Non-Verbal Sequential Memory in Broca's Aphasia

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Master of Science (Speech-Language Pathology)
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MANASAGANGOTHRI, MYSORE-570006
APRIL 2006

Certificate

This is to certify that this dissertation entitled ***"Non-Verbal Sequential Memory in Broca's Aphasia"*** *is a bonafide work in part fulfillment for the degree of Master of Science (Speech-Language Pathology) of the student Registration No. L0480005. This has been carried under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree.*

Prof. M. Jayaram
Director
All India Institute of Speech & Hearing
Mansagangothri, Mysore-570006

Mysore

April 2006

Certificate

*This is to certify that this dissertation entitled **"Non-Verbal Sequential Memory in Broca's Aphasia"** has been prepared under my supervision & guidance. It is also certified that this dissertation has not been submitted earlier to any other University for the award of any diploma or degree.*

Mysore

April 2006

Dr. S.P. Goswami
Guide
Lecturer, Speech Pathology
All India Institute of Speech & Hearing
Manasagangothri, Mysore-570 006

Declaration

This is to certify that this master's dissertation entitled "Non-Verbal Sequential Memory in Broca's Aphasia" is the result of my own study and has not been submitted earlier to any other University for that award of any degree or diploma.

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Dedicated to

My Loving Parents….

Whose love and belief got me

this far.

CHAPTER 1

INTRODUCTION

The importance of memory to our daily lives cannot be overstated. Memories define who we are and functions of memory allow to retrieve what we know and to learn new information. Memory problems can result from head trauma, stroke, anoxia, tumors, infections, and vitamin B1 deficiency or from excessive use of alcohol (Dworetzky, 2001).

Stroke or Cerebro vascular accident (CVA) is one of the most prevalent causes of aphasia (Center of Disease Control, 1999). A stroke occurs when blood flow to an area of brain is interrupted by blockage of a blood vessel or artery or by rupturing of an artery.

Although stroke is a major neurological disorder often leading to serious and long lasting sensorimotor, language and behavioral disabilities, little is known about severity and frequency of memory impairment following stroke. Memory is the power, act or process of fixing information in storage as well as retaining and retrieving this new information (Squire, 1987). Thus studying the development of post stroke memory impairments is of prognostic value. Moreover, it is also important to identify memory impairment at an early stage because of the possibility to prevent further decline. Although this view is routinely accepted, memory functions are not routinely assessed and planned in intervention in adult aphasics.

One of the main findings to arise from cognitive studies of memory in normal individuals, functional neuroimaging studies and neuropsychological investigations of individuals with memory loss, is that memory is not a unitary phenomenon (Giovanello & Verfaille, 2001). Rather, it consists of several functional systems each contributing in a unique way to the encoding, storage and retrieval and subsequent retrieval of information.

A major division of memory is based on the duration for which information is retained. Short-term memory (STM) or working memory (WM) refers to the retention of information over brief intervals of time. By contrast long-term memory (LTM) involves the acquisition and retention of information over longer periods of time. Short-term memory can be further divided into:

(1) Verbal memory

(2) Non-verbal memory

Impairments of both working memory and long-term memory have been observed in patients with aphasia (Chapey, 2001). There is some evidence to suggest that there is a relation between aphasic patients working memory and language abilities (Caspari, Parkinson, La-Pointe & Katz, 1998; Tompkins, Bloise, Timko & Baumgaetner, 1994). According to Goldman-Rakic (1995) working memory tends to be more active, flexible, dynamic and predictive of real-life outcome than long-term memory. Working memory or short-term memory has been implicated as an essential aspect of the higher order intellectual functions of language, perception and logical reasoning (Baddeley & Hitch, 1974).

There are many commercially available tests of memory that are accessible. However, there are relatively few tests that are appropriate for aphasic patients since most rely heavily upon processing of linguistic stimuli, verbal responses or both. Individuals in whom language is confounded, non-verbal tasks would provide a more rigorous and less biased assessment. However, there are very few non-verbal short-term memory tasks that are suitable for clinical assessment (Mc Callum, 2003).

It is important to note that it is not only the memory but also the ability to process order or sequential information, which is essential aspect of human cognition (Ebbinghaus, 1964). Simple tasks like recalling a telephone number to tasks as complex as language comprehension and production, require to store and retrieve information in its correct order is fundamental to cognition (Lewandowsky, Brown, Wright & Nimmo, 2006).

Short-term memory is generally assessed by calculating either the memory span or by drawing the serial position curve. The curve arises from the tendency for subjects to recall early items (primacy effect) and late items (recency effect) in a list of words rather than items from the middle of the list. (Capitani, Sala, Logie & Spinnler, 1992).

Most of the recent psycholinguistic research on the nature of normal linguistic storage has utilized verbal learning experimental procedures (Gough, 1965). The use of traditional verbal learning experimental procedures to assess memory in aphasics is likely to yield contaminated data as these materials seem to require direct utilization of mental processes which are presumably impaired in aphasics. Thus, by removing language barrier, these materials appear to offer a logical medium through which memory can be validly observed in aphasic population.

Hence, it can be encapsulated that the use of non-verbal materials would be helpful in assessment of memory skills in individuals with aphasia. This is because these non-verbal stimuli demand minimum linguistic processing which is impaired in aphasics.

Need of the study

There is dearth of studies in Indian context with respect to memory impairments and aphasia. Given the relative importance of memory in normal language functioning, assessment of memory has far reaching implications for planning an effective rehabilitation program for individuals with Broca's aphasia. Moreover it is not clear that whether language abilities and memory span in aphasics are inter related or independent.

Thus a study on non-verbal sequential memory would provide insights about the relationship between memory and language in aphasics, in whom testing memory using traditional procedures is questionable.

It has also been suggested that the kind of stimulus employed and type of response required from the participants for assessment of memory may also affect the performance of both normals as well as aphasics. Thus, assessing memory span using same response mode but different kind of stimuli would provide a better understanding of the effect of the stimulus on memory span. The present study was taken up to address such issues.

Aims of the study

1) To compare the non-verbal sequential memory span of Broca's aphasics and normal individuals.
2) To compare the effects of stimulus characteristics on quantitative and qualitative aspects of non-verbal sequential memory.

CHAPTER 2

REVIEW OF LITERATURE

Cognition refers to all the mental processes by which information is transformed, reduced, elaborated, stored, recovered and used (Neisser, 1997). The relation between aspects of cognition and language status of individuals with aphasias is not well established although there is some evidence that integrity of non-linguistic skills of attention, memory, executive function and visuo-spatial skills cannot be predicted on the basis of aphasia severity (Helm-Estrabrooks, 2002). Out of all the cognitive processes involved in normal language functioning, memory is one of the most important aspects. Memory can be defined as stored representation and process of encoding, consolidation and retrieval through which knowledge is acquired and manipulated (Bayles & Tomoeda, 1997).

Memory impairment associated with aphasia has been predominantly characterized as a reduction of immediate serial recall or span memory (Albert, 1976; De- Renzi & Nichelli, 1975; Heilman, Scholes & Watson, 1976; Gordon, 1983). Aphasia is an acquired communication disorder caused by brain damage characterized by an impairment of language modalities: speaking, listening, reading and writing, it is not the result of sensory deficit, a general intellectual deficit or a psychiatric disorder (Brookshire, 1992; Goodglass, 1993).

2.1 Types of Memory

A major division of memory is based on the duration for which information is retained. It can be divided into:

(1) Long Term Memory (LTM)

(2) Short Term Memory (STM)

2.1.1 Long Term Memory

It involves the acquisition and retention of information over longer periods of time. It can be further divided into

(a) Declarative memory

(b) Non -Declarative memory

2.1.1.1 Declarative Memory

It encompasses the acquisition, long-term retention and retrieval of events, facts and concepts (Squire, 1994). Declarative memory can be sub-divided as:

2.1.1.2 Episodic Memory: It enables individuals to recollect conscious experiences from their personal past e.g. remembering what you had for breakfast this morning (Tulving, 1983). Episodic memories are characterized by perceptual, conceptual and affective components that are placed within an ongoing context of personally relevant events.

2.1.1.3 Procedural Memory: It is involved in the acquisition of skills and habits, results from repeated practice and is relatively impervious to the effects of decay or interference.

2.1.1.4 Non-Declarative Memory

It refers to a variety of forms of memory in which learning is expressed as enhanced performance (Squire, 1994).

2.2.2 Short Term Memory

Short-term Memory or Working Memory refers to a complex set of interacting processes that allow for the temporary storage and maintenance of information (Baddeley, 1992).

According to Baddeley (1992), short-term memory is composed of a central executive and a number of material specific slave systems. The central executive is a set of executive control processes responsible for selection and execution of strategies, for maintaining and shifting attention when appropriate and for coordinating and manipulating information from a range of sources. Separate slave systems are dedicated to storing and maintaining different types of information.

Based on these slave systems, short-term memory can be further divided as:

(i) Verbal memory-It tends to refer to performance on measures of new learning of material that is symbolic, meaningful and conducive to semantic mediation (Mc-Callum, 2003). It may involve processing of material in the auditory sensory modality although it is clear that material that is visually presented may be verbally mediated.

(ii) Non-Verbal memory: It tends to include learning of material that has been variously described as visual, visual-spatial, perceptual, figural, unfamiliar, difficult to verbalize and difficult to encode verbally (Moye, 1997).

2.1.2.1 Size of Short-term Memory: There are two ways to measure the size of short-term memory. The first way involves the presentation of long lists of items to participants and asking them to recall as many items as possible. Then a graph is drawn to study the relationship between the position in which the item was presented and likelihood of recalling the word. This is called a serial position curve. The other method involves measurement of short-term memory size in terms of memory span or the number of items that can be correctly recalled. Miller (1956) proposed that humans could remember about seven items (plus-minus two items i.e. the range can vary from five to nine items).

2.1.2.2 Language and Short-term Memory

There has been a long-standing interest in the relation between linguistic and short-term memory systems (Vallar & Shallice, 1990; Baddeley, 1986; Craik & Lockhart, 1972). Evidence from both normal (Hulme, Maughan & Brown, 1991) and impaired population (Martin & Saffran, 1997; Martin, Shelton & Yaffee, 1994) suggests that the two systems share some underlying processes. Span size varies depending on the nature of items to be recalled. For e.g. in normals digit span is greater than for words (Berner, 1940) and span for words is greater than for non-words (Hulme et al, 1991, Martin & Ayala, 2004). Studies of short-term memory and word retrieval in aphasic population have provided further support for links between the two abilities (Saffran & Martin, 1990).

Baddeley and Hitch (1974) proposed to divide the unitary short-term memory into three separable components, based on a study in which participants were required to hold sequences of digits ranging from zero to eight, while at the same time performing a range of tasks that were assumed to depend on working memory. Their data indicated that there was a progressive impairment as the digit load increased. Thus they divided memory into three components, these were temporary verbal-acoustic storage system, visual subsystem and central executive.

Later, Baddeley (2003) proposed that short-term memory could be divided into 4 sub systems:

(1) **Phonological loop**: concerned with verbal and acoustic information.
(2) **Visuospatial sketchpad**: involves visual or non-verbal equivalent of phonological loop.
(3) **Central executive**: assumed to be responsible for attentional control of working memory.
(4) **Episodic buffer**: serves the function of combining information from different modalities into a single multi-faceted code.

2.1.2.3 Phonological Loop and Normal Language Processing

It was proposed that phonological loop could be broken into two sub-components, a temporary storage system which held memory traces over a matter of seconds, during which they decayed, unless refreshed by the second component. This involved a sub-vocal rehearsal that not only maintained information within the store, but also served the function of registering visual information within the store, provided the items can be named. Hence, if a subject is shown a sequence of letters for immediate recall, then despite their visual presentation, subjects will sub-vocalize them, and hence their retention will depend crucially on their acoustic or phonological characteristics (Baddeley, 2003).

A study on participants with lesions resulting in phonological loop deficits, and neuroimaging studies support the hypothesis of separable storage and rehearsal systems with Brodmann area 44 being the cortical area associated with storage, while sub-vocal rehearsal appears to be associated with Broca's area (Brodmann areas 6 and 40).

Baddeley, Gathercole and Papagno, 1998 summarized that there are different types of memory, some of which make significant contribution to various aspects of language processing such as sentence comprehension, speech production, vocabulary acquisition and reading.

2.2 Neuroanatomy of Memory

There are multiple theories and constructs regarding human memory, making this area of study both complex and controversial. However there is a consensus, that memory is not a unitary phenomenon. There are several types of memory systems and these are sub served by different brain regions and neurochemical system (Dworetzky, 2001).

Many brain structures are involved in the process of memory. All are linked in a limbic circuit first fully described by Papez in 1937. He was convinced that human cortex and hypothalamus were necessary for subjective human emotion. Over time, these same structures were found to be intimately involved with memory abilities. The linkage of memory and emotion is understandable given that experiences with strong emotional content are better retained.

The pre-frontal cortex is important in working memory or the attentional and organizational aspects of registration and retrieval of memory. Pre-frontal cortex also supports memory processes necessary for temporal ordering, knowing the time and place of the occurrence of event and also how information was acquired.

Neurophysiological studies of primates have found cells in pre-frontal cortex (PFC) firing during delay periods in tasks requiring the short-term initial maintenance of information (Fuster, 1996; Goldman-Rakic, 1987; Miller, 2000).

Neuroimaging studies in humans have consistently reported that left inferior frontal cortex (LIFC), dorsolateral prefrontal cortex (DLFC), pre-motor cortex (PMC), superior frontal cortex, supplementary motor area (SMA) and parietal cortex along the intraparietal sulcus to be involved in storage and manipulation of information during working memory tasks (Cabeza & Nyberg, 2000; D'Esposito, 2000).

Miller (2000) found that the, explicit and implicit memory processes are separable neuroanatomically. Explicit or declarative memory involves fact or knowledge acquisition. The medial temporal lobes are known to be important in this process. The hippocampus, which is located within temporal cortex near the temporal horns bilaterally, is also important in explicit or declarative memory.

Non-declarative memory does not involve hippocampus or any other structures named above. Non-declarative memory refers to performance sub-types based on unconscious learning and builds slowly over time with multiple repetitions. It is found to be sub served by corpus striatum.

Hence, it is evident that different anatomical structures including both cortical and sub-cortical structures are responsible for different functions of memory.

Insult to any of these structures can differentially affect the functions of memory.

2.3 Memory Impairments and Aphasia

As early as the 1800's, researchers began to explore the integrity of non-linguistic, cognitive processes such as memory in adults with neurogenic communication disorders.

Memory has been viewed as a multifaceted system dependent on many cortical and sub-cortical structures and pathways. Consequently numerous types and severities of memory disorders may occur after brain damage (Goldenberg, Dettmers, Grothe & Spatt, 1994). Patients with various neurogenic communication disorders are therefore, at risk for memory impairments. Indeed, a growing literature has documented that memory abilities may be compromised in this population including those with left or right hemisphere stroke, traumatic brain injury or dementia.

Memory impairments may negatively influence the functional communication abilities and response to treatment of adults with neurogenic communication disorders (Risse, Rubens & Jordon, 1984). Thus, speech language pathologists and other health care professionals must be cognizant of the types of memory problems that may occur in their patients (Murray, Ramage & Hopper, 2001)

Impairments of both short-term and long-term memory have been observed in patients with aphasia. Alport (1986) proposed that aphasics are a class of memory disorders. There is some evidence to suggest that there is a relation between aphasic patients working memory and language abilities (Caspari, 1998).

Although investigators have long pondered the role of cognitive functions such as memory in aphasia, empirical evidence has been slow to accumulate. Advancements on the area of memory and aphasia no doubt have been hindered, at least in part, by the challenge of developing reliable and valid assessments of aphasic memory deficits. For e.g. many commonly used memory tasks (e.g. digit span) are inappropriate because of their heavy linguistic demands (Murray, Ramage & Hopper, 2001).

Additionally investigators must distinguish age related memory changes from those due to brain damage, particularly in cases in which participants are 80 years or older, an age group for which most memory tests do not provide normative data.

In brief it can be stated that studying the relationship between language and memory in aphasics is challenging, it might help to understand a number of associations in these two systems.

2.4 Aphasia and Long-term Memory

Long-term memory (LTM) often has been described as being intact in individuals with aphasia because of their relatively preserved autobiographical memory (Schuell, Jenkins & Jimenez-Pabon, 1964; Mc Neil, 1982). However, selective impairment of LTM on a verbal learning task was reported in individuals with aphasia due to anterior lesions by Risse, Rubens Jordon (1984).

Milner (1982) found that individuals with excisions within the left frontal lobe, excluding Broca's area were impaired on verbal and non-verbal LTM tasks that require a serial recall strategy.

Jetter, Poser, Freeman and Markowitsch (1986) found that non-aphasic subjects with unilateral or bilateral frontal lobe damage performed poorly on delayed free recall task compared to subjects with post rolandic lesions.

Besson (1992) had aphasic patients and normal age matched controls immediately recall a word list during 10 learning trials and then after a 60-minute delay after the last learning trial. Words recalled on later learning trials and after the delays were believed to be stored in LTM. The results indicated that patients with anterior (e.g. frontal cortex, anterior deep white matter) lesions had more severe verbal LTM deficits than were found with posterior lesions.

Individuals with aphasia resulting from damage to anterior branches of middle cerebral artery are likely to have cortical damage in the dorsolateral frontal lobe, and are thus at risk for executive control impairment (Beeson, Bayles, Rubens and Kaszniak, 1993).

Glosser & Goodglass (1990) found that aphasic individuals with frontal lobe lesions were significantly more impaired on the Wisconsin Card Sorting Test (WCST) and additional experimental tests of executive functions than individuals with non-frontal lesions. Thus, executive control deficits would provide a plausible explanation for poor verbal LTM performance observed by

Risse, Rubens and Jordon (1984) in individuals with aphasia due to anterior lesions.

Thus, there is a consensus among researchers that long-term deficits are generally associated with aphasia, it is not clear as to which type of aphasia is more often accompanied by a LTM deficit.

2.5 Aphasia and Short-term Memory

Investigations have recently begun to examine working memory (WM) in aphasia. According to Just and Carpenter (1992), working memory has:

1) A limited capacity of processing resources
2) Storage and computation functions, both of which draw from the same limited capacity
3) Many resource pools dedicated to specific cognitive domains (e.g. separate pools for verbal vs. non-verbal functions).

Interest in WM has been fueled, by the repeated finding of little relation between STM and sentence comprehension in either normal or aphasic individuals (Martin &Fehler, 1990). One of the first studies to suggest that impaired short-term memory may lead to comprehension impairment was that of Saffran and Martin (1975) in which, it was observed that a patient with a short-term memory had difficulty in accurately repeating the sentences. The difficulty was more, if sentences were longer or irreversible.

This led researchers to hypothesize that sentence or discourse comprehension is mediated by WM or STM. In aphasia, WM capacity reduces and this capacity limitation causes comprehension breakdowns when aspects of linguistic processing are lost. Thus, when the demand for processing resources is low (e.g. processing syntactically simple or small amounts of linguistic information), WM capacity is not stressed and language comprehension, even in severe aphasia, will not suffer. By contrast, as linguistic complexity, and hence the demand for processing resources increases, WM capacity is exceeded and there is a marked decline in comprehension.

Aphasic subjects with word processing deficits generally have a span limitation although the reverse pattern does not necessarily hold. Subjects with a short-term memory deficit but no impairment of single word processing have been reported (Vallar & Shallice, 1984), and the existence of such cases has sustained the notion that short-term memory and lexical processing are independent domains (Martin & Saffran, 1997).

These selective deficits of short-term memory are usually accompanied by difficulty in processing longer sequences of words. Because word processing and short-term memory deficits are so pervasive in aphasia, this population offers an excellent opportunity to identify patterns that reflect links between the two systems.

Caspari, Parkinson, La Pointe and Katz (1998) found a relation between WM capacity, as measured by modified listening and reading versions of the Reading Span Test (RST), and performance on standard reading and aphasia test in patients with varying aphasia severity. They concluded that language comprehension abilities in aphasia could be predicted by WM capacity.

By contrast, Caplan and Waters (1994) pointed out that aphasic patients who do poorly on WM span tests often do well at comprehending sentences with complex syntactic structures, and so there must be a memory system specific to syntactic processing and separate from a general WM. They suggested that WM does play role in aphasia, but that this role needs to be more finely analyzed taking into account separate WM systems for different linguistic processes.

Thus, it can be conclude that inspite of the fact that there are large numbers of studies to understand associations between short-term memory and linguistic processing, but still a lack of clear account of how these systems are related in aphasics.

2.6 Aphasia and Verbal Short-term Memory

A reduction of immediate memory span is the characteristic of most aphasic syndromes, excluding the transcortical aphasia (Benson & Geschwind, 1973). Although it may appear that in the major aphasic syndromes this deficit is easily explained in terms of expressive or receptive disturbances, it has been frequently suggested that in some circumstances, the repetition deficit could reflect a defect of verbal short-term memory (Heilman, Scholes & Watson, 1967; Warrington & Shallice, 1969).

Many other studies in aphasia have documented impaired STM for both auditory and visual verbal material and have identified factors that may influence the severity of these deficits. Martin and Feher (1990) found that patients with fluent aphasia like non-brain damaged adults were better at recalling easy vs. hard to articulate word lists.

In contrast ease of articulation had no effect on the STM performance of patients with non-fluent aphasia. These results suggest STM problems in aphasia may reflect difficulties with covert articulatory rehearsal. The type of aphasia linguistic deficits also may influence STM abilities.

It was also found that on word list recall tasks, aphasic patients with phonological deficit showed a robust primacy effect (i.e. recall of words from the beginning of list, thought to be based on storage at semantic levels) whereas aphasic patients with semantic deficits had an enhanced recency effect (i.e. recall of words from the end of a list, thought to be based on storage at phonological levels (Martin & Saffaran, 2001).

Researchers (Capitani, Sala, Logie & Spinnler, 1992; Craik & Levy, 1970; Raymonds, 1964; Murdock, 1962) have suggested that primacy effect is influenced by presentation rate, item frequency, stimulus type and by semantic similarity. On the other hand recency effect is affected by a filled delay and by phonological similarity.

Atkinson and Shiffrin (1968) interpreted primacy effect that in the beginning of the list, participants were able to rehearse items and successfully transfer them to long-term memory. This process became increasingly difficult as the list progressed. However, items at the end of the list were still in short-term memory system when the subjects recalled the items, but are lost if recall is delayed by more than a few seconds. Ostergaard and Meudell, 1984 and Martin and Ayala, 2004 have also suggested that sub-vocal rehearsals or covert rehearsals are important for the maintenance of information in short-term memory.

These investigators proposed that different recall profiles reflected different memory strategies. Patients with phonological deficits relied more strongly on the integrity of their lexical-semantic system whereas patients with semantic deficits relied on their phonological systems.

Analysis of phonemic features of verbal information and retention has been shown to be impaired for aphasics in experiments by Goodglass, Denes and Calderon (1974) and by Warrington and Shallice (1969). These researchers concluded that impairments in linguistic abilities as evidenced in aphasia must result in impairments in verbal memory as well.

However, the possibility also exists that the aphasic's verbal memory deficits demonstrated may be a reflection of a more general memory deficit and not the result solely of impaired linguistic processing.

Thus, in order to rule out this possibility it would be necessary to investigate these patients retention of non verbal materials as well as verbal within the confines of same paradigm.

2.7 Aphasia and Non-verbal Short-term Memory

To establish the memory functions, a thorough assessment is required. Unfortunately many commonly used tests have linguistic processing and/or production demands that make them largely invalid for use with aphasic individuals.

Thus, studies on cognition in people with aphasia typically have employed cognitive tests with no obvious linguistic demands.

Sperlin (1963) and Wickelgren (1965) have shown that non-verbal visual stimuli are stored in memory in an auditory linguistic form. Their analysis of errors on a letter recall task showed that most errors occurred in reporting a letter, which sounded like the one presented, even when there was no visual resemblance. Such evidence can be interpreted to indicate presence of a type of internal verbalization on non-verbal tasks.

Therefore, by removing language barrier, these materials appear to offer a logical medium through which memory can be observed validly in the aphasic population. At the same time performance on non-verbal tasks appears to provide meaningful insights into verbal behavior (Taylor & Swinney, 1970).

But it is not only the memory, it is also the ability to process order or sequential information, which is an essential aspect of human cognition and normal language functioning (Ebbinghaus, 1964; Lewandosky, Brown, Wright & Nimmo, 2006).

Non-verbal sequential memory has been less researched despite its demonstrated role in various cognitive tasks (Heathcote, 1994). It has been suggested by Mc Callum (2003) that tests with reduced language requirements should be designed for memory assessment in aphasic individuals.

Thus, the review of literature shows that there is strong relation between memory and normal language functioning. Short-term memory is crucially involved in expressive and receptive language processes. Thus assessment and management of memory is required while dealing with aphasics. However, it is difficult to establish whether the observed impairments in aphasics reflect memory deficits or are secondary to linguistic disturbances. Hence, memory assessment protocols with minimal language processing requirements may provide a better knowledge of memory impairments in aphasics.

CHAPTER 3

METHOD

The use of traditional verbal learning experimental procedures to assess memory in aphasics is likely to yield contaminated data as these materials seem to require direct utilization of mental processes which are presumably impaired in aphasics. Thus by removing language barrier, these materials appear to offer a logical medium through which memory can be observe validly in aphasic population.

The present study was aimed to compare the non-verbal sequential memory span of aphasics and normal individuals and also to study the effects of stimulus characteristics on quantitative and qualitative aspects of non-verbal sequential memory.

3.1 The following ethical standards were followed during the study:

- Before requesting for the consent of participants in research, they were provided information in the language he/she was capable of understanding and wherever applicable use of signs, gestures and other modalities were used.
- Each individual was invited to participate in research and he/she was explained the aims, method of research and approximate duration of participation.
- An informed verbal consent was taken from normal participants and the aphasics themselves and their biological guardians.

3.2 Inclusionary Criteria for Experimental Group

a) A total of nine participants diagnosed as Broca's aphasia voluntarily participated in the study.

b) Participants were diagnosed as Broca's aphasia by a Speech Language Pathologist and/or Neurologist.

c) Participants with history of a single episode of brain attack due to cerebral vascular accident (CVA) were only included in the study.

d) Participants were at least 3-6 month post onset at the time of testing with an average time post stroke being 13.5 months.

e) Participants had no significant history of pre-morbid neurological, psychological or any other organic deficit.

f) Selected participants did not have any sensory deficits such as visual (e.g. visual neglect, visual agnosia) and/or auditory deficit.

g) All the participants included for the study were right handed pre-morbidly. The demographic data of aphasic participants is shown in table 1.

Table 1: Demographic data of aphasic participants.

Sl. No.	Aphasic subject	Age/Sex	Language (Mother tongue)	Time of post-onset at testing	Education	Site of Lesion
1.	A1	29/M	Kannada	1.5 years	Graduate	Left *MCA infarct
2.	A2	52/M	Kannada	8 months	P.U.C	Left MCA infarct
3.	A3	29/F	Kannada	2 years	P, U.C	Left MCA infarct
4.	A4	33/M	Kannada	5 months	Graduate	Left MCA infarct
5.	A5	29/M	Hindi	2 years	P.U.C	Left cerebral infarct
6.	A6	58/M	Hindi	1.5 years	Post Graduate	Left MCA infarct
7.	A7	53/M	Hindi	1 year	Graduate	Left cerebral infarct
8.	A8	46/M	Hindi	7 months	Post Graduate	Left infarction in frontal& parietal region.
9.	A9	63/M	Hindi	6months	Graduate	Ischemic infarct in Left hemisphere

3.3 Control Group

Nine normal participants matched with the aphasic group for age, gender, education, dexterity and language were included for the study. There were no obvious signs of neurological, psychological, visual and/or sensory deficits.

3.4 Tools

1) Western Aphasic Battery (Kertesz & Poole, 1974; Kertesz, 1979)

2) The stimuli for the experimental task included:

(a) Digits - Ranging from 2-7 units per presentation.e.g. The first trial involved presentation of the digits 3 and 8, one after another. The

* Middle cerebral artery

length of the digit string was gradually increased till the presentation of 7 digits in final trial.

(b) Meaningful units - Frequently occurring nouns, ranging from 2-7 units per presentation eg. cup and bus were presented one after another for the first trial. The length of the meaningful units string was gradually increased till the maximum that was 7 units.

(c) Non-meaningful units - It consisted of geometrical patterns ranging from 2-7 units per presentation (taken from Raven's Progressive Matrices).

Power Point presentation was prepared to present the stimuli. All the stimuli categories had colored photographs. Along with slides, flash cards of the size 3”x 4” were made for the stimuli across all categories.

3.5 Procedure

The participants were seated comfortably in front of the computer screen placed one and a half feet from the eye level. The presentation of the stimulus was as follows:

(a) Digits: Starting from 2 units per presentation followed by 3 units per presentation and similarly till 7 units of presentation.

(b) Meaningful units: For this stimulus also the experimental task started with the presentation of 2 units and continued till 7 units per presentation.

(c) Non-meaningful units: In this domain also, the experimental task started from 2 units per presentation and proceeded till 7 units per presentation.

Each stimulus item appeared on the screen for 2 seconds (approximate scanning time for aphasics, Swinney and Taylor, 1975) with an inter stimulus interval of 0.7 seconds. The flash cards were placed in the visual vicinity of the participants. The numbers of flash cards were always two more than the number of stimuli appearing on the screen.E.g In trial one for digits number three and eight were the targets and number and four and seven were used as distracters.

3.6 Instructions

The subjects were instructed in language he/she was capable of understanding to point in the same order as the stimuli appeared on the computer screen.

3.7 Scoring

A score of ‘1’ each was given for pointing the presented unit at the correct position. Thus maximum score of ‘2’ was possible for trial-1 across different domains while maximum score of ‘7’ was possible for trial-6 for all the tasks. A score of ‘0’ was given for each incorrect response. Further total score was computed for all the tasks across all the trials for both the groups.

3.8 Tabulation

The obtained data was appropriately tabulated and subjected to statistical analysis.

3.9 Statistical Analysis

For statistical analysis SPSS software (version 10.) was used (Garrett & Woodworth, 1979). The raw scores were converted into percentage scores.

Mean and standard deviation (S.D.) was computed for both raw scores and percentage scores.

Independent sample t-test was employed to compare the performance of aphasics and normals across the different trials for all the three tasks (digits, meaningful stimuli & non-meaningful stimuli).

A repeated measure ANOVA was used to observe the effect of stimuli on non-verbal sequential memory. Table 2 and 3 shows dependent variables considered for repeated measures of ANOVA:

Table 2: Various tasks used for repeated measures of ANOVA.

Factor	Dependent Variable
1	Mean of digits
2	Mean of meaningful stimuli
3	Mean of non-meaningful stimuli

Table 3: Various groups for repeated measures of ANOVA.

Group	Value Label
1	Aphasics
2	Normals

Further to study the significance interaction effect across various tasks and groups, data was subject to Bonferronis multiple comparisons test, which was carried out in two stages.

(1) In stage 1, the three different tasks were separately analyzed for the effect of the task on group.

(2) While in stage 2, the two groups were separately analyzed to see the effect of group on task.

CHAPTER 4

RESULTS AND DISCUSSION

The aims of the present study were:

1) To compare the non-verbal sequential memory span of Broca's aphasics and normal individuals.
2) To compare the effects of stimulus characteristics on quantitative and qualitative aspects of non-verbal sequential memory.

Nine individuals with Broca's aphasia and nine normal, age, sex, education and language-matched participants were taken for the study. Single episode of stroke or cerebro vascular accident was the cause of aphasia for all the nine aphasic participants. Participants were tested in the post stroke period ranging from 3 months to 2 years. All the nine aphasic participants were right-handed pre morbidly and had no obvious sensory deficits at the time of testing.

The memory span was obtained for the following tasks:

(1) Digits

(2) Meaningful stimuli

(3) Non meaningful stimuli

The data obtained was appropriately tabulated and subjected to detailed qualitative and quantitative analysis. The raw scores were converted into percentage. Mean and standard deviation was obtained for both raw scores and percentages. Independent sample t-test was carried out to compare the performance of aphasics and normals. Repeated measures ANOVA was carried out to see the effect of stimulus on non-verbal sequential memory and also to compare the three tasks (digits, meaningful stimuli and non meaningful stimuli) within groups, using SPSS software (version 10)

(Garrett & Woodworth, 1979). The results are discussed under the following sub-sections.

- Memory span of Broca's aphasics and normals for digit task
- Memory span of Broca's aphasics and normals for meaningful stimuli task
- Memory span of Broca's aphasics and normals for non-meaningful stimuli task
- Comparison of performance of participants using repeated measures ANOVA.

4.1 Memory Span of Broca's Aphasics and Normals for Digit Task

The memory span of Broca's aphasics and normal participants across various 2 trials of digit task were tabulated using the raw scores. Table 4 shows the mean and standard deviation (SD) values of raw scores for aphasics and normal group across trials of digit task.

Table 4: Mean and S.D of raw scores for different trials of digit task for aphasics and normals.

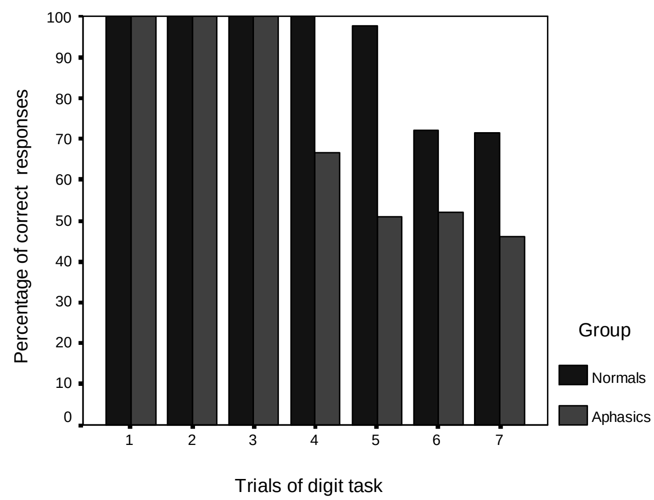
Group		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Aphasics	Mean	2.00	3.00	2.67	2.56	3.11	3.22
	S.D	_	_	1.32	1.01	0.78	0.67
Normals	Mean	2.00	3.00	4.00	4.89	4.33	5.00
	S.D	_	_	_	0.33	2.00	1.58

2 Trial-1: consisted of two items, Trial-2: consisted of three items, Trial-3: consisted of four items, Trial-4: consisted of five items, Trial-5: consisted of six items, Trial-6: consisted of seven items

The raw scores of both Broca's aphasics and normal participants were further converted into percentage. Table 5 furnishes the mean and S.D values for percentage scores for aphasics and normal groups across trials of digit task. The performance of participants is also shown in graph-1.

Table 5: Mean and S.D of percentage scores of different trials of digit task for aphasics and normals.

Groups		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Aphasics	Mean	100	100	66.67	51.11	51.85	46.03
	S.D	-	-	33.07	20.28	13.03	9.524
Normals	Mean	100	100	100	97.78	72.22	71.43
	S.D.	-	-	-	6.67	33.3	22.59



Graph 1: Comparisons of performance of normals and aphasics on various trials of digit task.

Table 5 represents the mean percentage values across different trials for the digit task. Further the results shows that the performance decreases from 100 % to 46.03% (SD=9.52) for the aphasic group and for the control group the digit span decreased from 100 % to 71.43 % (SD=22.59) from trial-1 to trial-6.

It has also been represented by graph 1, thus indicating that performance of both aphasics and normal participants decline as the number of items increases, the reduction in the memory span is more in aphasics compared to the normal participants. The results of the study are also in accordance to the reports stated by Baddeley and Hitch, (1974), who also found that as the digit load increases there was a decline in the memory span.

The results thus gives an idea that insult to the anatomical regions, which form the basis of language, will not only affect the language abilities of aphasics, but will also influence the memory span. Considering the fact that the present study employed only a non-verbal task, the poor performances on the memory span of digits cannot be attributed solely to the poor performances in language abilities. This statement is further strengthened by the fact that as the number of items increased, the memory span dropped off in the normal participants. Consequently indicating that memory and language were two distinct entities. Insult to the brain could affect either language or memory in isolation or as total. It can be accomplished that while designing assessment and intervention programs for Broca's aphasics care should be taken to include memory as a key measure, which should be language free. The results of the present study draw support from Caplans and Waters, 1994, who also recommended that memory assessment protocols for aphasic individuals should have minimum language processing demands.

The performance of Broca's aphasics and normal subjects was compared for each trial. Table 6 shows t-values and significance for Broca's aphasics and control group across different trials of digit task.

Table 6: Comparison of aphasics and normals across different trials of digit task.

Trial No.	t- values	df	Significance (2-tailed)
Trial-3	3.024	16	0.008
Trial-4	6.659	16	0.000
Trial-5	1.708	16	0.107
Trial-6	3.108	16	0.007

Results of t-test showed statistically significant difference in the scores of two groups, for trial-3, trial-4 and trial-6 at 0.05levels ($p<0.05$). This difference in trial-5 may be attributed to high standard deviation observed in normals for this trial. Thus the results show that insult to brain results in decline in the performances. These results are in much agreement with the study of Swinney and Taylor (1971) who found that aphasics performed poorly than controls on memory task.

Figures 1, 2, 3 and 4 illustrate the serial position curves for the different trials of digit task.

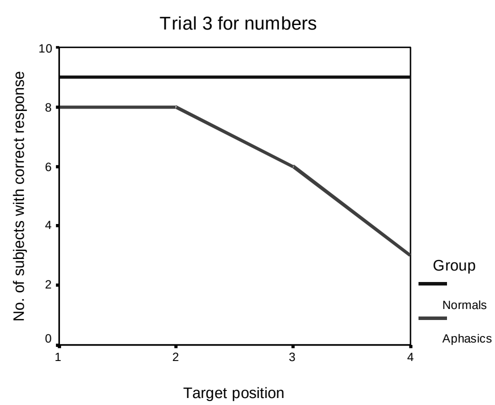


Figure 1: Serial position curve of trial-3 for digits.

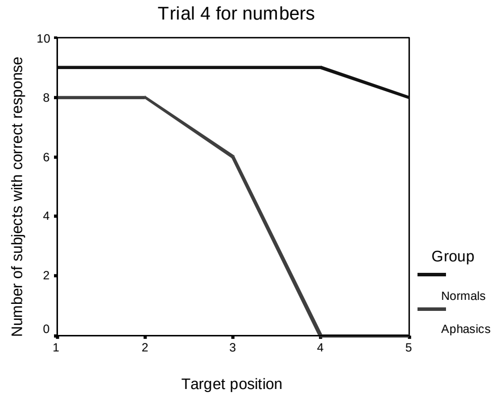


Figure 2: Serial position curve of trial-4 for digits.

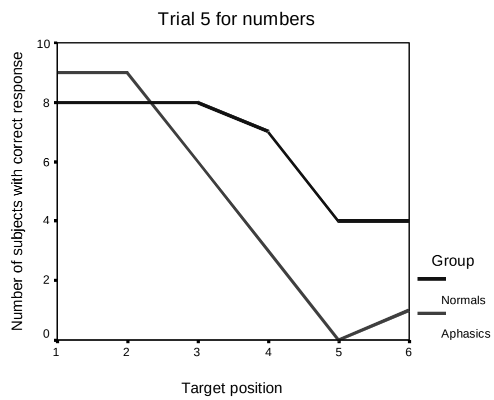


Figure 3: Serial position curve of trial-5 for digits.

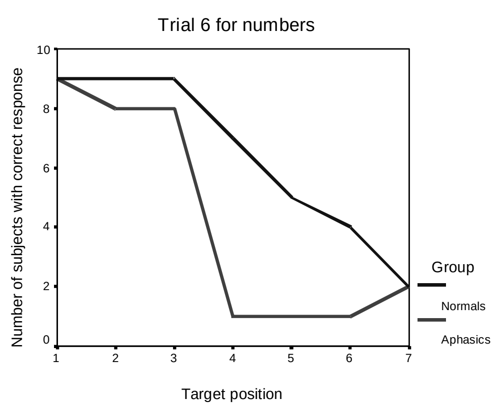


Figure 4: Serial position curve of trial-6 for digits.

It is evident from figure1 4 that a strong primacy effect was present for both Broca's aphasics as well as normal participants. It has been suggested that primacy effect is mainly because, at the start of the list, participants are able to rehearse the items and maintain them in memory (Capitani et al, 1992). Additionally the primacy effect has been observed to be affected by word frequency (Capitani et al, 1992; Raymonds, 1969). As digits are frequently used and highly redundant, it is possible that as in normal participants sub-vocal rehearsals are also present in Broca's aphasics. However, it is also noteworthy that although present, the primacy effect was lesser in aphasics as compared to normal participants which can be related to less efficient rehearsals in Broca's aphasics.

It can be accomplished that compared to normal participants, performances of Broca's aphasics is poor in digit memory span. Further results have also shown that language and memory are sub- served by two different systems, but are interrelated. The damage in the brain can affect either one of them or both. The result suggest that damage to brain results in less efficient sub-vocal rehearsals for maintenance of digits in short term memory

4.2 Memory span of Broca's aphasics and normals for meaningful stimuli task

The raw scores for memory spans of Broca's aphasics and normal participants across various trials of meaningful stimuli task were charted. table 7 depicts the mean and S.D values of raw scores for aphasics and control group across the trials of meaningful stimuli task.

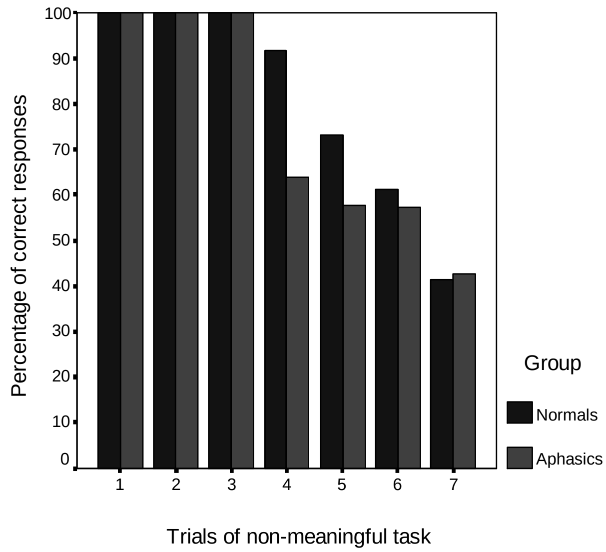
Table 7: Mean and S.D of raw scores across different trials for meaningful stimuli in aphasics and normals.

Group		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Aphasics	Mean	2.00	3.00	3.55	3.44	3.44	3.77
	S.D	_	_	0.73	1.13	1.88	1.30
Normals	Mean	2.00	3.00	4.00	4.77	4.56	4.33
	S.D	_	_	0	0.44	1.13	0.86

Additionally the raw scores of both Broca's aphasics and control groups were converted into percentage, mean and S.D values for percentage scores for aphasics and normals across trials of meaningful stimuli task is presented in table 8. The same is also graphically symbolized in graph 2.

Table 8: Mean and S.D of percentage scores of different trials of meaningful stimuli task for aphasics and normals.

Groups		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Aphasics	Mean	100	100	88.89	68.89	57.41	53.97
	S.D	_	_	18.16	22.60	31.30	18.59
Normals	Mean	100	100	100	95.56	75.93	61.90
	S.D	_	_	_	8.82	18.84	12.37



Graph 2: Comparison of performance of normals and aphasics on various trials of meaningful task.

It can be encapsulated from table 8 that the mean percentage values across different trials for the meaningful stimuli task decreases from 100 % to 53.97% (SD=18.59) for aphasic group and from 100% to 61.90 % (SD=12.37) for the control group, from trial-1 to trial-6.

Table 8 and graph 2 also suggest that the mean of meaningful stimuli memory span decreased from trial 1 to trial 6 for both the Broca's aphasia groups and the normal group. This is similar to the trend observed earlier for mean digit span. These findings also draw support from earlier findings of Martin and Ayala (2004), Swinney and Taylor (1971). These researchers established that as the number of the presented items ascends, memory span worsens. It is evident that both the groups performed uniformly when the numbers of items presented were less but as the number increased memory span deteorated. However, the extent of decline was more in case of aphasics as compared to normal participants. This reduction in memory span once again advocates that sub-systems serving language and memory are discrete.

Further a t-test was used to compare the performance of Broca's aphasia group and normal subjects for each trial of meaningful stimuli and the results are shown in table 9.

Table 9: Comparison of aphasics and normals across different trials of meaningful stimuli task.

Trial Number	t-value	df	Significance (2-tailed)
Trial-3	1.1835	16	0.085
Trial-4	3.297	16	0.005
Trial-5	1.521	16	0.148
Trial-6	1.066	16	0.302

As suggested from the table 9, there was no statistically significant difference observed for trial-3, trial-4 and trial-6 ($p<0.05$). A significant difference was found only for trial-4 ($p<0.05$). The results can be attributed to the fact that all the tokens used in this task were semantically loaded stimuli, thus even a brief presentation of the linguistic stimuli would have activated under lying semantic concepts and thus resulting in better retrieval abilities in both the groups. The results supports the fact that language and memory are closely related, and can be inferred that inclusion of semantically loaded load stimuli may not be an ideal for tapping memory assets in Broca's aphasics. Further the rate of decline on memory span for different stimuli varied in both groups. The rate of decline in normal was more for meaningful stimuli (Minimum value 61.9%) as compared to digits (71.3% Minimum value) while reverse pattern was observed in Broca's aphasics (for meaningful stimuli, 53.9% and for digits 46% Minimum values). Similar findings were reported by Martin and Ayala (2004).

Figures 5, 6, 7 and 8 represent serial position curves drawn for various trials of meaningful stimuli task.

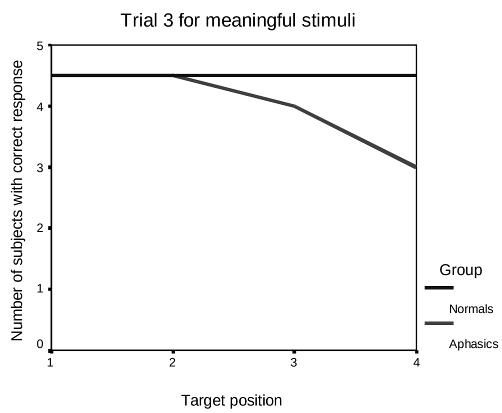


Figure 5: Serial position curve of trial-3 for meaningful stimuli.

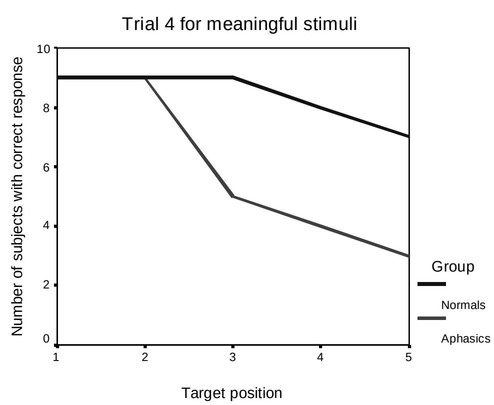


Figure 6: Serial position curve of trial-4 for meaningful stimuli.

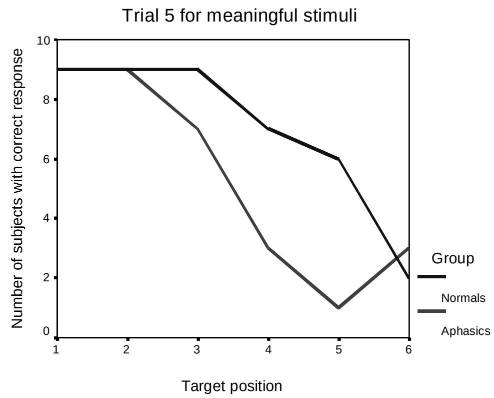


Figure 7: Serial position curve of trial-5 for meaningful stimuli.

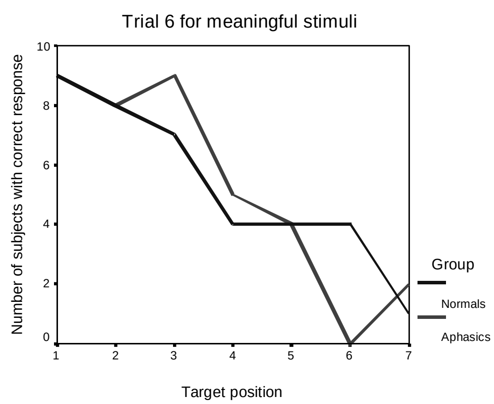


Figure 8: Serial position curve of trial-6 for meaningful stimuli.

As evident from figures 4 to 8, a strong primacy effect was found for meaningful stimuli. This effect can again be ascribed to word frequency, familiarity and semanticity (Capitani et al, 1992; Raymond, 1969). As all the items chosen for this task were frequently occurring, it is also possible that it would have lead to a robust primacy effect. These findings are also supported by the results of a study by Capitani et al., 1992 who found a strong primacy effect in frontal lobe damaged individuals.

To summarize with the addition of token there was deterioration in performance of both the groups when meaningful stimuli was employed. Also no obvious discrepancy was noticed between these two groups, which are in contrast with the results obtained from digit task. This suggests that the type of stimuli can influence the memory span.

4.3 Memory span of Broca's aphasics and normals for non-meaningful stimuli task

The memory span of Broca's aphasics and normals across various trials of non-meaningful stimuli task were tabulated using the raw scores. Table 10 below provides the mean and S.D values of raw scores for aphasics and control group across the trials of non-meaningful stimuli task.

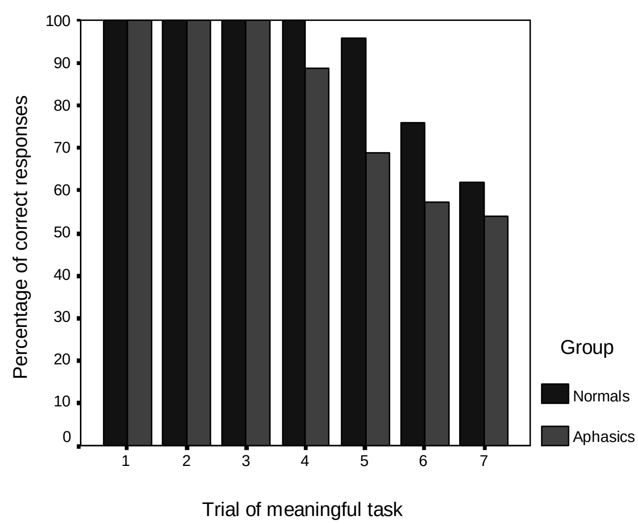
Table 10: Mean and S.D of raw scores of different trials for non-meaningful stimuli in aphasics and normals.

Group		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Aphasics	Mean	2.00	3.00	2.55	2.88	3.44	3.00
	S.D	_	_	1.23	0.60	1.23	1.41
Normals	Mean	2.00	3.00	3.66	3.66	3.66	2.88
	S.D	_	_	0.70	1.41	1.00	1.91

A percentage score was derived from the raw scores of both Broca's aphasics and normal participants. The mean and S.D values for percentage scores in aphasics and normals across trials of non-meaningful stimuli task are presented in table 11. The same is also graphically represented in graph 3.

Table 11: Mean and S.D of percentage scores of different trials of non-meaningful for aphasics and normals.

Groups		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Aphasics	Mean	100	100	63.89	57.78	57.41	42.86
	S.D	-	-	30.90	12.02	20.60	20.20
Normals	Mean	100	100	91.67	73.33	61.11	41.27
	S.D	-	-	17.68	28.28	16.67	28.07



Graph 3: Comparison of performance of normals and aphasics on various trials of non-meaningful task.

As evident from table 11, the mean percentage values across different trials for the non- meaningful stimuli task reduces from 100 % on trial-1 to 42.86 % (SD=20.20) on trial-6 for aphasic group, while for normals, the meaningful memory span reduced from 100 % on trial-1 to 41.27% (SD=28.07) on trial-6.

The other information, which can be summarized from table 11 and graph 3, is that, the mean of non-meaningful stimuli memory span decreased from trial-1 to trial-6 for both the Broca's aphasics and normals. This is in parallel to the trend observed earlier for mean digit span and mean span for meaningful stimuli. For this task also, as the number of the presented tokens were increased there was a decline in the memory span of all the participants. Also the rate of decline in both the groups was highest when non-meaningful stimuli were used (minimum value for normal=42.8% and for aphasics=41.27%). Martin and Ayala (2004) also reported that Broca's aphasics performed worst on non-meaningful stimuli as compared to digits and meaningful stimuli.

To compare the performance of Broca's aphasia group and normal subjects on each trial of non- meaningful stimuli, a paired t-test was used. Table 12 illustrates t-values and significance for Broca's aphasia and normals across different trials of non-meaningful stimuli tasks.

Table 12: Comparison of aphasics and normals across different trials for non-meaningful stimuli task.

Trial No.	t-value	df	Significance (2-tailed)
Trial-3	2.341	16	0.033
Trial-4	1.1519	16	0.148
Trial-5	0.419	16	0.681
Trial-6	0.138	16	0.892

As can be noticed from the table 12, there was a statistically significant difference observed only for trial-3 at 0.05 levels and as the complexity of the task increased both the groups showed similar trends. These findings support the fact that although language and memory are separately represented, they are inter connected. Thus, when the complexity of the task was low normal participants could supplement non-meaningful stimuli with abstract linguistic components, but they failed to do so as the difficulty level increased. On the other hand aphasic participants would have failed to employ these linguistic components, resulting in poor performance throughout.

The results of the study are in accordance to the reports stated by Ostergaard and Meudell (1984), where they found that verbal mediation play a significant role in memory for visually presented non-verbal material and this could account for the deficit in both the groups, but more so in Broca's aphasia. Perhaps these patients' deficiencies in rehearsal of verbally encoded materils put them at a disadvantage even in the non-verbal task. But the reports of the present study are in contrast to the reports of Helm-Estabrooks (2002) who stated that aphasic individuals performed better on non-linguistic tasks as compared to linguistic tasks.

It can be assumed from the results of the present study and reports of Helm-Estabrooks (2002) that there is still no clear agreement among the researcher whether the performance of aphasics would always differ for memory task when a non-meaningful stimuli is used. The type of stimuli and the type may affect the performance of the participants and severity of aphasia also plays an important role. Thus it is imperative that using a common tool for all types of aphasia should be used to arrive at clear consensus. Further it is also advocated that other variables such as type of stroke, literacy level, duration of post stroke, type of management, age should also be looked upon as these can influence the results.

Figures 9, 10, 11 and 12 depict the serial position curves for various trials of non-meaningful stimuli task.

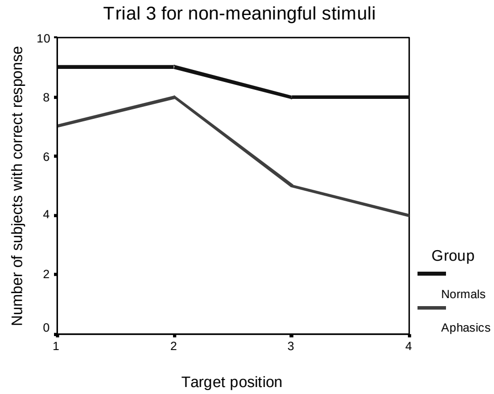


Figure 9: Serial position curve of trial-3 for non-meaningful stimuli.

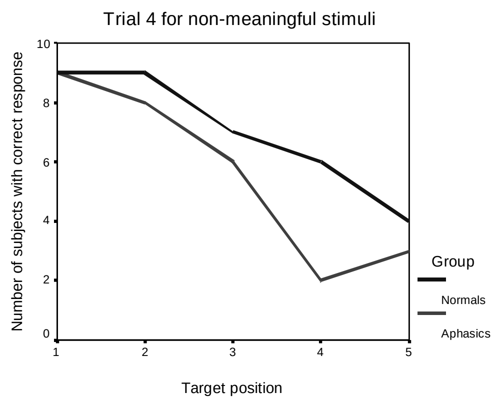


Figure 10: Serial position curve of trial-4 for non-meaningful stimuli.

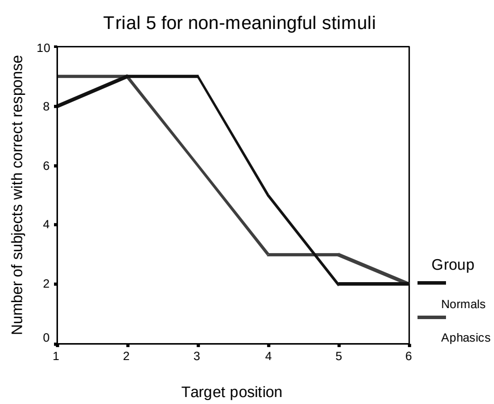


Figure 11: Serial position curve of trial-5 for non-meaningful stimuli.

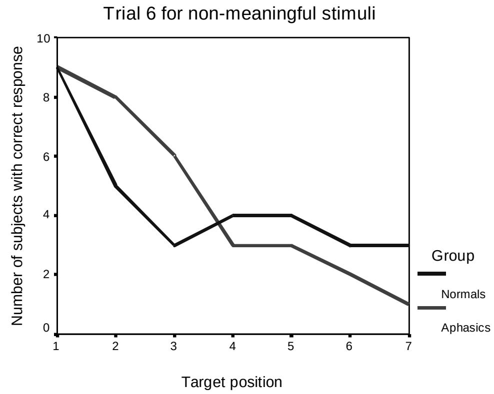


Figure 12: Serial position curve of trial-6 for non-meaningful stimuli.

As is evident from figures 9 to 12, a primacy effect was observed for non-meaningful stimuli also but it was not as robust as for digits and meaningful stimuli. This can be due to the fact that stimuli used for this task were not familiar and lacked any semantic load. This would have disrupted the sub-vocal rehearsals, resulting in poor retrieval of these tokens. Results of the present study draw support from Capitani et al, 1992, which stated that primacy effect may be affected by stimulus type, frequency and semanticity of the token. Research finding of Ostergaard and Meudell (1984) have stated that sub-vocal rehearsals strengthens an individual's ability to retain a stimuli.

4.4 Comparison of performance of participants using repeated measures ANOVA.

4.4.1 Stage-1

A repeated measure of ANOVA was done to study the interaction between tasks and groups and a significant interaction was found between the tasks (digits, meaningful stimuli and non-meaningful stimuli) and the two groups (2, 32) = 6.460, $p<0.05$.

The next analysis was undertaken to study whether there was a significant difference across various tasks when all the participants were taken as a single group. A statistically significant difference was found between task 1 and task 3 and also between task 2 and task 3 at 0.05 levels ($p<0.05$). Thus there was a significant difference in the performance of participants between digit task and non-meaningful task and also between meaningful stimuli and non-meaningful stimuli task. This is in accordance with the findings of Martin and Saffran (1997) and Martin and Ayala (2004) who reported that the kind of the stimuli used for the assessment of memory might affect the memory span for both normals and clinical populations. The various stimuli used in the present study differed in terms of semanticity, familiarity and redundancy. It can be stated that these factors differentially affect, both the memory span as well as the primacy effect in the serial position curve. Thus a careful selection of stimuli should be done while designing memory assessment protocols both for normals as well as aphasics. It can be stated that aphasia may be accompanied by memory deficits, which are not the result of language impairment, but due to concomitant impairment of memory processes.

It was also examined that whether there was a significant difference between the two groups (aphasics and normals) for the three tasks. When the data was subjected to Bonferroni test a statistically significant difference was found between the two groups, $F (1, 16) =13.05$ ($p<0.05$). Hence, it is evident that in general Broca's aphasics performed poorly than normal participants on memory tasks. The results cannot be attributed to reduced expressive language skills in this group because the test paradigm employed did not require any verbal response from the participants. This further suggests that memory and language systems are diverse but might be interrelated. Caplan and Waters, 1994, reported similar findings.

4.4.2 Stage-2

Further analysis was undertaken to study the difference between the tasks across different groups. Table 13 below represents the total mean scores for both normals as well as aphasics across all the tasks.

Table 13: Mean and S.D of total scores across different tasks for normals and aphasics.

	Digits	Meaningful stimuli	Non-meaningful stimuli
Normals	23.22	22.67	18.89
Aphasics	16.56	19.11	16.89

For normals, a significant difference was found across the various tasks (digits, meaningful stimuli and non-meaningful stimuli), $F\ (2,\ 16)=22.285$ ($p<0.001$). Additionally, Bonferroni analysis was done to examine difference between different tasks for normals.

A statistically significant difference was found between task-1 and task-3 and also between task-2 and tak-3 for normals ($p<0.05$). Thus a statistically significant difference was found for the normals between digit spans and non-meaningful stimuli span and also between meaningful stimuli span and non-meaningful stimuli span. This difference can be attributed to the fact that both digits and meaningful tokens employed for this task occur frequently and were redundant. This would have facilitated strong sub-vocal rehearsals, which in turn would have led to better retrieval of these stimuli. On the other hand non-meaningful stimuli lacked any semanticity, this attributed to poor sub-vocal rehearsals and hence, poor performance on this task. Research finding of Ostergaard and Meudell (1984), Capitani et al; 1992, Martin and Ayala (2004), have also stated that sub-vocal rehearsals strengthens an individuals ability to retain a stimuli.

In aphasics also statistically significant difference was noticed across different tasks, $F=(2, 16) =3.091$, $0.05<p<0.1$. Subsequently Bonferroni analysis was undertaken to study the difference between the tasks across the aphasic group.

In this group a statistically significant difference was found in aphasics between meaningful stimuli span and non-meaningful stimuli span (i.e. for task-2 and tak-3) at 0.05 levels ($p< 0.05$). This difference again suggests that language and memory are discrete, and Broca's aphasics might be using their intact comprehension skills to supplement the memory deficits. This is suggested because the task employed was a non-verbal pointing response and the stimuli utilized across both the tasks varied only in terms of semanticity. Thus when meaningful tokens were presented even for a brief duration, it would have been comprehended and subsequently lead to better retention. On the other hand non-meaningful stimuli could not have been supplemented by any language cues and hence lead to a poor performance. This suggests that tokens, which demand linguistic processing may not, provide a correct picture of the memory impairments associated with aphasia. Murray, Ramage and Hopper, 2001, also suggested this.

CHAPTER 5

SUMMARY AND CONCLUSION

The present study intended to investigate non-verbal sequential memory span of Broca's aphasics. The aim of the study also included to study the effects of stimulus characteristics on quantitative and qualitative aspects of non-verbal sequential memory.

Review of literature revealed the existence of deficit in both long-term memory and short-term memory of aphasics. However, there is no consensus among the researchers that whether the memory impairments manifested in aphasics are the result of impaired linguistic processing or an overall deficit of the memory domain itself. This controversy is due to the fact that most of the tests employed for assessing memory demand linguistic processing, which is impaired in aphasics.

Thus, a non-verbal assessment protocol has been suggested for assessing the memory in aphasics. Moreover it is also important to study how different kinds of stimuli can affect the performance of both normals as well as aphasics. This would have important clinical implications while designing tools for memory assessment in aphasics.

A total of nine Broca's aphasics and nine normal individuals matched for age, gender, handedness and language participated on various tasks of memory span in the present investigation.

The memory span was calculated for three different tasks:

- Digits
- Meaningful stimuli
- Non-meaningful stimuli.

Appropriate tabulation of data was computed. Statistical analyses were performed using SPSS (version 10,) statistical package. The raw scores were converted into percentages and mean and standard deviation (S.D.) of both the raw scores were obtained from the participants on different tasks. To explore the difference in performance between the aphasics and normals across different trials of various tasks, a paired t-test was done. Further Repeated Measures ANOVA was done to study the interaction between various tasks and groups. Subsequently to study the significance of interaction a two-stage analysis was done. First stage compromised of studying the effect of task on group while in the second-stage the effect of group on task was studied. Serial position curves were drawn for qualitative analysis.

Listed below are the important findings drawn from the present study:

1. Performance of both Broca's aphasics and normals decreased when the complexity of the task was increased for all the three types of stimuli i.e. digits, meaningful stimuli and non-meaningful stimuli.
2. The rate of decline was more in aphasics as compared to normals.
3. There was a significant difference between aphasics and normals across various trials of digit span suggesting that the insult to brain results in decline in non-verbal sequential memory span.
4. A robust primacy effect was observed in both aphasics and normals for digits, suggesting sub-vocal rehearsals. However, the strength of primacy effect was less for aphasics as compared to normals suggesting that language impairment may affect covert rehearsals also.
5. There was no significant difference observed between aphasics and normals for meaningful stimuli task. This suggested that presentation of semantically loaded stimuli would have activated underlying intact

concepts in both Broca's aphasics and normals, thus resulting in better retrieval.

6. A strong primacy effect was found for meaningful stimuli which could be ascribed to word frequency, familiarity and semanticity of tokens employed.
7. On various trials of non-meaningful stimuli, no significant difference was observed between aphasics and normals suggesting that memory and language are discrete but may be inter-related.
8. A primacy effect was found for non-meaningful stimuli but it was not as robust as it was for digits and meaningful stimuli. This might imply that due to lack of semanticity, these tokens could not be rehearsed and hence, resulting in poor performance.
9. It was also found that the kind of stimuli employed for memory assessment had an effect on the performance of Broca's aphasics and normals.
10. A difference was also found for tasks within groups. In normals, a difference was found between digits and non-meaningful stimuli and also between meaningful and non-meaningful stimuli. On the other hand for aphasics, difference was found between meaningful and non-meaningful stimuli.

Implications

The results of the study have far reaching implications while designing assessment and intervention program for Broca's aphasics. Findings of the study also suggest that inclusion of different kind of stimuli can be employed to tap the memory skills during the course of therapy.

Thus it can be concluded that there is a significant difference between normals and aphasics in memory span. The results have strongly suggested that there are obvious observable memory deficits in Broca's aphasics. Further the results of the study also advocate that the stimuli employed for assessing the memory can influence non-verbal sequential memory span. In order to generalize these results in other types of aphasia, similar studies should be conducted.

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APPENDIX I

DIGITS

TRIAL No.	TOKENS	DISTRACTORS
1	3, 8	4, 9
2	5, 7, 2	6, 1
3	9, 4, 1, 5	3, 2
4	6, 3, 8, 2, 7	1, 5
5	4, 1, 9, 7, 5, 3	8, 2
6	2, 8, 3, 4, 6, 1, 5	9, 7

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3	4

5	6
7	8


SCHOOL BUS
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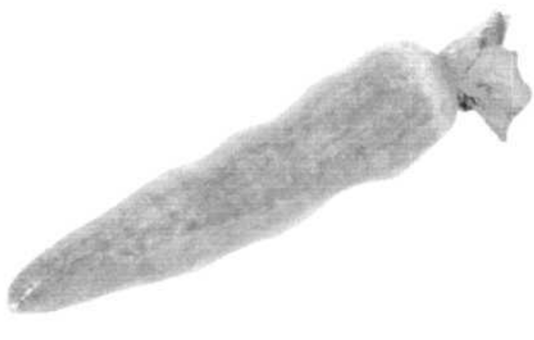


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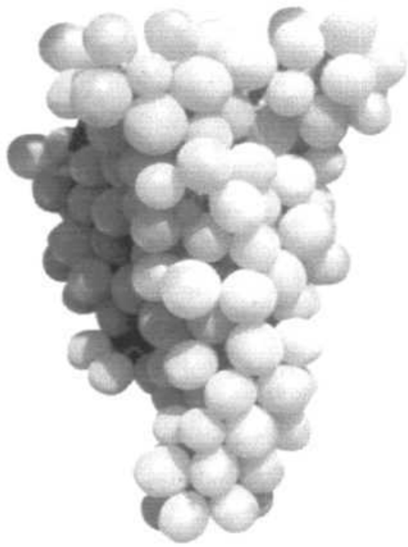

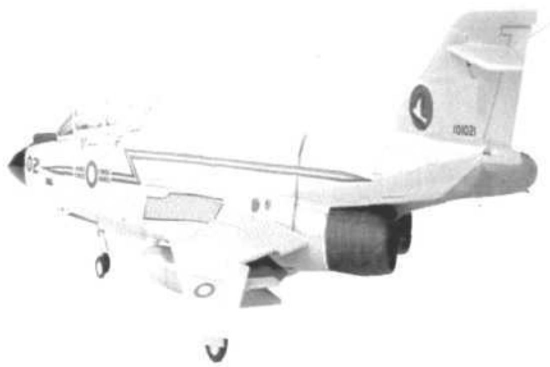
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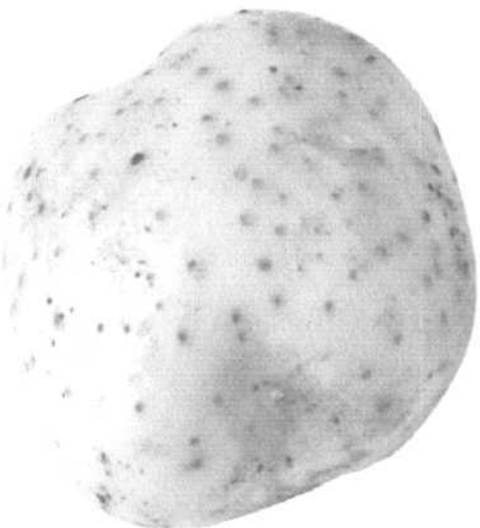





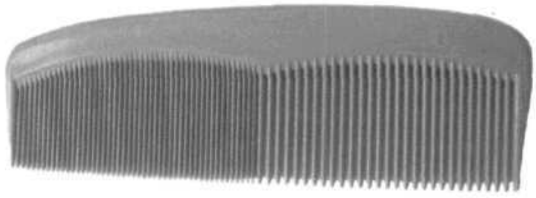
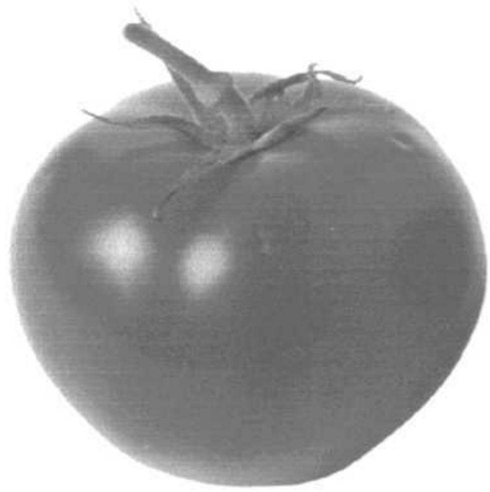

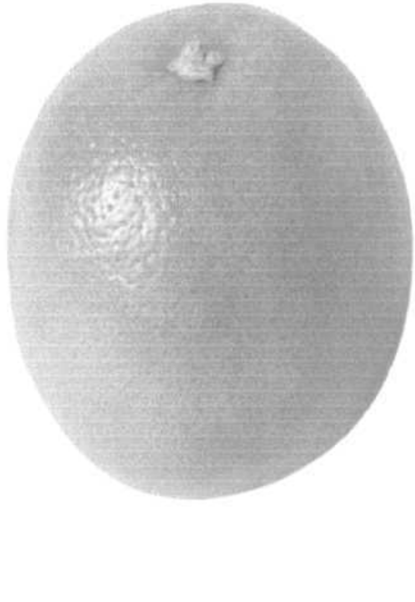

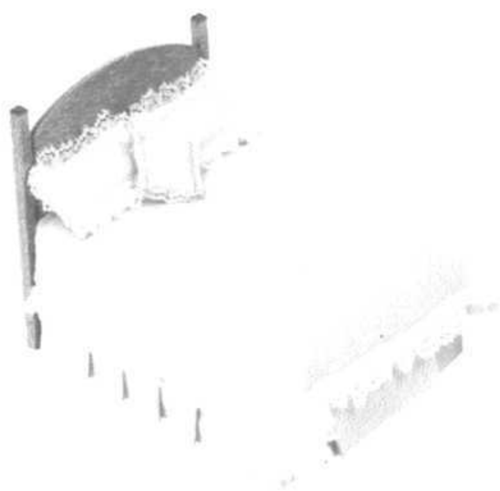

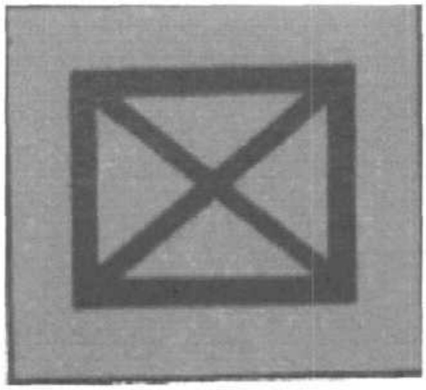

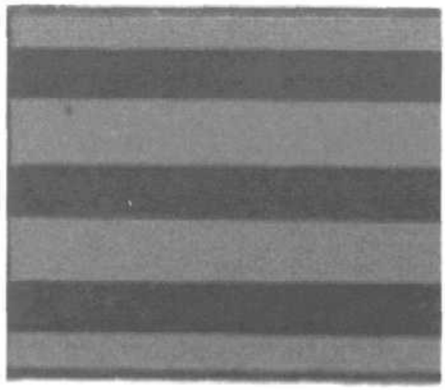

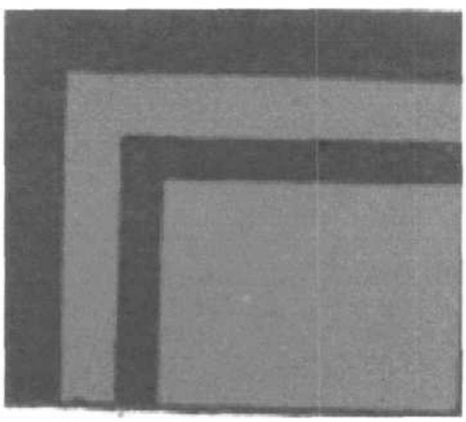

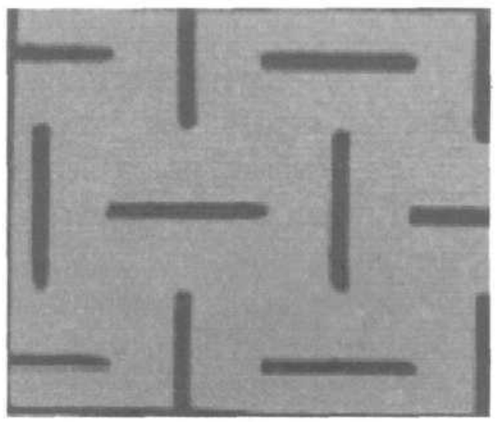

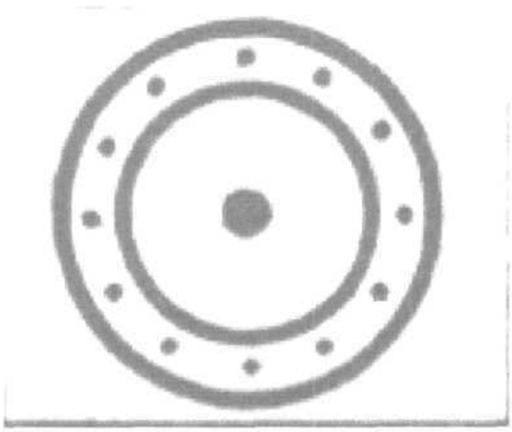

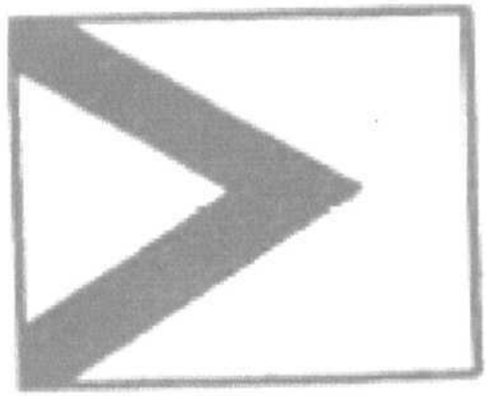

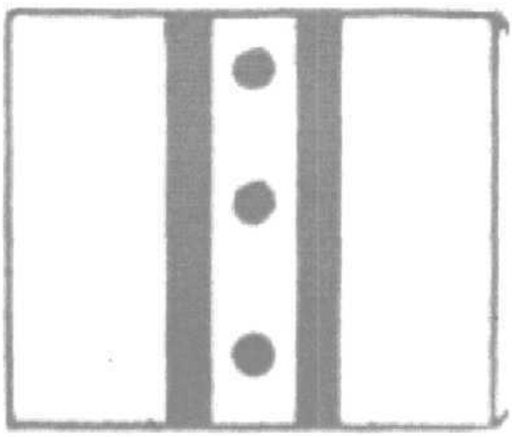

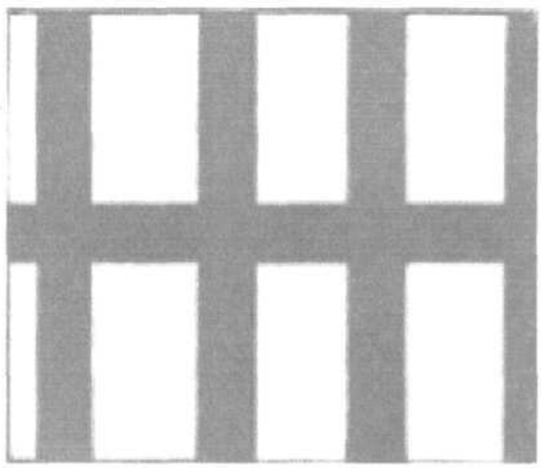

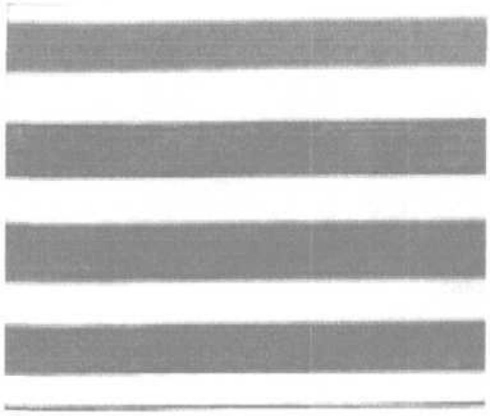
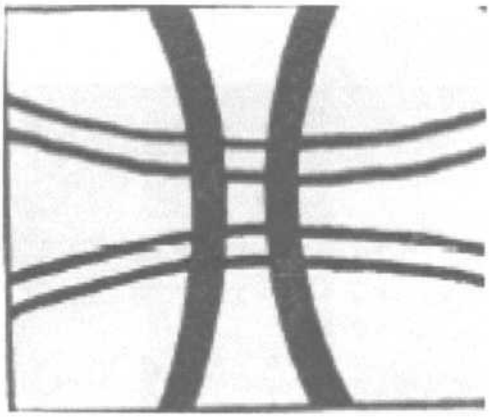
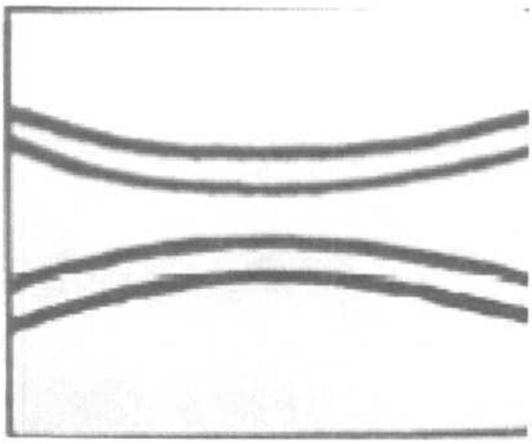
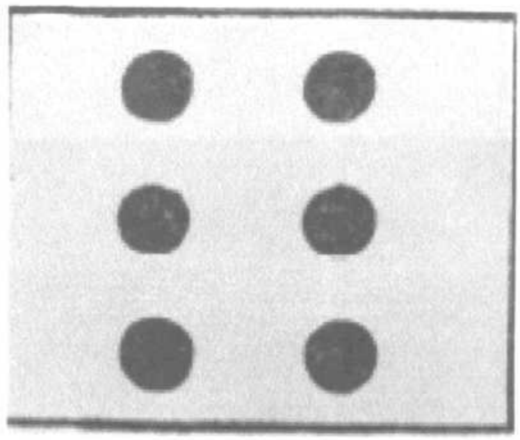

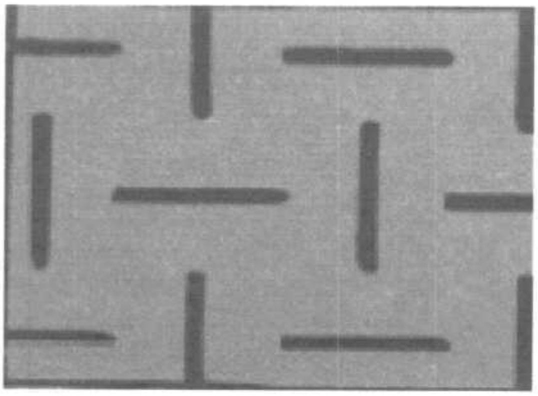

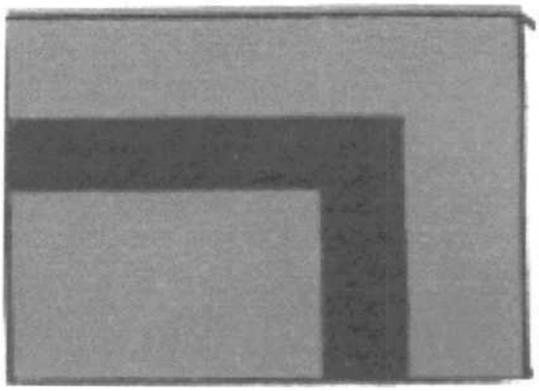

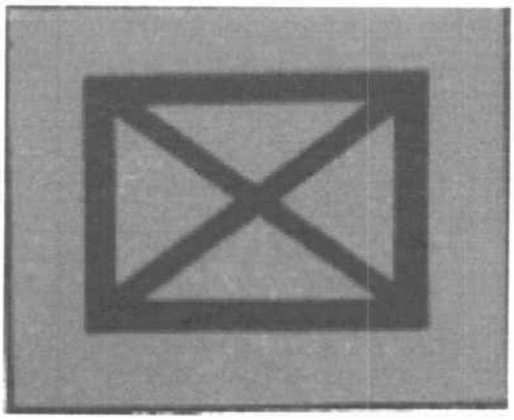

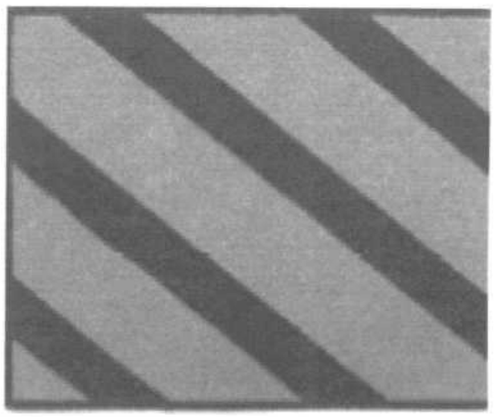

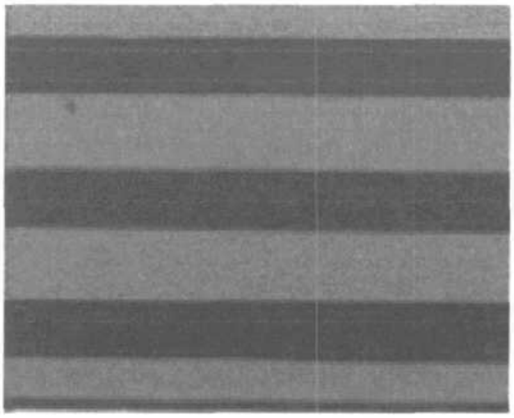

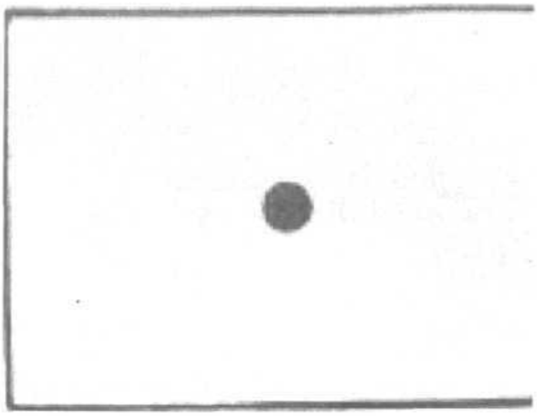

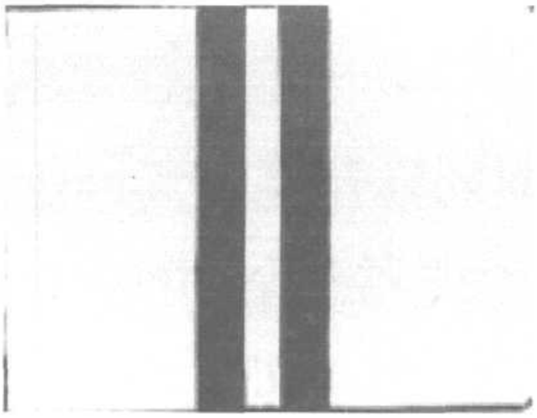

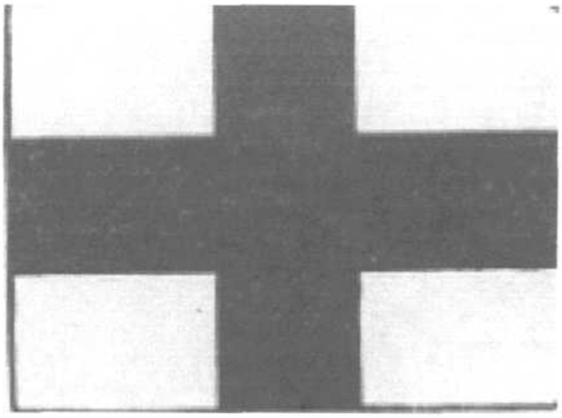

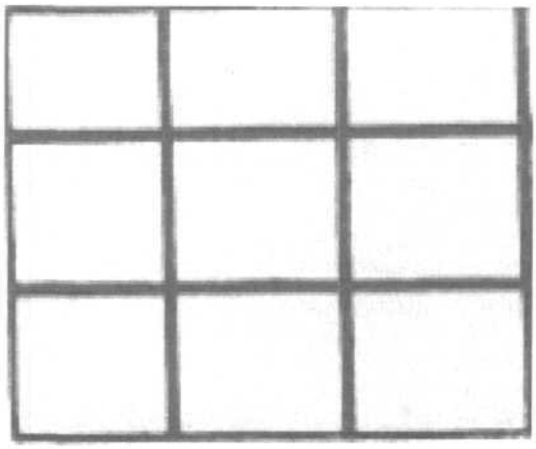
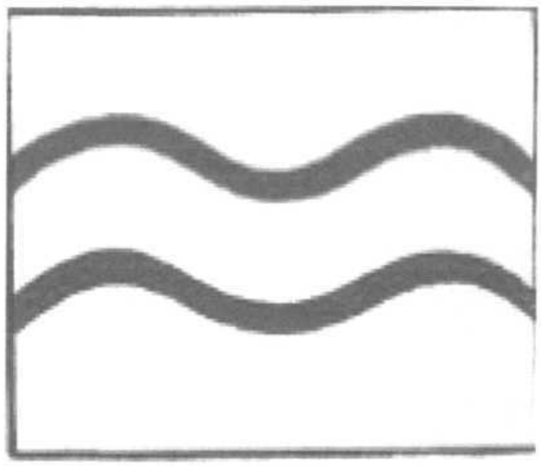
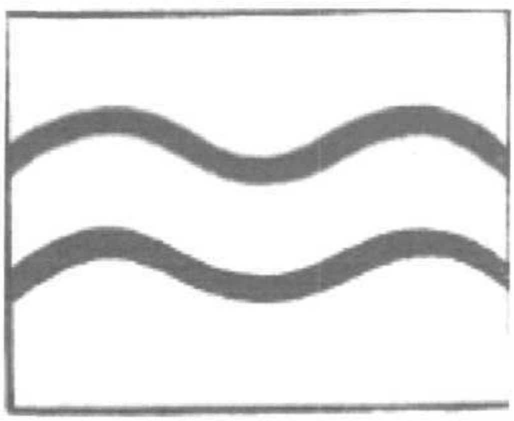
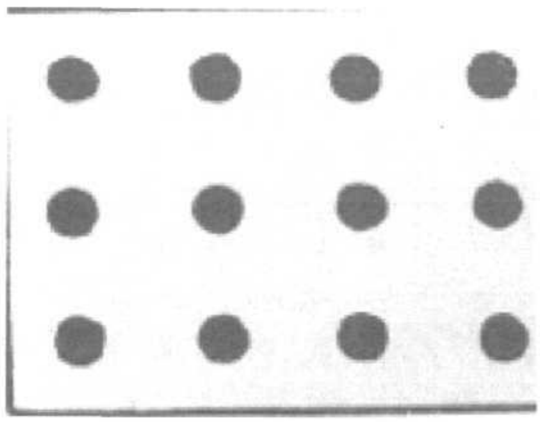

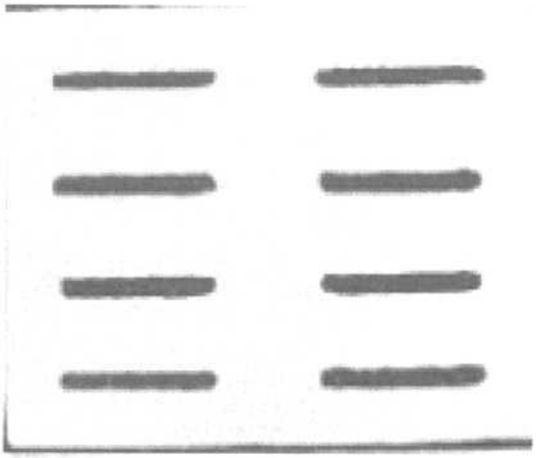
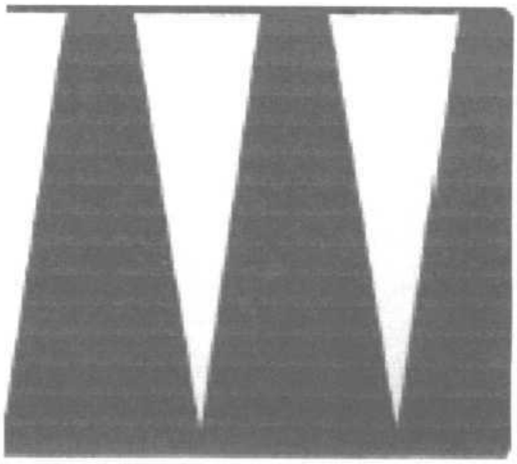
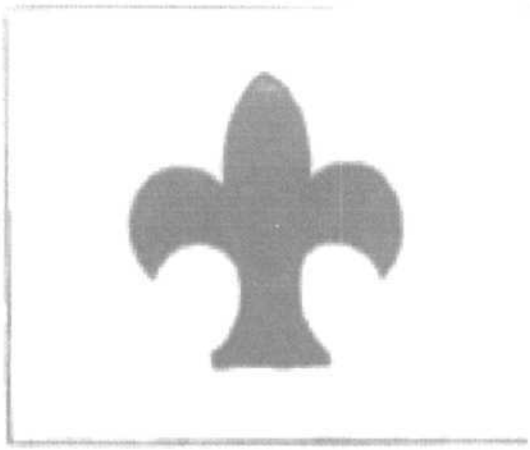
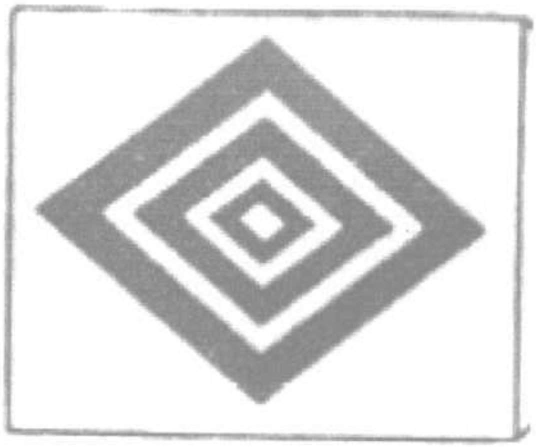

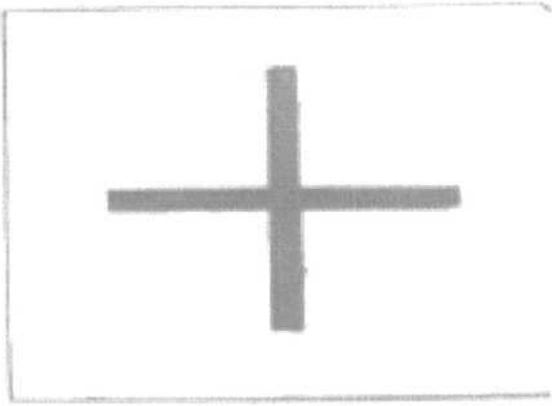

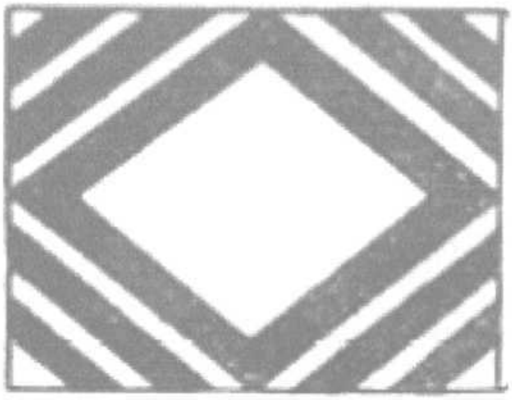

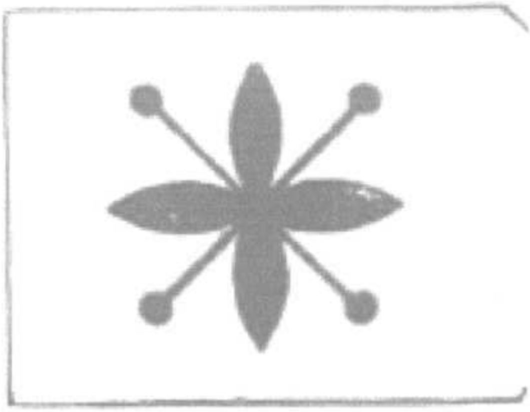

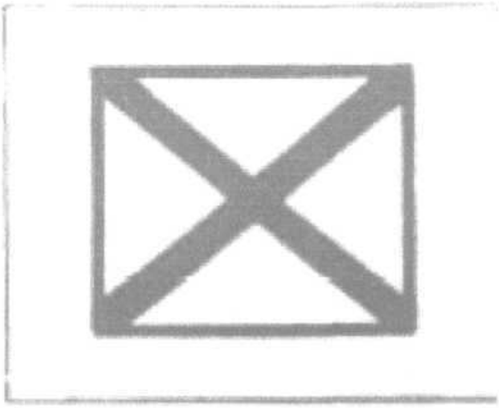

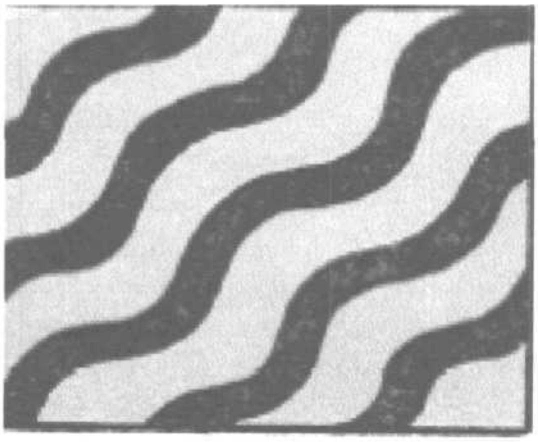
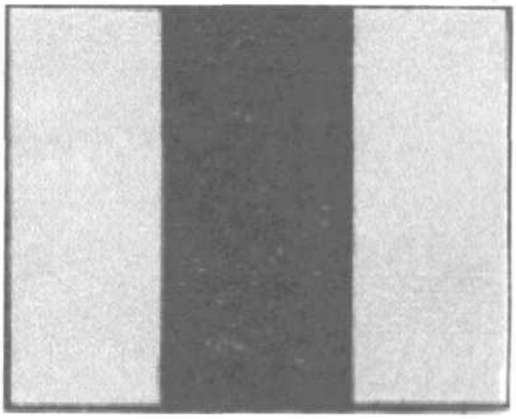
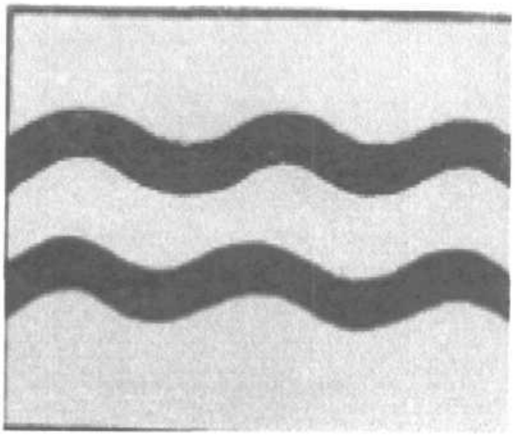
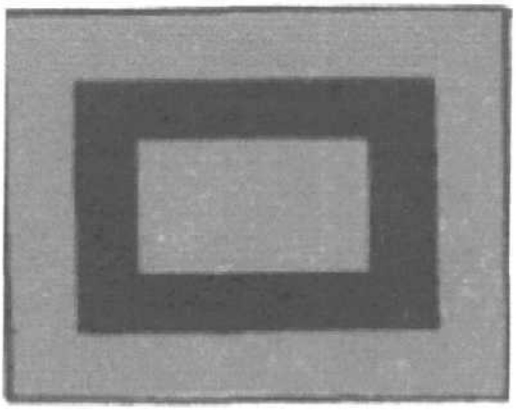

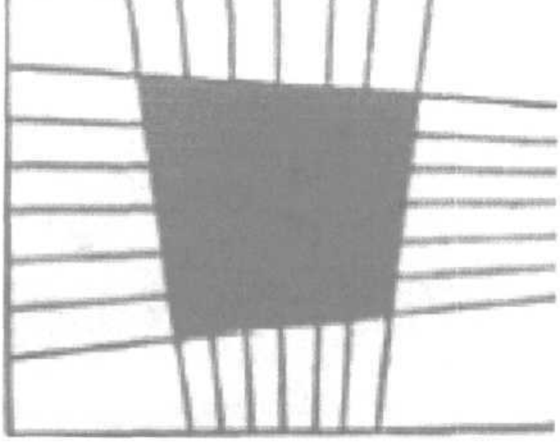

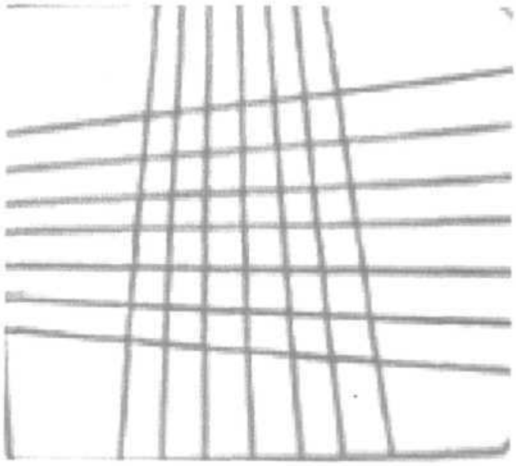

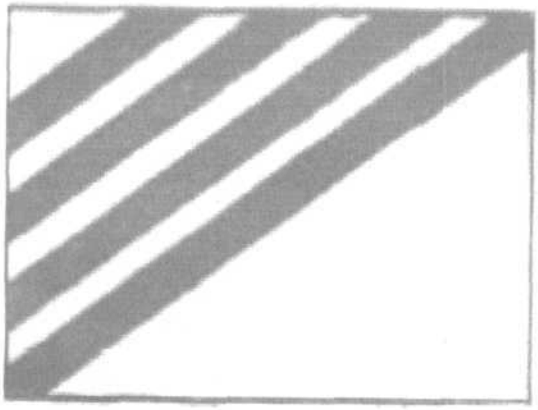

APPENDIX II

MEANINGFUL STIMULI

TRIAL No.	TOKENS	DISTRACTORS
1	Cup, Bus	Brush, Carrot
2	Clock, Scissor, Cap	Grape, Aeroplane
3	Cow, Window, Flower, Bucket	Bag, Elephant
4	Peacock, Cycle, Comb, Tomato, Fan	Orange, Crow
5	Umbrella, Potato, Ship, Dog, Shirt, Tree	Ball, Candle
6	Banana, Table, Lock, Knife, Shoes, Cat, Pen	Carrot, Bed