific memory task.

From an experimental design standpoint, studies in which evidence as to I/O adequacy is presented from the results of separate perceptual and/or motor measures are inefficient ways to achieve control of these extraneous variables. In effect, the proportion of the error variance in the memory task data, which is attributable to I/O insufficiency, is estimated by indirect measures and then subtracted from the total memory task variance leaving the residual as the estimate of the percentage of the task failure actually due to memory impairment.

A more elegant and statistically more powerful way of determining the proportion of the variance actually due to memory factors is to design tasks such that the error variance due to the influence of extraneous variables is eliminated from the analysis or at least reduced as much as possible. One way to accomplish this would be to simply omit from analysis the data from patients who showed any difficulty on the separate control task(s). While an improvement, this strategy is wasteful of data since on some trials these patients may have adequately perceived the memorandum and on some memory trials even those patients who did not exhibit difficulties with the separate I/O task(s) may be inattentive, etc. or have other, perhaps transient, I/O deficiencies.

The most direct way to control this error variance is on a trial-by-trial basis. Data which is to be used to make a statement regarding memory must come only from those trials in which there is convincing evidence that this patient actually perceived this memorandum and is able to make the required response correctly when no demands on memory are made. All other "memory" task data must be rejected as inadmissible evidence because of the potentially confounding effects of I/O difficulties.

A very few clinical tests, such as the BVRT, offer the investigator a systematic way to estimate the relative contributions of gnostic and praxic factors to performance on the retention task. By administering separate copying or matching-to-sample versions, the examiner can obtain an estimate of the likelihood of I/O insufficiency which would cause failure on the more complex memory administrations. Although the BVRT control procedures use memoranda which are essentially similar to that used in the memory tasks, there is still no assurance that this patient accurately perceived this figure on this memory trial. If a patient experiences fluctuations in the levels of control abilities, for example, generalizations may be quite misleading, especially if the memory and the I/O tasks are administered at quite different times.

In spite of the necessity for separate test administrations to rule out I/O impairments, in practice the control tests do not appear to be frequently given, probably because of time limitations. If the control procedures were built into the memory task, however, they would never be omitted and a much more efficient way of collecting data regarding the adequacy of memory functions and the adequacy of I/O functions would result.

For any task which requires a response involving unlimited alternatives, the necessity for determining the adequacy of the patient's praxic abilities for this response is clear. Thus for all tasks involving a reproduction demand as the demonstration of retention, it must be verified that the subject is able to copy the memorandum correctly while it is still in view. For tasks where the retention demand requires only choice from a limited number of alternatives, though, the praxic requirements are minimal and the capacity for such simple responses as being able to point where desired or being able to indicate a yes/no decision is all that need be determined. If memory is to be investigated in severely limited populations, however, even these elementary functions may be compromised. Again, in order for the investigator (or especially for anyone else) to regard the data collected as useful information regarding memory per se, evidence must be presented that memory task failure was not due to an inability to simply execute the required responses.

When memory tasks are used with normal subjects, I/O sufficiency is generally taken for granted. Although the supposition may be justified when simple verbal materials are used, there are reasons for being more cautious in

accepting this assumption when NVM is the focus of study. The problem here is that in order to reduce the effects of verbal mediation, say in a recognition task, the canards must be selected such that they are sufficiently similar to the memorandum to prevent discrimination based on labelling cues. In some instances this may mean that the perceptual discriminations required are too difficult even for some normal subjects. If this were in fact the case, the data from these subjects would add only error variance to any analysis of memory effects. The most convincing way to demonstrate that the data obtained from a memory task are referable to memory functions alone is again to check the adequacy of I/O processing for each subject on each trial and reject those trials on which there is some doubt.

Although the idea of controlling for I/O factors in memory measurement is not a new one, its importance has not been widely recognized. At least part of the reason for this neglect has likely stemmed from the historical overemphasis on the use of verbal materials for the study of memory. If a patient can speak adequately and can apparently understand what is said, there has seemed to be little need to verify the ability to either register or reproduce the specific verbal memoranda. With

obvious aphasics, however, receptive and/or expressive limitations clearly pose problems for the reliable assessment of memory. Patients with more subtle linguistic impairments may present even greater difficulties of interpretation for the investigator since there is no way of knowing if failure on task is due to language deficits or memory deficits unless some kind of I/O control procedure is used.

Although I/O controls are thus useful in at least some situations where verbal memory is being evaluated, they appear to be essential in all instances of NVM assessment and it has been consideration of the special measurement problems in this area which has prompted their development and use in the following series of tests. Although patients with clear aphasic symptoms would likely be easily identified by the memory investigator and an attempt made to take their limitations into account, those patients with similar levels of agnosia or apraxia may be more easily overlooked and their task failures more likely misattributed to a memory disorder.

Patients with more subtle perceptual or motor deficiencies are even more likely to be mislabelled unless effective and appropriate I/O control procedures are built into the memory tasks used. The combination of a

high possibility of not recognizing the presence of gnostic/praxic limitations and a high level of demand, especially for making subtle perceptual discriminations, make the adequate control of these potentially confounding variables essential in any memory study, whether nomothetic or idiographic, involving brain-damaged patients.

Although I/O control procedures appear to be a logically essential component of any NVM task they have been included only extremely rarely as an integral part of the measurement procedure. One exception has been in the subcortical stimulation work of Ojemann (e.g., 1971) and Fedio (e.g., Fedio & Van Buren, 1975) in which the matching-to-sample of a random shape always preceded the delayed recognition test for this same memorandum. One other line of work in which I/O verification has been consistently employed in the measurement of NVM has been in studies using the Rey-Osterrieth figure (e.g., Taylor, 1969; Jones-Gotman & Milner, 1978). In these investigations, the complex figure is copied initially, and then delayed reproductions from memory can be compared to this baseline performance to determine the rate of forgetting over time. The value of this approach has been supported in a recent communication by Snow (Note 16), who has

reported correlational data which suggests that Rey-Osterrieth percentage recall scores are less dependent on visuopraxic ability than are BVRT memory scores, the latter being more closely associated with copying skills.

There are also some recent indications that investigators may be starting to build better I/O controls into new verbal memory tests as well. Fuld's (Note 17) "guaranteed stimulus processing" procedure is an example of this trend which is a logical outgrowth of the levels-of-processing approach popularized by Craik and Lockhart (1972).

### Procedural Options

The criteria for determining if a particular task can be considered a valid test of memory have been specified in the four-stage model of measurement presented earlier. Although a wide variety of commonly used "memory" tests may appear to meet these criteria, it is important to examine each task closely to determine if, in actuality, all conditions do obtain before concluding that the task is an acceptable measure of memory. Although indirect sources of evidence regarding the status of each demand may offer some support, the only truly valid way of ensuring that all criteria have been met is for the investigator to exercise control over each step in the measurement process.

If the investigator presents the memorandum to the patient then (s)he can be sure that presentation did, in fact, occur and can next verify registration. Many tasks which purport to evaluate long-term or remote "memory" employ memoranda which the investigator assumes was presented (or occurred naturally) to the patient at some time before the current assessment session. If the patient fails to respond correctly to the retention demand, however, the interpretation is ambiguous. Is the patient's memory deficient, or did the patient simply not experience the memorandum event initially?

"Remote memory" tasks of this kind are weak measurement designs also because the investigator has no assurance that registration occurred even if the memorandum event did take place in the subject's presence. Furthermore, there is no assurance that the memorandum did not occur multiple times thus creating a learning rather than a memory situation. Finally, the investigator usually has no information regarding, nor control over, the extent of rehearsal of the material during the retention interval. For all these reasons, tasks in which the investigator does not control the presentation of the memorandum are not suitable for the scientific study of the fundamental nature of memory.

Measurement procedures involving the use of public events or well-known faces as memoranda (e.g., Warrington & Sanders, 1971; Squire, 1974) have become popular recently as ways to estimate the extent of a retrograde amnesia. Because of the inferential problems discussed above, results from these kinds of tests are not admissible as evidence regarding the status of pure memory, however. Most items from mental status exams are similarly confounded with various nonmemory factors and are undesirable for use in determining the adequacy of memory functions per se.

In order to draw valid inferences regarding memory, uncontaminated by other factors, the investigator must have control over all aspects of the information processing sequence from the original presentation of the memorandum to the ultimate test of its retention. Tasks in which one or more of the essential steps are not under the investigator's control may be more properly designated by some term other than "memory" (e.g., tasks in which the investigator controls only the phase in which the subject is requested to demonstrate retention may be referred to as retrieval tests).

Although the requirements of the four-stage model of memory measurement place limitations on the kinds of tasks which may be legitimately accepted as tests of memory, there is still considerable scope within this broad paradigm for the investigation of most variables commonly associated with the general concept of memory. Using the set of criteria as a guide, to ensure that unconfounded memory is in fact being assessed, specific tasks can be designed to measure any combination of memory factors desired. Some of the possibilities are discussed in the following pages.

The presentation phase of the paradigm offers several opportunities for manipulation of important measurement

variables. Among the factors which can be systematically explored here are type of material (e.g., verbal or non-verbal), mode of presentation (e.g., auditory, visual, or tactile), and number of items in the memorandum list. Variations in the type of stimulus material may be further divided into comparisons of subtypes (e.g., various kinds of nonverbal memoranda may be compared as to their memorability under the same conditions). The third option, that of systematically increasing the number of memoranda presented on each trial produces the familiar memory-span procedure. The series of NVM tests presented in the following chapter provides an example of how tasks may be built for the evaluation of important presentation phase factors in the clinical assessment of a patient.

After the memorandum has been removed, the next point occurs at which parametric exploration is possible. Here, the investigator may manipulate factors relating to the retention interval (i.e., the time between when the memorandum is removed and when the demand to demonstrate retention is made).

Length of the retention interval has traditionally been a factor of great interest and control over this variable may be achieved in several ways within the

general measurement paradigm. For example, several memoranda may be presented before the demand is made to demonstrate retention of the first item in the list. In this situation, the retention interval may be increased by simply lengthening the list of memoranda. Alternatively, the retention interval for any item may be lengthened by placing it further along in the test list if sequential presentation of memoranda and canards is used during the retention phase. Whatever the procedure employed, the general paradigm permits the precise measurement of the retention interval for each memorandum separately and comparisons can be made across items.

In procedures where several memoranda are presented before the response phase begins, the retention interval occurs "naturally" as a consequence of the time taken to present the additional items and to test for their retention. In situations where it is desired to minimize list length interference, however, (i.e., typically those procedures in which retention is assessed for each item before the next is presented), the investigator may simply introduce a pause between Step 3 and Step 4 to study length of retention effects. In these procedures, the pause time is referred to here as a delay interval and may be considered a special kind of a retention

interval. Delay intervals may of course be unfilled or be taken up by some task intended to prevent rehearsal. In either event a delay interval is distinguishable from a retention interval in that during the former the subject is not presented with any material related to the memory task (i.e., no memoranda or canards) whereas the patient is presented continually with these during a retention interval.

The response phase of the paradigm provides the third and last point at which manipulation of measurement variables is possible. Here, the investigator may ask the patient to either recognize or reproduce the memorandum to demonstrate retention. For some memoranda, such as geometric figures, either mode of response may be equally possible. With some kinds of materials such as faces or colours, only a recognition demand will normally give satisfactory results while with other tasks, such as block tapping, a reproduction demand is the most feasible. Although the choice between recognition or reproduction response modes is partially determined by the type of memoranda used, the investigator must determine also what kind of information is most useful to obtain, since the two alternatives may yield quite different measures of retention. (e.g., See Brown, 1976, for an extensive discussion of this point).

If a recognition mode of response is to be used, the investigator may explore how variations in the number and kind of canards affect memory. For NVM, the degree of similarity between the canards and the memorandum is a critical factor in determining the nonverbalness of the task and this "distance" is an important factor to study experimentally. The particular way in which the canards are presented with regard to the memorandum also offers the investigator several alternatives for collecting different kinds of information regarding memory. The patient may, for example, be asked to identify the memorandum from a simple 4-choice array or the memoranda and canards may be presented sequentially to obtain better control over retention interval and interference factors.

Although the reproduction method of demonstrating retention may yield richer information regarding the quality of the patient's stored representations, it may also raise formidable scoring difficulties because of the problem of evaluating partially correct responses. The reproduction mode may also place substantial demands on praxic skills and the investigator must be able to demonstrate, such as via an I/O control task, that the patient's capabilities are sufficient to accomplish the response

task in the absence of a memory component. This requirement may prove to be a considerable limitation for patients with severe sensory or motor handicaps and in order to reliably assess memory in these individuals, tasks must be designed in which the I/O requirements are minimal. If tasks are to be used with brain-damaged patients, in particular, they should be constructed such that they may be successfully performed by patients who have only one visual field intact and only one body side available for responding.

In the following sections, three new tests are described. Each of these methods is an example of how the general principles discussed in the preceding pages could be operationalized. The tasks presented are similar in that they are designed to effect measurement within the general domain of NVM and that the visual mode only is employed. All tests meet the 4-stage criteria presented earlier and thus may be considered valid measures of memory unconfounded by other determinants.

CHAPTER EIGHT: THREE NEW TESTS OF NONVERBAL  
MEMORY FOR CLINICAL USE

The following pages provide detailed descriptions of three tasks which have been designed with the intent of producing the best measures of NVM currently available. In each one, an attempt has been made to minimize the involvement of verbal mediation by following the material selection/arrangement recommendations of chapter 5. The specific items used for each test have been selected by using the results of the CA study reported in chapter 6. Finally, these tasks also illustrate how to operationalize the basic principles of memory measurement, as discussed in chapter 7.

The three measures have been developed (following a lengthy series of clinical trials) specifically for use with brain-injured patients. Evaluation of NVM abilities is usually possible, through the use of these tests, even in cases complicated by hemianopsia, hemiplegia, unilateral neglect, or expressive aphasia. With some procedural modifications, to increase the level of difficulty, these tests may be adapted for use with normal subjects in NVM experiments.

It should be noted that the tasks described in this chapter are only preliminary attempts at test

construction. They are experimental versions only and should not be considered formal "tests" suitable for general clinical use. Although each has evolved to its present form through a long process of trial and error with patients plus the continual incorporation of empirical data, much work remains in order to determine if each has acceptable psychometric properties. Questions to be resolved include those pertaining to reliability, normative data, number and difficulty level of items, etc. In short, these tasks must now be evaluated (and revised if necessary) to be consistent with the recommendations in the American Psychological Association's Standards for Educational and Psychological Tests (1974). They are presented here, in their current and tentative forms, to illustrate the progress made thus far in achieving construct validity and to standardize them for future psychometric evaluation.

This task provides a simple method for the measurement of NVM using empirically selected sets of hues as test materials. Each memorandum is presented briefly and the patient must demonstrate adequate ability to match to sample before recognition for that item is assessed. Retention for each of 10 memoranda is measured, without delay, by requiring the patient to choose the previously presented colour from a 4-choice array. The canards, for both the matching and the recognition arrays, are selected such that they provide a measure of degree of error.

All materials for this test are defined by the Munsell system of colour notation. Ten hues with the lowest CA scores (item nos. 1,4,8,9,10,12,13,16,18 and 20, from Table 5) have been chosen as memoranda. For each of these stimuli, the associated 4-choice array from the CA study serves as the set of recognition alternatives. Matching-to-sample sets have been constructed using a duplicate of the memorandum plus three other canards. All arrays include canards at 5, 7.5, and 10 steps removed (along the hue continuum) from the memorandum. For each array, the hues are placed in a vertical column with the positions labelled A,B,C and D. The location of the memorandum in each of the matching and recognition sets is indicated by

the underlined letter on the data sheet in appendix B2. This sheet also indicates the degree of error represented by each canard.

All hues used in this test are of equal brightness and saturation ( $V=6$ ,  $C=8$ ), all have a matte finish and all are presented against a white background. The materials for the matching and recognition phases of each trial are shown to the patient in a specially constructed 3-part display arrangement which permits the investigator to perform the procedural steps in a smooth and orderly manner.

Besides evidence from the original spacing research (Newhall, et al., 1943), Davidoff's (1976) data also indicated that normal subjects are able to make hue discriminations as fine as 2.5 steps apart even when the stimuli are presented very briefly. In addition, several other investigators (e.g., Newhall, et al., 1957; Nilsson & Nelson, Note 1) have reported extremely precise delayed matching abilities in normal subjects when brief delay intervals are used. Finally, normative data from Burnham and Clark's (1955) study, in which longer retention intervals and a much larger selection array were used, showed that, under these more difficult conditions, normal subjects made delayed matches with a mean error of only 2.2 hue steps on the Munsell scale.

From the encoder data of the CA study it may be

seen that normal subjects made an average of 1.8 errors (range = 0 - 4) in attempting to remember the 10 items used in the Colour Recognition Test. Since this test employs a similar presentation time and retention interval to that used in the CA study, the results can provide an approximate baseline, against which to evaluate patient performance, until more adequate normative data are collected.

There is some slight but consistent evidence in the literature to suggest that hues in some areas of the spectrum are more difficult to remember than others. Nilsson and Nelson (Note 1), who have collected the best controlled data on this point, report that stimuli at 440 and 460 (blue), at 525 and 540 (green) and at 625 and 640 nanometers (red) produced the largest deviations in recalled wave length. In their study, memoranda at 425 (violet), 575 (yellow) and 595 nm. (orange) were reproduced with negligible deviations. Their results are roughly in accord with those of Burnham and Clark (1955) who also found that blue and green hues produced the most variable delayed matching responses, while the smallest errors were made to hues in the reddish-yellow range. In the Colour Recognition Test, the memoranda have been ordered such that there is

a general progression from the most to the least stable (in terms of the above-cited results). Other than this possible influence, all memoranda should be approximately equal in difficulty.

Good performance on this test indicates that the patient is able to perceive and retain, for a very brief period at least, information which is sufficiently precise to enable her/him to make very fine hue discriminations. Given the close similarity in wavelength between the memorandum and the recognition canards it appears unlikely that the memory task could be accomplished by the use of verbal labels. The expectation here is that almost any verbal description likely to be generated by the patient in response to the memorandum would apply equally to the canards as well.

Recognition choices based upon verbal cues are made less probably also by avoiding the presentation of all stimuli at once, as has been the case in earlier colour memory tests (e.g., Lantz & Stefflre, 1964). In the present test, the patient never sees the memorandum together with the particular canards (s)he must discriminate it from until the recognition array is presented and thus never has an opportunity to develop comparative labels. As opposed to other procedures (e.g. Burnham

and Clark's test) where the entire range of stimuli are available for repeated viewing, and thus possibly for differential linguistic coding, the patient responding to the Colour Recognition Test is presented with no more than three different stimuli at any one time and once the recognition response is made these particular hues are never seen again.

In addition to these rational arguments, empirical evidence is available from the study reported in chapter 6 to document the construct validity of this measure of NVM. Six of the ten items used in the Colour Recognition Test had CA scores within the range which indicated chance-level responding. For these items, it must be concluded that it is not possible to make the required delayed discriminations based on verbal cues alone. By extension, it must be considered extremely unlikely that any individual responding to these items would be able to employ verbal mediational strategies to effect success. For the other four items, with CA scores slightly above the cut-off level, it appears that while some subjects may be able to generate useful verbal discriminanda, these are not generally available. Here, the "nonverbalness" of these items, although not ideal,

appears to be substantial.

Overall, the items used in this test had a mean CA score of 8.4 and none had a CA score greater than 11. These facts together with the careful design features of the Colour Recognition Test argue for consideration of this task as the best available measure of NVM using any type of material.

Those patients who are able to match colours adequately with the model in view but who fail the recognition test may be considered as exhibiting some impairment in NVM, which may be designated as one of greater or lesser severity depending on the kind and number of errors made. Failures on the concurrent-matching phase indicate an I/O handicap which limits the amount of memory data that may be obtained. Some estimate of NVM adequacy may still be possible, however, by considering only those trials on which the control task was accomplished successfully.

Appendix B includes two additional sources of information concerning this test:

1. Detailed instructions regarding administration and scoring.
2. A data sheet for the recording of responses from an individual patient (P).

### The Random Shapes Test

This task provides a simple measure of NVM using empirically selected sets of polygons as test materials. Each memorandum is presented briefly and the patient must demonstrate adequate ability to match to sample before recognition for that item is assessed. Retention of 10 memoranda is measured by requiring the patient to choose the previously presented shape from a 4-choice array. The procedure includes unfilled delay intervals, ranging from zero to 60 secs., thus allowing the investigator to evaluate the patient's ability to retain visuospatial information over increasingly lengthy periods of time.

All materials for this test are derived from the series presented by Vanderplas and Garvin (1959a). The 10 shapes with the lowest CA scores (item nos. 1,2,6,7,10,11,12,18,19, and 20 from Table 5) have been chosen as memoranda. For each of these stimuli, the associated 4-choice array used in the CA study serves as the set of recognition alternatives. A duplicate of the memorandum plus three other canards, selected from the same complexity level as the memorandum, have been assembled to form matching-to-sample arrays.

Each of the 90 shapes employed is printed on .10m x .13m matte paper with the stimuli appearing as solid black polygons against a white background. These stimulus cards have been mounted, singly and in 4-choice arrays, on cardboard sheets which have been inserted into a loose-leaf book. A specially constructed 3-part display arrangement permits the examiner to perform the procedural steps in a smooth and orderly fashion.

The task entails that the patient remember only one memorandum at a time and is thus a measure of the simplest possible memory load in terms of list length. The procedure includes a preliminary input/output (I/O) control phase in which the patient is required to demonstrate her/his ability to discriminate the memorandum from similarly appearing canards and to make an accurate pointing response. If the I/O phase is completed successfully, the memorandum and the matching-to-sample array are covered and the recognition test array is presented, after the appropriate delay interval. Recognition testing is conducted only on those trials in which the preliminary matching has been done correctly. This control avoids confounding the retention test score with

nonmemory influences and may permit the collection of some memory data even from those patients with serious I/O deficiencies.

Each of the multiple-choice displays contains a copy of the memorandum shape plus three canards arranged in a vertical column with the positions labelled A,B,C, and D. The location of the memorandum in each of the matching and test arrays is indicated by the underlined letter on the data sheet (See Appendix B2).

For the first and last memoranda, the recognition arrays are presented immediately after the patient successfully completes her/his matching response and thus, on these trials, the retention period is minimal. The other eight memoranda are followed by a delay interval of 15, 30, 45, or 60 seconds. The delay periods are ordered by length, in an increasing and then decreasing sequence, in an attempt to avoid interactions with practice or fatigue effects. There are thus two trials at each delay interval length. Each interval begins when the matching array and the memorandum are covered; it ends with the presentation of the recognition array. During each delay interval, the patient is asked to close her/his eyes and to try

to visualize the memorandum shape.

Good performance on the test indicates that the patient is able to form, hold and retrieve veridical percepts, of both simple and complex configural stimuli, over retention intervals which encompass a range most investigators would consider to be representative of STM.

Patients who are able to match shapes correctly but who fail, significantly more often than normal, in the recognition phase may be considered as having some impairment in either the storage or retrieval stages of the retention process. In either event, their recognition failures may be confidently attributed to a memory deficiency, since other explanations have been precluded by the task design.

If a matching error is made, that trial is eliminated and does not contribute to any further evaluation of memory performance. The number of correct recognitions can thus be expressed as a percentage of the total trials on which the patient did not make a matching error. This ratio gives the best estimate of memory efficiency, unconfounded by the perceptuo-motor limitations of the patient.

To examine the influence of delay-interval length,

the number of recognition errors made at each interval can be plotted. Inspection of this function may reveal further anomalies, as compared to normative data, in the patient's rate of forgetting.

Because no distracting activity is introduced into the delay interval, good performance on the Random Shapes Test reveals only that the patient is able to hold an imaginal representation of the memorandum when (s)he is allowed to use uninterrupted concentration. No generalizations should be made to similar situations in which competing activity intervenes. Performance under interference conditions must be evaluated by other measures in which distractor tasks are employed.

From the E data of the CA study it may be seen that normal subjects are able to remember these memoranda without a single error in a memory task having a similar presentation time and (for test items I, II, IX and X, at least) a similar retention interval to that used in the Random Shapes Test. This result can provide an approximate baseline, against which to evaluate patient performance, until more adequate normative data are collected.

The E data from the CA study also suggest that

the matching phase of the test is extremely simple for normals to perform. Thus, any failure on this part of the test by a patient indicates the possibility of severe I/O impairment which should be investigated more thoroughly with measures, such as perceptual tests, designed specifically for this purpose. Although patients with I/O handicaps normally pose difficult interpretive problems in the assessment of memory functioning, the Random Shapes Test should facilitate the identification of these individuals and even permit the examiner to gather some valid evidence regarding their mnemonic capacities. For patients with perceptual deficiencies, for example, some estimate of their memory ability could be obtained from those trials on which matching performance was adequate, by considering the percentage of these memoranda which were recognized successfully.

Empirical evidence as to the nonverbalness of the test items comes from two sources. Firstly, Vanderplas and Garvin (1959a) have demonstrated that these materials do not readily elicit verbal associations. (Mean association value for the 10 memoranda is 25.2.) Secondly, the CA study reported in chapter 6 indicated that subjects are only partly successful in being

able to encode, transmit and retrieve these memoranda using language cues only. (Mean CA score for the 10 memoranda is 12.2 and none has a CA score above 14.) These data suggest that the particular items used in this test are fairly good (but not completely adequate) measures of NVM. It is still possible that some patients may be able to use some degree of verbal mediation to successfully remember the memoranda. In spite of this qualification, the test is still the only measure of NVM, using random shapes, currently available which can make some substantial claim to construct validity.

Appendix C includes two additional sources of information regarding the Random Shapes Test:

1. Detailed instructions regarding administration and scoring.
2. A data sheet for the recording of the patient's responses.

### The Facial Recognition Test

This test provides a brief measure of the patient's ability to distinguish between faces which have been seen before and those which have not. The patient first views an inspection series of eight memoranda photos and gives a concurrent-matching response, as each is presented, in order to verify registration. Immediately following this presentation phase, a sequence of 32 test faces is shown and the patient must indicate which eight are the memoranda. Errors made may be categorized as to type (false positive or false negative), sex of the face, and amount of interference occurring between presentation and the test of familiarity.

All materials for this test have been selected from a large series of (1978 and 1979) graduation photos from the University of Victoria. Each stimulus is a matte-finish print, in colour, enlarged to approximately .09m by .11m. All photos show the head and shoulders of the subject but since all are wearing identical gowns, no discriminative information is available below the neck. Since no caps are worn, factors such as hair style, colour and length vary across subjects and must be considered

part of the subject's "face" for the purpose of this test.

The specific memoranda for this test are the eight subject faces with the lowest CA scores (item nos. 1,2,7,8,13,15,16 and 17). The photos comprising the 4-choice arrays from these items have been used to create a sequence of 32 recognition-test possibilities.

Concurrent-matching arrays have been constructed using another photo of the memorandum subject plus three other similarly appearing canards. For each array, the photos are placed in a vertical column with the positions labelled A,B,C and D. The location of each memorandum in it's array and in the recognition sequence is indicated on the data sheet (See Appendix D2).

Altogether, photos of 56 unique subjects (8 memoranda, 24 matching canards and 24 recognition canards) are used to construct the test. There are four male and four female memorandum faces and sex of the matching and recognition test faces is alternated on every trial.

The photos selected for this test include front and three-quarter views primarily, with a few profiles also. The oblique and side perspectives are about

equally divided as to left and right orientation. Each canard face is unique and appears only once (i.e., there is no duplication of canard faces either within or between the matching and the recognition test sets). Thus, a canard photo may be taken from either side and may show a profile, three-quarters or front view.

Memoranda photos also vary in the orientation of the face but here, three different views have been used for each memorandum face. The patient is first presented with photo A of a particular memorandum face and must find photo B of the same face in the matching array. Later, in the test sequence, the patient is shown photo C of this face. Each of the three photos of the same face is different in terms of camera angle and also in terms of facial expression. Since virtually all of the photos show smiling subjects, the change in expression from one photo to another (of a memorandum face) is only slight to moderate. The use of different photos of the memorandum subject ensures that the test is one of person recognition rather than just picture identity. Changes in perspective and expression across photos also reduce the likelihood of these factors being used as discriminative cues or as the basis for verbal

labelling of the memoranda faces.

During the presentation phase, the patient first looks at the memorandum photo and then is shown the selection array and asked to find a (different) photo of the same person with the original still in view. When all of the eight memoranda photos have been presented in this manner and the patient's matching responses recorded, the examiner presents the 32 test photos in sequence asking the patient, for each one, to indicate if (s)he has ever seen this person before.

In the test sequence, the memoranda faces are arranged in the reverse order from that in which they were originally presented. (The position of each memorandum face in the recognition series is presented in Appendix D2.) Since there is no reason to assume that there are any inherent differences in memory difficulty across the eight faces, any differences seen in error rate should therefore be attributable to the effect of the variation in the amount of interference between the presentation of a memorandum and its test of familiarity. Item difficulty is thus expected to increase progressively from memorandum VIII, which should be the easiest, to memorandum I which should be

the most difficult.

From the almost errorless performance of the E subjects in the CA study, it may be inferred that the concurrent-matching task is extremely easy for normals. Any patient who makes even one error in this phase, therefore, may be severely impaired in the ability to discriminate among faces even without a memory component. The performance of such a patient on the recognition task must be evaluated with this limitation in mind. Some evidence as to the mnemonic capacity of even the perceptually deficient patient can be obtained, however, by considering her/his performance on those recognition items for which (s)he was able to accomplish the matching task successfully.

For those patients who are able to match-to-sample adequately, failures on the recognition phase may be confidently attributed to a memory disorder since other explanations have been rendered unlikely by the task design. Because of the nature of the material used and the way in which the faces have been selected and presented, it is reasonable to assume that inadequate performance in the recognition phase represents a failure of NVM primarily.

The eight items used to construct this test had a mean CA score of 10.5 (range = 7 - 12).

Whereas only two items met the criterion of unambiguous nonverbalness, none of the other six appeared to be easy to encode and transmit in words. Thus, although some patients may be able to successfully employ verbal mediational strategies to remember some memoranda, overall, the Facial Recognition Test would appear to offer a substantial degree of construct validity for the measurement of NVM.

Good performance in the recognition phase may be taken as indicating that the patient is adequately able to store and retrieve the information contained in human faces, at least over the brief retention intervals used in this test. Good performance further reveals that the patient is able to retain facial information in spite of considerable interference from other similar stimuli. Because different views are used for the memorandum faces, success on the recognition task signifies also that the patient is able to retain a representation of a person's face which is robust enough to permit successful recognition performance regardless of variations in angle of presentation or expression.

Appendix D contains the following additional information regarding the Facial Recognition Test:

1. Detailed instructions for administration and scoring of the test,
2. A data sheet for the recording of a patient's responses.

## Reference Notes

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Appendix A: Instructions to Subjects for the  
Communication Accuracy Study.

"I'm going to show a picture to L (name of the subject on the left) and her/his job will be to try to describe it in words well enough so that R (name of subject on the right) will be able to recognize it even without having seen it before. L will have 20 secs. to communicate as much important information about the picture as possible. While L is describing the picture, R's job will be to listen carefully and to try to remember what (s)he says.

After the 20 secs. is up, I will take the picture away from L and then I will show R a set of four pictures. One of these four will be identical<sup>1</sup> to the one L saw while the others will be close but not quite the same. R's task will be to choose the one that L just described by recalling what (s)he said about it.

After R has made her/his decision, I will show the multiple-choice set to L and ask her/him to show me which one it was (s)he described. Once L makes a choice we're finished with that picture and then we will continue with the next one. This time, you two will change roles. R will become

the sender of information and L, the receiver. As we go along you will change from one role to the other at each new picture.

There are five different kinds of pictures and 20 of each kind to describe. We'll take a short break between sets.

When you are the receiver, you may not ask questions about the picture or talk at any time. When you are the sender, you should try hard to find something unique or distinctive about the picture you are looking at so that you can get your partner to make the right choice. Her/his success depends mainly on your skill at description. The object of this game is to get the most correct choices possible by working together as a team. You two will be competing against other pairs of subjects and the team with the best score for each type of picture will win \$6.

Any questions? "

---

<sup>1</sup>Before presenting the faces, subjects were informed that there could be changes in camera angle and expression.

Appendix B1: Instructions for the Colour Recognition  
Test.

Materials

1. Loose-leaf binder titled, "Colour Recognition Test. This book contains 10 items each composed of: (a) a memorandum colour (mounted on a half page), (b) a matching array of four colours, and (c) a recognition array of four colours. The memorandum half page is attached to the bottom of the matching-array page and folds up to remove the memorandum from view. A cover sheet is attached to the top of the matching-array page and this folds down to conceal this array.

Administration

1. Say, "I am going to show you some colours. Some of them are very similar to each other. I would like you to look at them carefully so that you will be able to tell them apart. Here is your first colour."
2. Open the book to the first presentation page and fold down the half sheet to expose memorandum I. While P is looking at this colour, lift up the next cover sheet to present the matching array.
3. Say, "One of these four colours is exactly

the same as this one" (Point to the memorandum).

"The other three colours are close but not quite the same. Show me which one of these colours is exactly the same as this one" (Point to the memorandum).

4. Record P's choice. Fold down the top sheet to cover the matching array.

5. If P has chosen incorrectly, fold up the bottom sheet, turn the first presentation page and the first recognition page together and continue with step 8.

6. If P made a correct match, point to memorandum I and say, "Now look at this colour carefully and try to remember it." After P has had five seconds to study the memorandum, fold up the bottom sheet.

7. Turn the page to present the recognition array. Say, "One of these four colours is exactly the same as the large one you just saw. The other three are close but are a bit different. Show me which of these colours is the same as the large one you just saw." Record P's response and turn the page.

8. Fold down the half cover sheet and present the next memorandum.

9. Continue in this manner to present all 10 memoranda. Record P's matching response for each one. If P takes longer than five seconds to make a matching

response, make note of the amount of time taken.

If P matches correctly, present the recognition test.

If P fails the matching step, omit the recognition test and present the next memorandum for matching.

### Scoring

1. Determine the number of memoranda which were matched correctly and enter this sum as the total correct score for matching. Express this score as a percentage of 10.

2. Of those memoranda which were correctly matched, determine the number which were recognized correctly and enter this sum as the total correct score for recognition.

3. Count the number of recognition items attempted and enter this sum as the denominator for total correct recognitions. Express this ratio as a percentage.

4. For each matching or recognition error, score -2, -3 or -4 points as indicated on the data sheet. Sum these points and enter each total in the appropriate row as the deviation score numerator.

5. Use 40 for the denominator of the deviation score for matching. Express the matching deviation score as a percentage.

6. Determine the number of recognition items attempted, multiply this amount by four and enter the result as the denominator of the deviation score for recognition. Express the recognition deviation score as a percentage.

## Appendix B2: Data Sheet for the Colour Recognition Test

P \_\_\_\_\_ Date \_\_\_\_\_

Item	Matching			Recognition		
I	A	7.5R	-3	A	10R	-2
	B	10YR	-2	<u>B</u>	5YR	
	C	5YR		<u>C</u>	2.5Y	-3
	<u>D</u>	5Y	-4	D	5R	-4
II	A	5RP	-3	A	10PB	-3
	B	7.5P		B	7.5RP	-4
	<u>C</u>	7.5PB	-4	C	7.5P	
	D	2.5P	-2	<u>D</u>	2.5RP	-2
III	A	10Y	-2	<u>A</u>	5Y	
	B	5Y		<u>B</u>	10YR	-2
	<u>C</u>	7.5YR	-3	C	5YR	-4
	D	5GY	-4	D	2.5GY	-3
IV	A	2.5RP	-2	<u>A</u>	7.5RP	
	B	7.5P	-4	<u>B</u>	7.5R	-4
	C	7.5RP		C	10P	-3
	<u>D</u>	5R	-3	D	2.5R	-2
V	<u>A</u>	5PB		A	5B	-4
	<u>B</u>	10PB	-2	B	10B	-2
	C	7.5B	-3	<u>C</u>	5PB	
	D	5P	-4	<u>D</u>	2.5P	-3
VI	A	5G	-4	<u>A</u>	5GY	
	B	7.5Y	-3	<u>B</u>	5Y	-4
	C	10GY	-2	C	10Y	-2
	<u>D</u>	5GY		D	2.5G	-3
VII	A	7.5B	-4	A	10B	-3
	B	2.5PB	-2	B	2.5P	-2
	C	7.5PB		C	7.5P	-4
	<u>D</u>	5P	-3	<u>D</u>	7.5PB	

(continued next page)

P \_\_\_\_\_ Date \_\_\_\_\_

Item		Matching		Recognition	
VIII	A	5BG	-4	A	10GY -2
	B	5G		B	2.5BG -3
	C	7.5GY	-3	C	5GY -4
	D	10G	-2	D	5G
IX	A	5PB	-3	A	7.5PB -4
	B	2.5B	-2	B	7.5B
	C	7.5BG	-4	C	10BG -3
	D	7.5B		D	2.5PB -2
X	A	7.5G		A	10GY -3
	B	7.5GY	-4	B	7.5BG -4
	C	5BG	-3	C	2.5BG -2
	D	2.5G	-2	D	7.5G

	Total correct		Deviation score	
Matching:	$\frac{\quad}{(10)} = \%$		$\frac{\quad}{(40)} = \%$	
Recognition:	$\frac{\quad}{( )} = \%$		$\frac{\quad}{( )} = \%$	

Time \_\_\_\_\_

## Appendix C1: Instructions for the Random Shapes Test

### Materials

1. Loose-leaf binder titled, "Random Shapes Test". This book contains 10 items each composed of: (a) a memorandum shape (mounted on a half page), (b) a matching array of four shapes, and (c) a recognition array of four shapes. The memorandum half page is attached to the bottom of the matching-array page and folds up to conceal the memorandum. A cover sheet is attached to the top of the matching-array page and this folds down to remove this array from view. There is a blank page inserted between each of the matching and recognition pages except the first and last ones.

### Administration

1. Say, "I am going to show you some funny-looking shapes. They are not supposed to look like or mean anything in particular. Here is your first one."

2. Fold down the half sheet of the first page to present memorandum I. As P is looking at the memorandum lift up the cover sheet to present the matching array.

3. Say, "Show me which of these shapes is the same as this one." (Point to the memorandum.)

4. Record P's choice for memorandum I in the matching column. Fold down the top sheet to cover the matching array.

5. If P chose incorrectly, fold up the bottom sheet, turn this page and the next page over together and continue with step 8.

6. If P chose correctly, point to memorandum I and say, "Now look at this shape carefully and try to remember it." After P has had five seconds to look at the memorandum, fold up the bottom sheet.

7. Turn the page immediately to present the recognition array for memorandum I. Say, "Now show me which one of these you have seen before." Record P's response and turn the page.

8. Repeat steps 2 through 7 for memorandum II. If P has matched the memorandum shape correctly, turn the next (blank) page over and say, "Now close your eyes and try to visualize what the shape looked like. Concentrate on it and try not to lose the image."

9. After a delay interval of 15 secs. is over, turn the page to present the recognition array for memorandum II and ask P to choose the one (s)he saw

before. Record P's response and turn the page.

10. Continue, in this manner, to present all 10 memoranda. Record P's matching responses for each one. If P takes longer than five seconds to make a matching response, make note of the amount of time taken. If P matches correctly, present the recognition test. If P fails the matching step, omit the recognition test and present the next memorandum for matching. Note the increasing and then decreasing delay interval lengths over the remaining items. Continue to remind P to try to visualize each memorandum, with eyes closed, during the delay interval.

### Scoring

1. Record the total number of correct matching responses. Express this as a percentage of 10.

2. Record the total number of correct recognition responses.

3. Express, as a percentage, the ratio between the number of correct recognition responses and the number of recognition responses attempted.

4. If P matched all memoranda correctly, add the recognition errors for each delay interval and plot the results on the graph.

## Appendix C2: Data Sheet for the Random Shapes Test

P \_\_\_\_\_ Date \_\_\_\_\_

Item	Sides	Matching	Delay	Recognition		
I	12	A	14	0	$\overline{A}$	27
		B	26		$\overline{B}$	19I
		C	13		$\overline{C}$	24
		$\overline{D}$	27		D	25
II	8	A	15	15	A	24
		B	23		$\overline{B}$	29
		$\overline{C}$	29		$\overline{C}$	16
		$\overline{D}$	17		D	20I
III	24	$\overline{A}$	26	30	A	19I
		$\overline{B}$	14		$\overline{B}$	26
		C	17		$\overline{C}$	23I
		D	13		D	15I
IV	6	A	16	45	$\overline{A}$	30
		B	23		$\overline{B}$	15
		C	21		C	26I
		$\overline{D}$	30		D	22
V	12	A	10	60	A	22
		$\overline{B}$	30		B	21
		$\overline{C}$	18		$\overline{C}$	30
		D	28		$\overline{D}$	16I
VI	24	$\overline{A}$	29	60	A	21I
		$\overline{B}$	10		B	18I
		C	25		$\overline{C}$	29
		D	30		$\overline{D}$	22I

(continued next page)

P \_\_\_\_\_

Date \_\_\_\_\_

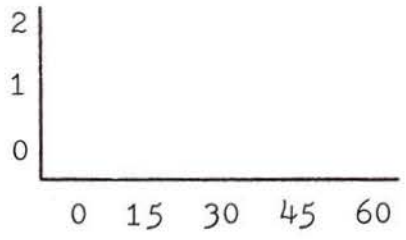
Item	Sides	Matching	Delay	Recognition		
VII	8	A	19	45	A	21I
		B	22		B	18
		C	25		C	28
		<u>D</u>	28		<u>D</u>	26I
VIII	12	<u>A</u>	29	30	A	20I
		B	12		B	15
		C	23		C	17
		D	11		<u>D</u>	29
IX	6	A	18	15	A	19
		B	28		B	28
		<u>C</u>	17		<u>C</u>	24I
		D	20		D	25I
X	24	A	12	0	A	20I
		B	24		B	27
		C	28		C	16
		<u>D</u>	11		<u>D</u>	28

Total correct

Errors

Matching: \_\_\_\_\_ = %  
(10)

Recognition: \_\_\_\_\_ = %  
( )



Time \_\_\_\_\_

Appendix D1: Instructions for the Facial Recognition  
Test.

Materials

1. Eight (memoranda) graduation photos labelled I to VIII.
2. Eight matching arrays of graduation photos also labelled I to VIII.
3. Thirty-two graduation photos numbered consecutively 1 to 32.

Administration

1. Say, "I am going to show you some photographs of different people. They are students from a university and all are wearing graduation gowns."
2. Present memorandum photo I. Say, "Here is the first person. While P is looking at photo I, present matching array I (without removing photo I) and direct P's attention to it.
3. Say, "Here is a group of four pictures. One of these pictures is also of this person (point to photo I) but is a different view of them. Show me which picture here (point to array) is of the same person." Record P's choice. Remove array I.

4. Direct P's attention to memorandum photo I. Say, "Now I would like you to look at this person's face carefully so that if you see another picture of this person you will be able to recognize them." Remove memorandum I after P has had five secs. to look at it.

5. Continue in this manner and present photos and arrays II through VIII. Encourage P to look carefully at each memorandum photo for five secs. after removing the matching array for that photo. Record each of P's matching responses. If P takes longer than five seconds to make a matching response record the amount of time taken. If P makes three or more matching errors, discontinue the test.

6. Say, "Now I am going to show you some more pictures. Some of these people you have seen before and some you have not. I would like you to look at each picture carefully and tell me if you have seen the person before or not."

7. Present recognition photo 1. Say, "Have I shown you a picture of this person before?" If P indicates yes, record a plus sign beside recognition photo 1. If P indicates no, record a minus sign in this space.

8. Continue similarly for the rest of the recognition photos. For each, encourage P to

carefully consider, "Have you seen a picture of this person before?" Record P's response for each as a plus or minus sign.

### Scoring

1. Record the total correct responses made in choosing from the arrays.
2. Count the number of errors made for the eight memoranda photos (as indicated by the Roman numerals) in the recognition phase. Since a correct response should be affirmative for these photos, a minus sign indicates an error. Record the total number of minus signs for these eight photos as false negative errors.
3. If P made a recognition error on any memorandum for which (s)he also made a matching error, do not include this response in the total for false negative errors. Adjust the denominator accordingly for this ratio.
4. Count the number of plus signs recorded for the other 24 recognition photos and enter this total as false positive errors.
5. Sum all correct choices on the odd-numbered recognition photos and enter this total as hits

under the male column.

6. Calculate female hits similarly using the even-numbered photos.

7. Add male and female hit scores to obtain total correct.

## Appendix D2: Data sheet for the Facial Recognition Test

P \_\_\_\_\_ Date \_\_\_\_\_

Item	Sex	Matching	Memorandum	Recognition	
				Male	Female
I	F	A B C D	(VIII)	1	_____
				2	_____
				3	_____
				4	_____
II	M	A B C D	(VII)	5	_____
				6	_____
				7	_____
				8	_____
III	F	A B C D	(VI)	9	_____
				10	_____
				11	_____
				12	_____
IV	M	A B C D	(V)	13	_____
				14	_____
				15	_____
				16	_____
V	F	A B C D	(IV)	17	_____
				18	_____
				19	_____
				20	_____
VI	M	A B C D	(III)	21	_____
				22	_____
				23	_____
				24	_____
VII	F	A B C D	(II)	25	_____
				26	_____
				27	_____
				28	_____
VIII	M	A B C D	(I)	29	_____
				30	_____
				31	_____
				32	_____

Time \_\_\_\_\_

Matching: \_\_\_\_\_

Hits: (16) + (16) = (32)

False positive errors \_\_\_\_\_

False negative errors \_\_\_\_\_

Appendix E: Examples of descriptive responses

Benton design #3: "On the left side there is a diamond cut in half. Next to that there is an arrow facing down with a line from the middle to the bottom left corner. Then a small circle in the bottom right.

Colour #2: This is a purple, a lavender or mauve. It's about the colour of Easter eggs or purple Smarties! It's not really light, not really dark; a little deeper than violet -- a really nice colour.

Face #8: Her face is quite round; she's wearing make-up; eyes are quite small; has a large nose; a short hair-cut, parted at the side; blue eye shadow; brownish hair; mole on her left cheek; blue, deep-set eyes.

Nonsense fig. #17: It could look like a heart lying on it's side and pointing to the upper right-hand corner, but the bottom isn't joined together; it's not closed. Then it looks like threes intersecting it at two different points.

Random shape #11: It's like an archway. One side is straight up; the other side has an angle to it. In the middle is sort of a triangular white space. It looks a bit like a flat head. The whole thing looks like the Star-Trek insignia."

VITAE

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THE MEASUREMENT OF NONVERBAL MEMORY

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