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DELAYED RECOGNITION MEMORY FOR LATERALLY-PRESENTED ABSTRACT
AND CONCRETE WORDS AND DRAWINGS

by

Stephan Kennepohl

B.Sc., McGill University, 1991

A Thesis

Submitted to the Faculty of Graduate Studies and Research
through the Department of Psychology
in Partial Fulfillment of the
Requirements for the Degree
of Master of Arts at the
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Abstract

The present study used a divided visual field (DVF) paradigm to investigate possible hemispheric asymmetries in delayed recognition memory for lists of words and drawings. The influence of sex and certain stimulus characteristics (i.e., abstract vs. concrete words and drawings) on these lateralization effects were also examined. Forty four right-handed participants with no history of neurological problems were asked to recognize lists of words and designs initially presented to the left or right visual field using a tachistoscope. A non-parametric measure of recognition discriminability was used as the dependent measure. 2 x 2 x 2 mixed factorial ANOVAs were conducted on these discriminability scores for both drawings and words to assess the effects of visual field of presentation, stimulus type, and sex. These ANOVAs revealed no significant effects of sex or visual field for either words or drawings. Significant effects of stimulus type (abstract vs. concrete) were observed for both drawings and words, as well as a significant interaction between visual field and word type. These findings are discussed in terms of the possible lateralization of memory processing in the two hemispheres and the dual-coding hypothesis of memory encoding (Paivio, 1990).

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INTRODUCTION

Ever since Kimura's (1961, 1967) landmark set of studies using verbal dichotic listening methods to investigate possible hemispheric differences in neurologically intact individuals, researchers have attempted to study and understand information processing asymmetries within the normal human brain. Studies of cerebral localization had hitherto been restricted to either the study of individuals with specific and localized brain lesions (e.g., Milner, 1958; Kimura, 1963) or the clinical investigation of "split-brain" patients, individuals whose corpus callosum had been surgically sectioned for the relief of intractable epilepsy (e.g., Gazzaniga, Bogen & Sperry, 1963, 1965).

The methods proposed by Kimura and others offered the possibility of studying the functional roles of the cerebral hemispheres in large groups of neurologically intact subjects. Although the techniques themselves were by no means recent developments, the literature referring to "split-brain" patients gave these investigators a renewed sense of assurance that their findings reflected basic differences between the cerebral hemispheres and were not due to extraneous variables (Davidoff, 1982; Beaumont, 1982). Since that time, countless studies have been conducted using normal subjects in an effort to elucidate

these cerebral asymmetries (e.g., Hardyk, Tseng, & Wang, 1977; Marsolek, Squire, Kosslyn, & Lulenski, 1994).

Regardless of the method or subject sample used, studies of cerebral lateralization have typically supported the notion of basic differences between the hemispheres in most if not all people. In the overwhelming majority of individuals, the left hemisphere seems preferentially suited to deal with verbal material. In contrast, although to a lesser degree, the right hemisphere appears better equipped to deal with nonverbal material, and the "visuo-spatial" aspects of functioning in particular. There are several factors such as sex and handedness that seem to affect the extent to which this dichotomy is apparent. It is nevertheless striking the extent to which these trends have been observed across the majority of studies of cerebral organization (for reviews of these issues and findings see Bradshaw & Nettleton, 1983; Iaccino, 1993; Springer & Deutsch, 1993). This does not imply that all studies have consistently supported this dichotomy, or that consensus has been reached as to the aspects of functioning that are lateralized to either hemisphere. Rather, most investigators prefer to discuss these issues in terms of "relative" instead of "absolute" lateralization (Iaccino, 1993). Indeed, methodology seems to have a considerable influence on the outcome of many lateralization studies.

Visual Approaches to the Study of Functional Asymmetries in the Intact Human Brain

Although the first attempts to specifically investigate underlying functional hemispheric differences in neurologically-normal subjects used auditorily presented stimuli, it wasn't long before the logic of these studies was extended to the visual modality. The visual system is wired such that information in a particular visual field is almost exclusively projected to the contralateral cerebral hemisphere. In this way, information in the right visual field (RVF) is preferentially processed by the left visual cortex, while information in the left visual field (LVF) is sent to the right visual cortex. An instrument called a tachistoscope enables stimuli to be shown in either visual field quickly enough to prevent the eyes from centrally fixating the presented item (central fixation allows both hemispheres the opportunity to "see" the stimulus). Thus, it is possible to project a stimulus to a given visual half-field and, in turn, to a specific cerebral hemisphere (for an extensive review of methodological issues in divided visual field studies, see Young, 1982).

Due to its relative simplicity and accessibility, this paradigm gained immense popularity in the late 1960's and 70's, and generated a large amount of published lateralization data. Although a detailed review of these

studies would be beyond the scope of this discussion, it would nevertheless seem useful to provide an overview of some of the issues and conclusions generated by these studies.

The most consistent and robust finding using the divided visual field (DVF) paradigm has been the observation of a RVF (i.e., left hemisphere) advantage for most verbal or linguistic stimuli. With accuracy of report as the dependent measure, consistent results have been observed using single letters or digits presented unilaterally (Bryden & Rainey, 1963; Kimura, 1966; Hines & Satz, 1971). Short word presentations also seem to show the expected RVF advantage in a number of languages, with methodology having little or no effect in the majority of cases (McKeever & Huling, 1970; (Japanese) Sasanuma, Itoh, Mori, & Kobayashi, 1977; Leiber, 1982; (German) Mannhaupt, 1983; (Spanish) Nieto, Hernandez, Gonzalez-Feria, & Barroso, 1990). However, word presentations have occasionally shown the opposite (i.e., LVF) advantage or no visual field advantage (VFA) under certain conditions, such as when written in a more complex or unusual typeface (Gordon & Carmon, 1976).

Although LVF (right hemisphere) superiorities for nonverbal stimuli have generally been more difficult to observe, there are some stimuli that seem to show more

consistent lateralization effects. These include the detection and localization of random-dot projections (Kimura, 1966; Bryden, 1976) and the recognition of photographed or cartooned faces displaying strong emotions (Hilliard, 1973; Ley & Bryden, 1979). However, it has proved difficult to demonstrate consistent LVF advantages for other types of nonverbal stimuli such as abstract forms. Whereas some investigators have reported the expected LVF advantage (Dee & Fontenot, 1973; Hatta, 1976), others have found no VFA (Bryden & Rainey, 1963; Hines, 1978). Furthermore, studies employing simple pictures of easily named objects typically display either a clear RVF advantage or no VFA (Wyke & Ettlenger, 1961; Nieto, Hernandez, Gonzalez-Feria, & Barroso, 1990).

In view of these findings, it is clear that in normal subjects the task requirements have a tremendous effect on whether a VFA will be observed or not. The same stimulus can actually demonstrate opposite VFAs depending on the methods of presentation or demands put upon the individual (Bradshaw & Nettleton, 1983). For example, Hatta (1981, cf. Hatta, 1992) reported that widely differing lateralization effects could be observed using the same type of stimuli (Kanji script). In his study, a RVF advantage was apparent while using a semantic processing task (identifying the meaning of a word), a LVF superiority in a physical matching

task, and no VFA while using a lexical decision task (deciding whether the stimulus was a word or not).

These discrepancies have led theorists such as Moscovitch (1979) to argue that lateralization effects might be better observed in higher-order as opposed to lower-level or perceptual processes. According to this viewpoint, hemispheric differences are minimal at the earlier, sensory levels of processing, and only emerge consistently at higher levels of analysis where sensory inputs have become more categorized or representational. If this notion is valid, then a study evaluating the memory for different stimuli would seem well suited to observe hemispheric differences.

Lateralization of Memory Function in Clinical Populations and the Dual Coding Hypothesis

Research involving patients with focal brain lesions has often been cited as providing evidence for material-specific differences in memory function in the two hemispheres. This has particularly been the case for epileptic patients receiving selective temporal lobe excisions for the relief of intractable seizures (Milner, 1958; Corsi, 1972; Milner, 1975). Preoperative memory assessment in these cases is a crucial and necessary step in evaluating the prognosis of patients following surgery. Studies using the Intra-carotid Sodium Amytal Procedure

(ISAP), which selectively and temporarily anaesthetizes one hemisphere (Jones-Gotman, 1987), has provided additional clues as to the specific roles of the hemispheres in memory. The familiar dichotomy associates the left hemisphere, and the mesial temporal lobe and hippocampus in particular, with memory for verbal and linguistic material. Its counterpart in the right hemisphere seems to be involved in the memory for nonverbal and visuo-spatial stimuli (Jones-Gotman, 1986; Milner, 1975).

Some authors have proposed that these types of findings support the notion of a dual memory code with distinctive and independent processing for verbal and nonverbal material (Paivio, 1969, 1990). Studies evaluating this hypothesis have mostly focused on the role of imagery in verbal stimuli and the influence of naming in nonverbal stimuli*.

In support of this hypothesis, information that is easy to consider in terms of both a verbal and visual "code" (e.g., concrete words) are better remembered, even when

* In view of the high degree of overlap and correlation between the abstract-concrete and imageability concepts (Paivio, Yuille, & Madigan, 1968), many authors have used these terms interchangeably in discussing their relevance to the dual-coding hypothesis. It is, however, possible to have a word such as "anger" that is both abstract but highly imageable. In most studies, imageability as a factor does seem the better predictor for lateralization effects in memory, and is more coherent in terms of the dual-coding hypothesis. In our discussion, both sets of terms will be used to describe the same concept in terms of their applicability for dual-coding. In this way, "abstract" words are defined as being difficult to code visually, while "abstract" designs are difficult to code verbally.

variables such as word frequency and meaningfulness are taken into account (Paivio, 1969). Dual-coding theory proposes that these two codes (verbal and nonverbal) are in fact orthogonal and independent of one another, implying that their impact on memory is therefore somehow additive. It is important to note that dual-coding theory in itself does not imply that these functional differences (i.e., verbal vs. nonverbal) necessitate hemispheric specialization. Paivio himself (1990; p.260) states that "any (emphasis ours) anatomical-regional correlation with performance on verbal and nonverbal tasks can be equally informative theoretically".

Nevertheless, many studies of brain-damaged individuals have found dual-coding theory useful in assessing functional hemispheric differences. For example, some patients with left-temporal lesions have been shown to improve their memory for certain words by using an image-mediated mnemonic strategy (Jones, 1974), while dyslexics with left-sided lesions have been reported to have greater difficulty reading abstract as opposed to concrete words (Coltheart, Patterson, & Marshall, 1980). Additionally, some patients with right-temporal lobe lesions only seemed to be hindered when learning concrete words (Jones-Gotman & Milner, 1978).

The role of imagery in the encoding of verbal stimuli has not gone unnoticed by researchers using DVF methods. Some researchers have reported a greater RVF advantage for abstract rather than concrete words (Ellis & Shepherd, 1974; Hines, 1976; Day, 1979), while others have not observed this effect (Bradshaw & Gates, 1978; Lambert & Beaumont, 1983; Boles, 1983; Howell & Bryden, 1987). Some interesting studies on the topic have involved the use of Japanese and Chinese script. In Japanese, for example, both phonetic (Kana) and pictorial (Kanji) symbols are used in everyday written language. Using Kanji script, Elman and his associates (Elman, Takahashi, & Tohsaku, 1981), as well as Hayashi (1985, cf. Hatta, 1992) have reported LVF advantages for concrete but not for abstract Kanji symbols.

The possible role of dual-coding has also been investigated with pictorial stimuli. As previously mentioned, easily-named pictures typically show a RVF advantage (Wyke & Ettlenger, 1961), while abstract shapes either produce no VFA or a weak LVF effect (Hines, 1978; Dee & Fontenot, 1973). As with most tachistoscopic studies, however, these studies vary greatly in their methodologies and measures of laterality. It is therefore extremely difficult to derive any conclusions about the role of imagery or naming in the preceding studies.

Divided Visual Field Studies Investigating the Role of Memory for Verbal and Nonverbal Material

Many researchers have investigated the possibility that memory may be a critical factor in some of the lateralization effects observed in many tachistoscopic studies. A number of studies have suggested that while VFAs were not observed in many perceptual processes, there were significant VFAs when a memory component was involved (Hatta, 1976; Hardyck, Tzeng, & Wang, 1977, 1978; Madden & Nebes, 1980).

Most studies specifically investigating memory effects with verbal material have reported significant RVF advantages. These investigations have used stimuli such as digits (Madden & Nebes, 1980), letters (Kirsner & Brown, 1981), and single words (Leiber, 1982; Mannhaupt, 1983). However, these results have not always been replicated (e.g., White, 1970). With respect to nonverbal material, Dee and Fontenot (1973) compared the recognition accuracy of complex forms following delays of increasing length. Not only did they find a LVF advantage for the recognition of these forms, this lateralization effect seemed to increase with longer delay intervals. Although similar findings were replicated by Hatta (1976), other researchers have failed to find similar VFAs in the memory for complex shapes (Hannay, 1976 (females); Birkett, 1978).

It is notable that most of the studies discussed above have either been variations of a simple perceptual paradigm with increased delay of response or versions of Sternberg's (1966) memory search paradigm. Both of these techniques focus exclusively on short-term or "working" memory for the recall or recognition of short lists of items. This point is of particular importance if one is to compare DVF studies with those in the clinical literature, where memory is typically assessed using longer lists of items and/or considerable delays.

As mentioned previously, most clinical accounts of lateralized memory disturbances have been associated with damage to the mesial temporal lobe. Complete removal or damage of this area bilaterally can result in a complete inability to encode new information into long-term store. These lesions do not however, usually affect short-term or working memory (Scoville & Milner, 1957; Squire, 1987, 1992). Keeping this in mind, one may question whether many of the lateralized memory findings using DVF techniques can be considered equivalent to those observed in clinical settings. Indeed, very few studies combining DVF methods with more traditional memory testing paradigms have been conducted.

Juan de Mendoza and his colleagues provided some

evidence that lateralization effects may be observed in normals using more conventional memory evaluation methods. Items were initially presented to either visual field using a tachistoscope, with subjects recalling and then recognizing the target items from a list of distracters. Their findings suggested that free recall but not recognition for a list of short French words would display a significant RVF advantage (Juan de Mendoza & Grosso, 1980). A more recent study assessing the effect of imagery on the memory for similar words reported no general VFA, although there was a significant interaction between the visual field of initial presentation and imagery in the recognition task. Whereas abstract words showed the expected RVF advantage, concrete words demonstrated the opposite LVF advantage (Juan de Mendoza, 1992). It should be noted that this latter study used a short list of words (16) that were not controlled for frequency or familiarity, attributes that have been shown to have a considerable effect on memory (Boles, 1983).

In 1984, Masui and his associates presented a relatively long list of Kana (phonetic) words to groups of temporal lobe epileptic patients and normal controls using a tachistoscope (Masui, Niwa, Anzai, Kameyama, Saitoh, & Rymar, 1984). Following the presentation of the items to either visual field, the subjects were asked to recognize

the words from a list of similar distracters. The patient group with the epileptic focus in the left temporal lobe did not show the expected RVF advantage for the Kana words. The authors cited this lack of a RVF superiority for the recognition memory for words as indicative of a specific verbal memory impairment consistent with left temporal lobe dysfunction.

In another set of studies, Christianson, Nilsson, Saisa and Silfvenius (1992) also used groups of temporal-lobe epileptics and normal controls to investigate the lateralization of memory functioning. In a first experiment, concrete and abstract words were presented using a DVF technique, and measures of latency and naming were taken in addition to the usual recognition and recall indexes of memory. A second study using the same groups measured recognition memory for a list of complex shapes. Although there was an apparent general RVF advantage for the recall and recognition of words across groups, there was no equivalent laterality effect for complex shapes. The results also suggested that patients with a left temporal-lobe focus had a selective memory impairment for abstract but not concrete words.

In a recent set of experiments, Marsolek and his associates (Marsolek, Squire, Kosslyn, & Lulenski, 1994;

Marsolek, Kosslyn, & Squire, 1992) demonstrated that a LVF superiority for the memory for words could be elicited using an implicit memory procedure. In these studies, words were presented centrally during the initial presentation phase. Word stems were then displayed laterally in an effort to cue a response from the subject. They found that if the same typeface is used in both the encoding and the test phase, a LVF advantage for words could be observed, implying what they termed a "form-specific" system in the right hemisphere. It should be noted that this paradigm differs somewhat from previous studies in its assessment of "implicit" as opposed to "explicit" memory and lateralized presentation at the retrieval rather than the encoding stage of memory. In implicit memory tasks, subjects are unaware that the task is a memory test. This distinction is significant in that implicit and explicit memory have been associated with distinct memory systems in clinical populations (Bauer, Tobias & Valenstein, 1993) and could partially account for the reversal of the VFAs in these studies.

This last group of experiments point to the fact that it may be possible to test for discernible memory lateralization effects using methods similar to those in traditional memory tests. Very few systematic studies have been done in this way to compare these results with clinical

cases of memory asymmetries. Christianson and his associates (1992) have proposed that DVF and dichotic listening methods be used as adjuncts to the highly-invasive ISAP procedure as part of a preoperative memory battery assessing lateralization in epileptic patients scheduled for surgery (Christianson, Nilsson, Saisa, & Silfvenius, 1992). Although DVF paradigms have fared rather poorly in comparison to the ISAP in assessing memory lateralization in individual patients (Channon, Schugens, Daum, & Polkey, 1987), it is hoped that the DVF method may nevertheless be useful as a tool in conjunction with other tests of memory lateralization. For the moment, it remains to be shown that any particular DVF procedure can be used reliably to demonstrate consistent memory laterality differences in normal subjects before they can be used in clinical settings.

The Effect of Sex on Lateralization

The effect of sex on the lateralization of functions in the two hemispheres has been extensively studied. Although the majority of these effects are small, most authors agree that there exist significant differences in the general patterns of functioning between males and females. These include an advantage for females over males on tasks of a verbal nature, and conversely, better performance on some visuo-spatial tasks in males than in females (for reviews

see McGlone, 1980; Iaccino, 1993). More important to our discussion, however, is the claim that laterality effects generally tend to be greater in men, implying a more even and bilateral distribution of function in the brains of women.

Visual-field studies evaluating these sex differences have reported greater lateralization differences for males in tasks such as the processing of words (Bradshaw & Gates, 1978) and dot localization (Bryden, 1976). However, as with all studies of sex differences, these differences are small in magnitude, and indeed have not consistently been replicated (e.g., Hannay & Boyer, 1978).

Statement of Purpose and Hypotheses

The purpose of the present study is to investigate the effects of lateralized presentation, stimulus type (i.e., abstract vs. concrete words and drawings), and sex in a recognition memory task. Although these issues have been addressed by other investigators, a few additional differences were included in an effort to shed some light on differing issues:

First, a measure of retention based on signal detection theory was used as an assessment of the subjects' accuracy at recognizing the stimuli, allowing recognition scores to

be evaluated relatively free of decision variables and biases. This is important, as biases have been shown to occasionally affect retention scores in certain recognition memory tasks (Swets, 1973). It should be noted that none of the recognition studies cited above have controlled for these decision factors. It is possible that as different stimuli (verbal and non-verbal) and stimulus types (abstract vs. concrete) vary, so do the decision criteria, which could ultimately affect the subjects' response patterns.

Second, the nonverbal complex designs used in this study were an extension of a list of items that had previously been shown to be selectively sensitive to right temporal-lobe damage (Jones-Gotman, 1986). Most studies investigating similar effects have used complex polygons of the type developed by Vanderplas and Garvin (1959), providing mixed results in terms of their laterality effects. However, it should be noted that Jones-Gotman's (1986) study was based on a free recall paradigm, and that the present study involved recognition. Additionally, the items used in Jones-Gotman's study only represent a subset of the items in this study.

Lastly, this study used a much longer delay period between initial presentation of the items and the final recognition phase. This was done in order to better mimic

more conventional memory assessment techniques that use a significant delay in evaluating memory performance in clinical populations.

Based on previous studies investigating the influence of the various factors on the memory for verbal and non-verbal material, the following hypotheses were proposed:

(1) Although it is extremely difficult to predict the role of sex in such a DVF study, it is likely that in cases where sex differences are apparent they would involve a greater lateralization of function in male subjects. This should particularly be evident for the retention of verbal material (McGlone, 1980).

(2) In accordance with the traditional left hemisphere/verbal and right hemisphere/nonverbal dichotomy, it is predicted that recognition memory will be better for words initially presented in the RVF and drawings presented in the LVF.

(3) It is hypothesized that recognition memory for words and drawings will generally conform to the predictions made by the dual-coding theory. Accordingly, items that may be easily remembered in terms of both a verbal and visual code (i.e., concrete words and drawings) should generally be

better recognized.

(4) If the preceding two hypotheses are supported, then relative lateralization effects should occur according to stimulus type, with abstract items showing the greatest relative VFAs. Based on previous studies, these effects are predicted to be greatest for abstract words. On the other hand, concrete drawings may show either no VFA or even a slight RVF advantage due to their highly verbal nature. Abstract drawings however, may be expected to show a significant although possibly weak LVF advantage, depending partially on the strategy used by the individual to encode them into memory.

METHOD

Subjects:

Thirty-nine (15 male, 24 female) undergraduate students were recruited from introductory psychology classes on a volunteer basis, and received extra credit for their participation in the study. An additional five male volunteers were recruited from the community. Twelve undergraduate student volunteers were also recruited for a pilot study to measure baseline levels for the recognition memory task.

All subjects were right-handed as assessed by the Edinburgh Handedness Questionnaire (Oldfield, 1971). Handedness has consistently been shown to be related to the lateralization of certain functions, with left handers exhibiting a more bilateral organization of function, particularly for linguistic material (for reviews see Springer & Deutsch, 1993; Iaccino, 1993; Bradshaw and Nettleton, 1983). Nine of the total forty-four experimental subjects reported a family history of sinistrality. This was not considered an exclusionary criteria as subsequent statistical analyses indicated no significant difference in performance due to familial sinistrality. All participants had normal or corrected-to-normal vision.

Stimuli & Apparatus:

The stimuli were presented on 10.2 cm x 15.2 cm white cards in a Gerbrands, T-2B-10 2-field tachistoscope. Verbal stimuli consisted of two lists of words chosen from Paivio, Yuille & Madigan's (1968) word ratings according to their concreteness, meaningfulness, and imageability. The list of abstract words is currently being used at the Montreal Neurological Institute as part of their memory assessment battery for patients with intractable epilepsy (Jones-Gotman, personal communication). A similar list consisting of concrete (high-imagery) words was therefore constructed that matched the original abstract word list for meaningfulness, frequency, and word size. All words were between 3 and 7 letters in length. The lists of abstract and concrete words are presented in Appendix A (p.57).

Non-verbal stimuli consisted of two lists classified according to how easy they were to verbalize. The list of abstract designs was chosen from lists also used at the Montreal Neurological Institute. As mentioned previously, recall for a subset of these lists has already been shown to be sensitive to right hippocampal damage (Jones-Gotman, 1986). A comparable set of concrete drawings was taken from a standardized set of object pictures (Snodgrass & Vanderwart, 1980). The drawings were chosen for their average ratings in familiarity and complexity while

maintaining a high naming factor. The lists of abstract and concrete drawings are presented in Appendix B (p. 58).

Procedure:

Pilot Study: Prior to the actual study, a pilot study involving 12 subjects was undertaken in order to set baseline levels for recognition memory for the drawings and words. The procedure used was similar to the experimental procedure except for the locus of initial stimulus presentation, which was kept at the centre of fixation. The target stimuli consisted of 32 drawings (16 abstract & 16 concrete) and 32 words (16 abstract and 16 concrete). These were to be recognized from an equal number of distracters (32 drawings and 32 words). The list of drawings was always presented first in order to mimic the order of presentation used in the Montreal Neurological Institute's list-learning tasks. In addition, other studies have shown that prior presentation of lateralized verbal material may significantly affect the subsequent processing of non-verbal material (Kimura & Durnford, 1974).

Recognition memory for laterally presented pictures and words:

To ensure central fixation prior to stimulus presentation, subjects were instructed to fixate a centrally presented dot for 2 seconds and depress a button as quickly

as possible following its disappearance. Participants were given a number of practice trials to familiarize themselves with this procedure. This methodology allowed a quantitative estimate of the subject's tendency to fixate centrally prior to the stimulus presentation. All trials in which reaction time exceeded 800 ms or in which the participant responded before the disappearance of the dot were discarded (less than 5% of trials). In order to account for possible activation effects due to the hand used in pressing the button, exactly half of the trials were conducted with the right hand and the other half with the left hand. Subsequent statistical analyses confirmed that there was no significant effect on performance due to the use of a particular hand in pressing the button (see Appendix C, p. 62).

Subjects were given specific instructions to try and remember the items, and were told that they would be asked to recognize them later. The stimulus was flashed for 130 ms to the left or right of fixation exactly 500 ms following the disappearance of the central fixation dot. All items (drawings and words) were presented in a framed square of 4.5 cm x 4.5 cm. The centre of the frame was positioned at 3.62 degrees of horizontal visual angle to the left or right of fixation, with the interior and exterior borders subtending visual angles of 1.44 and 5.71 degrees,

respectively. Examples of these cards are presented in Appendix D (p. 63). The interval between the presentation of each item was approximately 5-6 seconds. The thirty-two stimulus items were semi-randomly assigned to either a left or right visual field presentation group, with both groups having equal numbers of abstract and concrete items (words or designs). There was a maximum of three consecutive presentations in any given visual field.

Following the presentation of the design and word lists, subjects engaged in a test of motor speed (Finger-Tapping Test; Reitan & Davies, 1974) which served as a distractor task and lasted approximately 10 minutes. The participants were then asked to recognize the target items from an equal number of distractors. These were presented tachistoscopically in the central position until the subject responded. In order to maximize the semantic component for word recognition, different cases were used in the initial presentation (upper-case) and recognition (lower-case) phases. This was also done in view of findings that words presented in the same type occasionally display LVF advantages (Marsolek, Squire, Kosslyn, & Lulenski, 1994).

In order to obtain a measure of response accuracy relatively free from bias or other decision criteria, a measure of recognition based on signal detection theory was

used (for review see Swets, 1973). Using a simple rating scale evaluating the certainty of subjects' responses, it is possible to graph the "Memory Operating Characteristic" (MOC) curve, also called the isomnemonic function (Banks, 1970; Green & Swets, 1974).

In our study, subjects were given five categories of response for each item during the recognition phase, ranging from One = "Sure it was on the list", Two = "Quite sure it was on the list", Three = "Don't know", Four = "Quite sure it wasn't on the list", and Five = "Sure it was not on the list". These ratings are then used to construct a 5 X 2 decision matrix (Table 1) that represents the cumulative proportion of "hits" (correct target recognitions) and "false alarms" (occasions where the subject incorrectly judges distracters to be targets). The values in this matrix are related to the subject's confidence in recognizing each of the items. As the subjects' confidence increases, so do their chances of producing a false alarm. These points are plotted on the MOC graph ranging from lowest (a) to highest confidence (d) ratings (For a more detailed explanation on plotting the MOC function curve from confidence ratings see Green and Swets, 1974).

Following the suggestion made by Swets and Pickett (1982), the area under the MOC curve, or A_g , is used as the

Table 1

Decision Matrix for Plotting the MOC graph

Proportion of Hits and False Alarms

	Hits	False Alarms
"One"	x1	y1
"Two"	x2	y2
"Three"	x3	y3
"Four"	x4	y4
"Five"	x5	y5

Cumulative Proportion of Hits and False Alarms

	Hits	False Alarms
a	x1	y1
b	x1+x2	y1+y2
c	x1+x2+x3	y1+y2+y3
d	x1+x2+x3+x4	y1+y2+y3+y4

measure of recognition accuracy in each case. By using such a non-parametric measure of accuracy, no assumptions are made about the distributions underlying the MOC curve. A value for A_g is then calculated to provide an index of recognition discriminability for each of the variables under study. The value of A_g for each variable was calculated as follows (see Table 1):

$$A_g = ((x_1 * y_1) / 2) + (x_1 * y_2) + ((x_2 * y_2) / 2) + \\ ((x_1 + x_2) * y_3) + ((x_3 * y_3) / 2) + ((x_1 + x_2 + x_3) * y_4) \\ + ((x_4 * y_4) / 2) + ((x_1 + x_2 + x_3 + x_4) * y_5) + \\ ((x_5 * y_5) / 2)$$

(For a complete numeric example of the calculation and graphing of A_g , see Appendix E, p.66).

For each subject, a value for A_g was calculated according to stimulus type (abstract vs. concrete) and initial visual field of presentation (left vs. right) for both drawings and words. In total, eight values of A_g were calculated per participant, four for the drawings and four for the words. Overall, this 2 X 2 X 2 experimental design allowed for the evaluation of the effect of stimulus type (abstract vs. concrete) and visual field of presentation (left vs. right) within subjects, as well as the effect of sex (male vs. female) between subjects.

RESULTS

As mentioned previously, the dependent variable was the recognition discriminability index (A_g) for each of the groups. Independent variables consisted of Sex (male vs. female), Visual Field of presentation (left vs. right), and Drawing or Word Type (abstract vs. concrete). Results of evaluation of the assumptions of normality of sampling distributions and homogeneity of variance (both univariate and multivariate) were satisfactory (all p 's < 0.05).

Drawings:

Relevant descriptive statistics related to the recognition discriminability for drawings are given in Table 2. A 2 X 2 X 2 mixed factorial analysis of variance (ANOVA) was performed, with Sex serving as the between-subjects factor and Visual Field of presentation and Drawing Type as within-subject variables. This ANOVA revealed a highly significant main effect of Drawing Type [$F(1,42) = 64.40, p < 0.001$], with concrete drawings being better recognized than abstract drawings (see Figure 1). In addition, the main effect of Sex was of borderline significance [$F(1,42) = 3.0, p = 0.1$], suggesting a possible slight advantage for males in recognition discriminability for drawings (see Figure 2). There was no main effect of Visual Field [$F(1,42) = 1.56, p > 0.05$] (see Figure 3).

Table 2

Recognition Discriminability for Drawings as a Function of
Sex and Design Type

Condition

Sex	Design Type	
	Abstract	Concrete
Males (<u>n</u> =20)		
<u>M</u>	72.25	83.75
<u>SD</u>	14.32	10.50
Female (<u>n</u> =24)		
<u>M</u>	65.40	81.36
<u>SD</u>	12.67	13.62

Note. The values represent mean percentages of recognition discriminability of targets from distractors.

Figure 1:

Recognition Discriminability for Designs Effect of Design Type

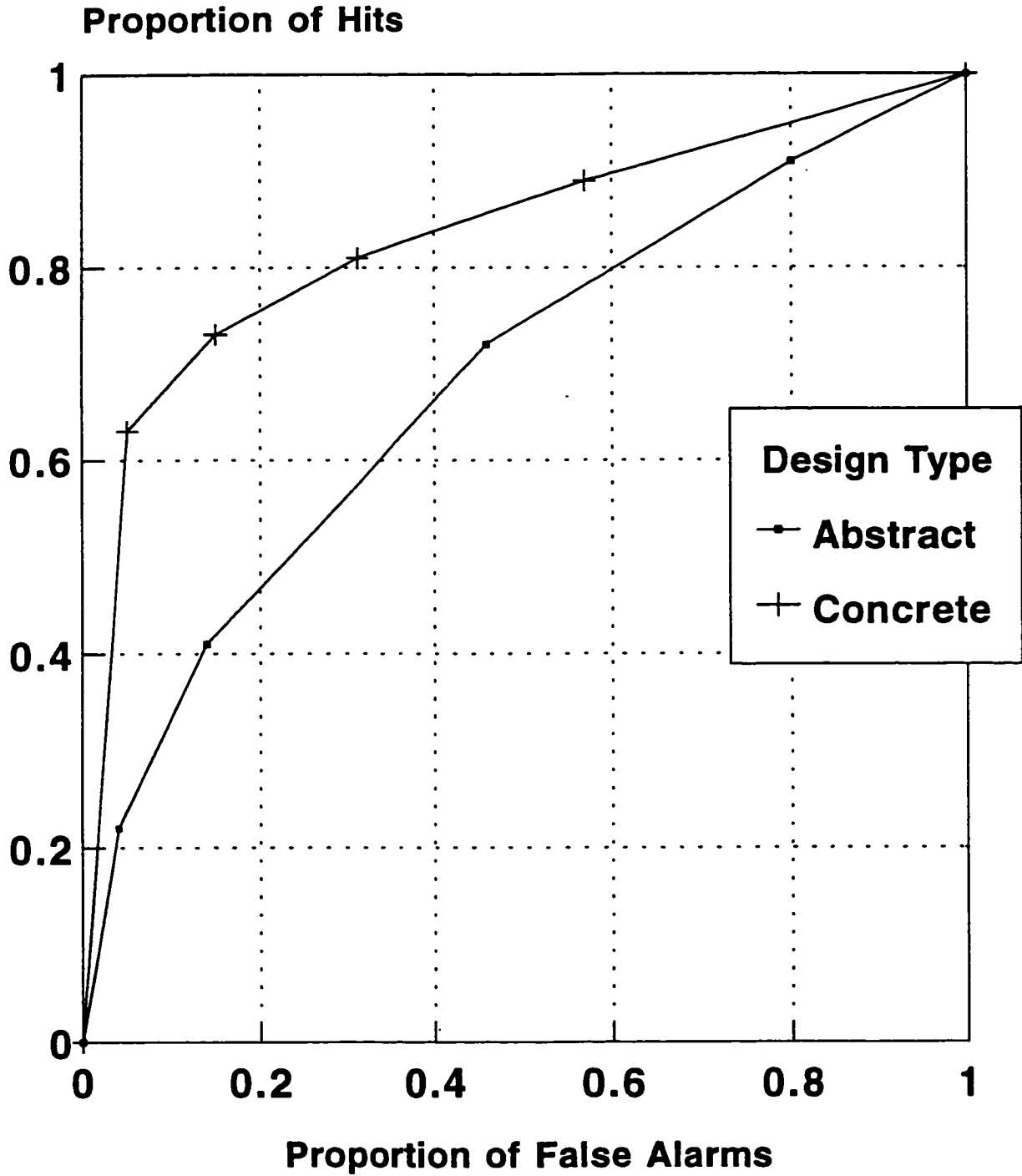


Figure 2:

Recognition Discriminability for Designs Effect of Sex

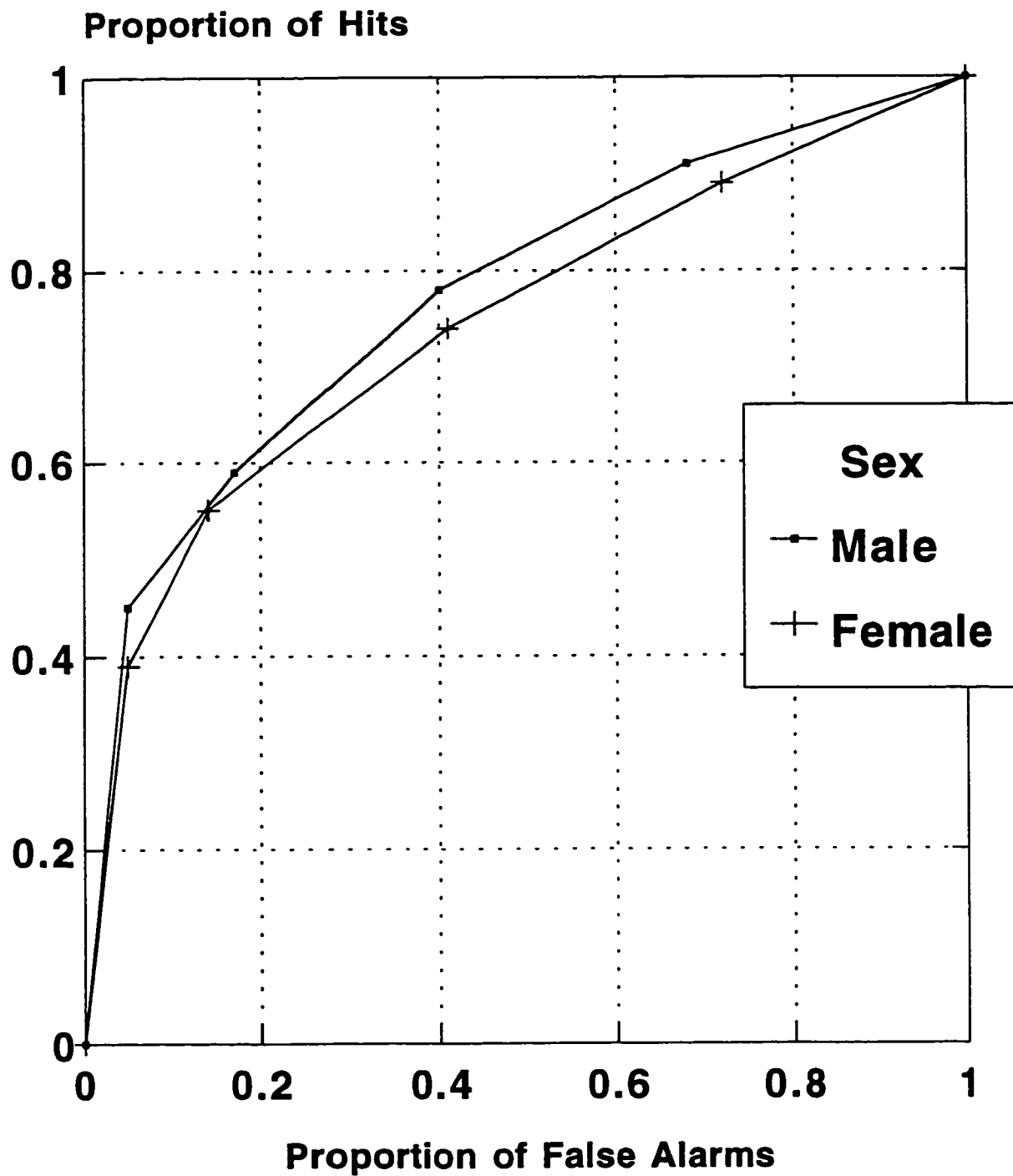
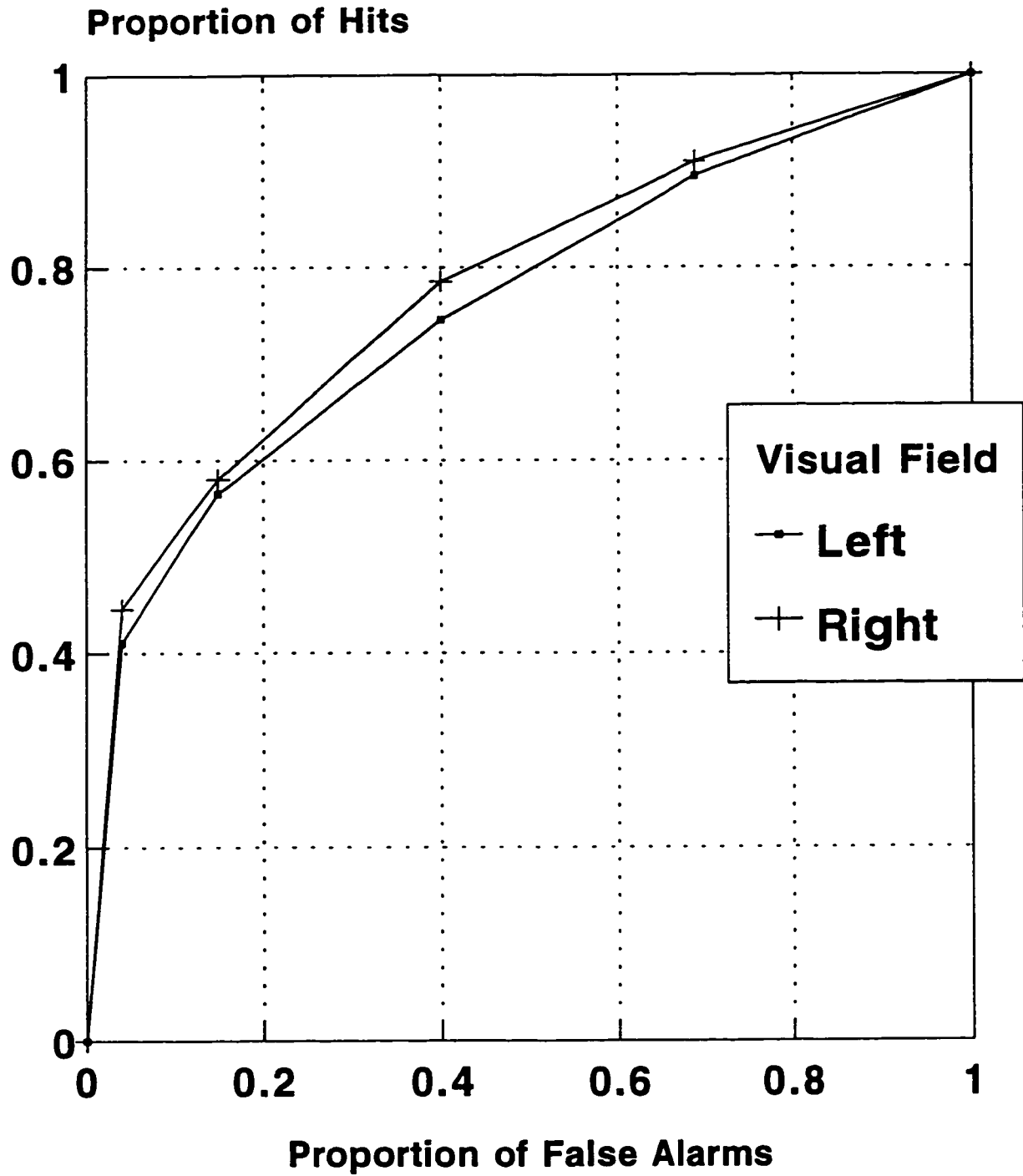


Figure 3:

Recognition Discriminability for Designs Effect of Visual Field



Words:

Relevant descriptive statistics for the recognition discriminability for words are given in Table 3. The same type of 2 X 2 X 2 mixed factorial ANOVA was performed using the recognition discriminability data for words. This revealed a significant main effect of Word Type [$F(1, 42) = 6.05, p < 0.02$] (see Figure 4). However, there was also a significant interaction between Word Type and Visual Field [$F(1, 42) = 4.26, p < 0.05$]. Post-hoc analysis of the means using the Studentized Newman-Keuls test indicated that concrete words presented in the right visual field were better recognized than all other groups at the 0.05 level of significance (see Figure 5). There were no significant main effects of Sex [$F(1, 42) = 0.65, p > 0.05$] or Visual Field [$F(1, 42) = 1.41, p > 0.05$] (see Figures 6 & 7, respectively).

Table 3

Recognition Discriminability for Words as a Function of
Visual Field of Presentation and Word Type

Condition

Visual Field	Word type	
	Abstract	Concrete
Left Visual Field		
<u>M</u>	71.9	71.9
<u>SD</u>	14.2	14.2
Right Visual Field		
<u>M</u>	70.5	78.0
<u>SD</u>	15.6	13.9

Note. The values represent mean percentages of recognition discriminability of targets from distracters.

Figure 4:

Recognition Discriminability for Words

Effect of Word Type

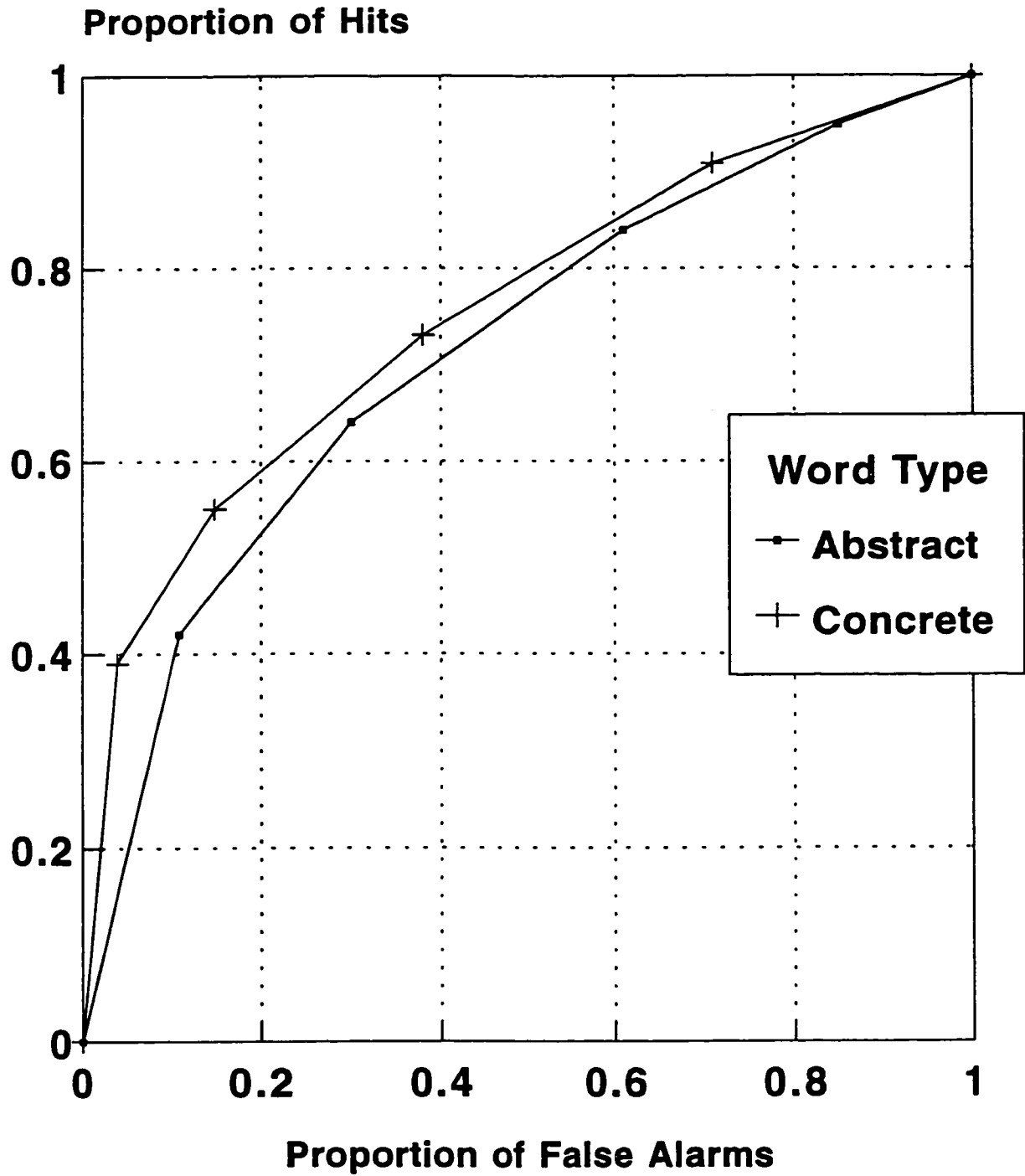


Figure 5:

Recognition Discriminability for Words

Effect of Visual Field and Word Type

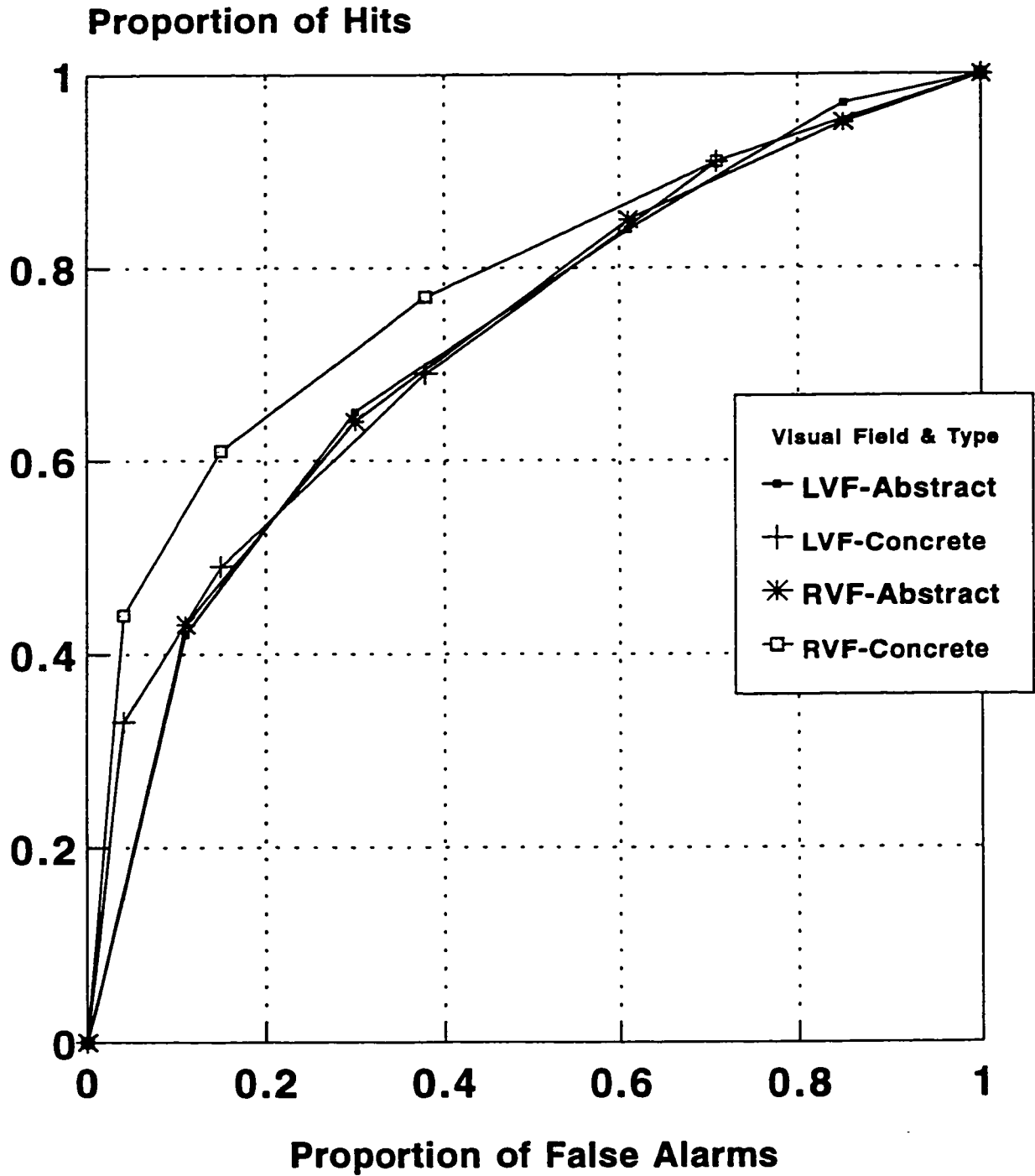


Figure 6:

Recognition Discriminability for Words Effect of Sex

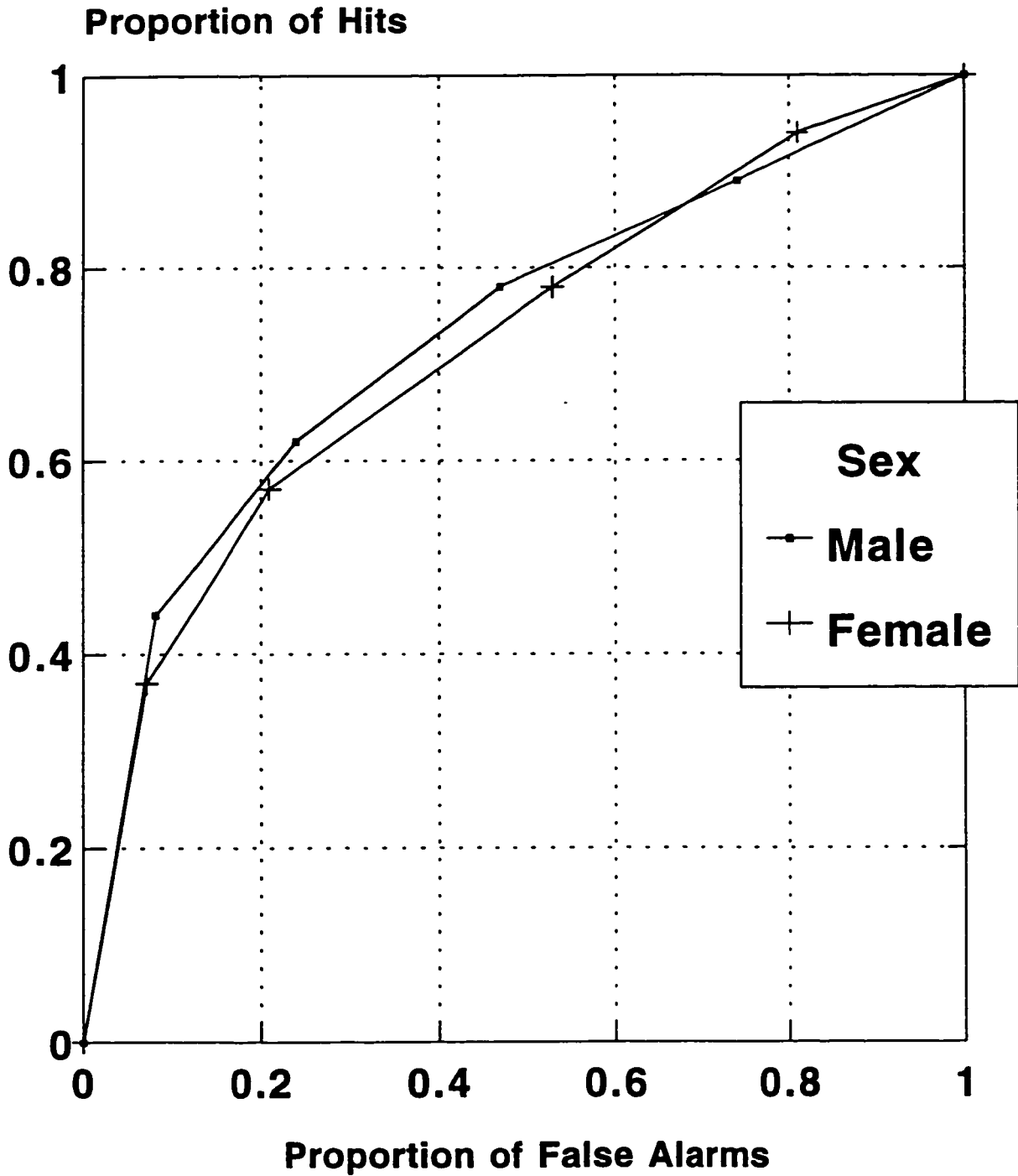
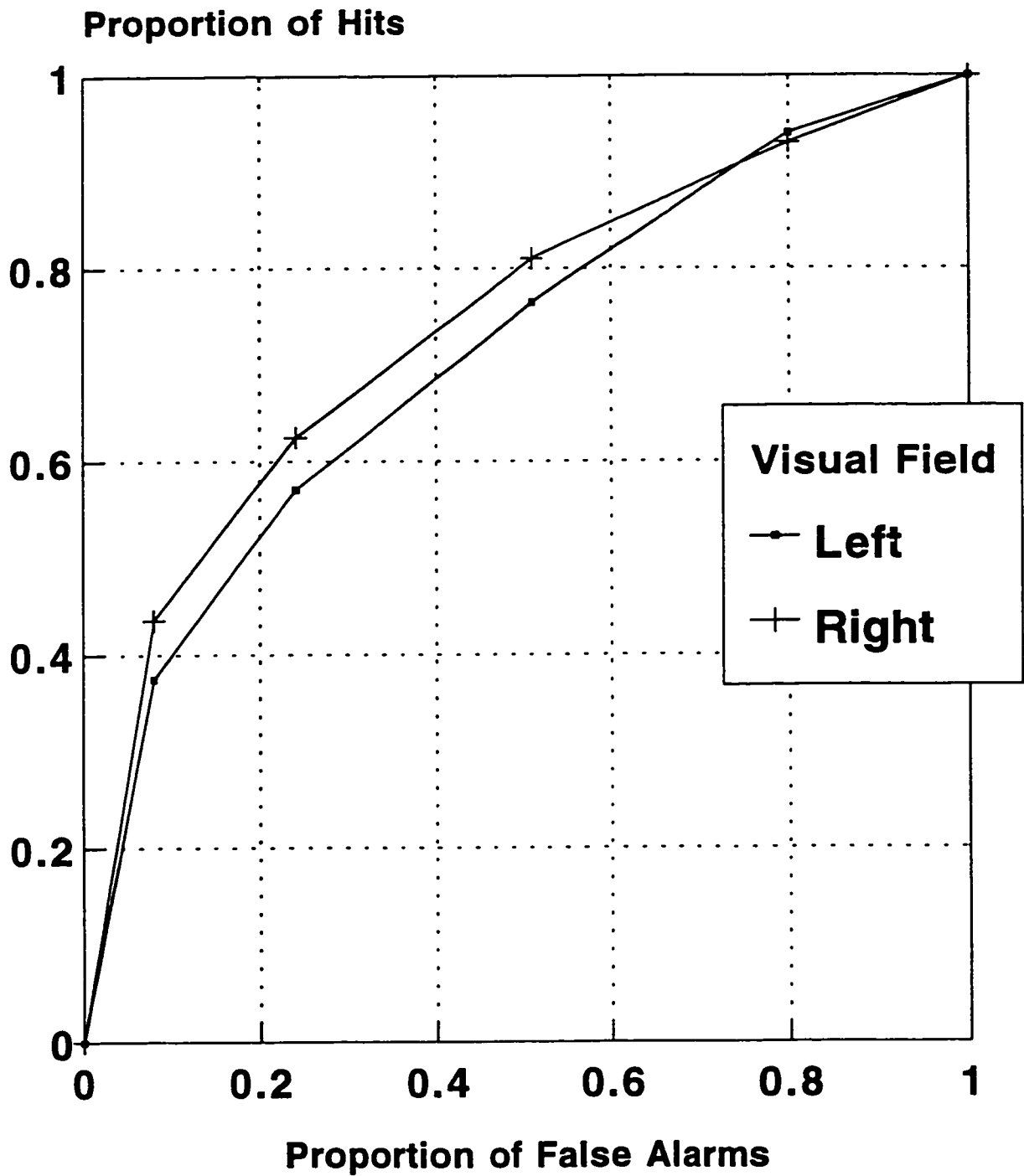


Figure 7:

Recognition Discriminability for Words Effect of Visual Field



DISCUSSION

This study investigated the effects of sex, visual field of presentation, and stimulus type on the delayed recognition memory for words and drawings. Based on prior studies, a number of predictions were made, namely that: (1) a significant interaction of sex and visual field would be observed, and more specifically, that males would display greater lateralization of function than females, (2) words would be better recognized when initially presented in the RVF, whereas drawings would be better recognized when presented in the LVF, (3) in accordance with the dual-coding hypothesis, concrete words and drawings would be better recognized than abstract items (4) assuming that the previous two hypotheses were supported, it was predicted that abstract drawings and words would show the greatest VFAs, with questionable lateralization effects for concrete items. In light of the obtained results, each of these hypotheses will now be addressed in turn.

Hypothesis 1:

As the only between-subjects variable, sex was expected to influence the outcome of recognition memory scores by increasing laterality effects in males. This predicted interaction between sex and visual field of presentation was not borne out in this study. Sex differences involving cerebral lateralization have not been consistently

replicated, and when found have been notably small in magnitude (Iaccino, 1993). It was therefore not entirely unusual that the predicted sex effect was not observed.

However, it is interesting to note that there was a non-significant tendency for males to discriminate drawings better than females. This finding may be related to prior studies suggesting that males may be slightly better at dealing with visuo-spatial material than females (McGlone, 1980).

Hypothesis 2:

In accordance with the generally accepted left hemisphere/verbal and right hemisphere/non-verbal dichotomy, the second hypothesis postulated that words and drawings would be better recognized when presented to the RVF and LVF, respectively. As one can see from the results, this hypothesis was clearly not supported for the drawings, and was only partially supported for the words.

The results for nonverbal stimuli (drawings) revealed no effects of visual field for either abstract or concrete drawings. Although this pattern contradicts a priori predictions, these findings are not surprising in light of inconsistent results in studies using nonverbal stimuli (see Davidoff, 1982). Our findings would therefore seem to

support the notion that both hemispheres are equally well equipped to deal with and recognize nonverbal material from memory. However, this conclusion may only apply to neurologically intact subjects, as studies evaluating individuals with right hemisphere dysfunction consistently show significant deficits in nonverbal memory (e.g., Jones-Gotman, 1986; Corsi, 1972).

The results for verbal stimuli only partly supported the hypothesis of a RVF advantage for words. Statistical analyses revealed a significant interaction between Visual Field of presentation and Word Type, with concrete words being the only group to display the expected RVF advantage. Abstract words showed no such VFA. Indeed, a review of the means indicated that recognition discriminability for abstract words in both visual fields to be practically identical.

There are a couple of possible methodological factors that may account for the lack of expected RVF-LVF advantages for verbal and non-verbal material. The first involves the possibility that increased delay may have somehow attenuated any lateralization effects. It is easy to picture how, assuming normal inter-hemispheric transfer, the process through which items are encoded into long-term store and eventually recognized may become less lateralized with a

delay. This would be particularly pronounced with neurologically intact individuals, where connecting fibres are presumed to be intact. However, if the initial encoding stage is affected, as may be the case with some brain-injured individuals, then it would seem plausible that lateralization effects would increase with time, as poor initial encoding and decreased access to working memory would negatively affect performance (e.g., Corsi, 1972, Jones-Gotman, 1986).

Second, the use of a recognition paradigm instead of recall in investigating the lateralization of memory functioning may also have affected the outcome. As well as generally being more effortful, studies using recall paradigms may differ from recognition studies in the underlying processes involved (Glass & Holyoak, 1986). Whereas recall demands the specific production and retrieval of items from memory "store", recognition requires the comparison of presented stimuli with possible matches in memory. In addition, subtle factors such as vague familiarity and/or decision criteria may have a greater influence on recognition. In other words, recall and recognition may involve different cortical areas at both the encoding and retrieval stages. Examples in the literature do suggest that clearer lateralization effects may be found using recall rather than recognition tasks (e.g., Juan de

Mendoza & Grosso, 1980).

Hypothesis 3:

As predicted by the dual-coding hypothesis, stimuli that can easily be stored in terms of both a verbal and a visual code (i.e., concrete words and drawings) should be better remembered than abstract stimuli that are generally encoded using a single code (either visual or verbal).

This prediction was clearly supported in the case of the drawings, as concrete designs were better recognized than the abstract designs regardless of the visual field of presentation. This finding is hardly surprising, however, as the lists of concrete and abstract drawings were from different sources. Unlike the words, variables such as familiarity or meaningfulness were not controlled in constructing the design lists.

The results concerning differences in recognition between concrete and abstract words are less clear. There was a significant main effect of Word Type, with the expected finding that concrete words were better recognized than abstract words. However, there was also a significant interaction between Word Type and Visual Field of Presentation indicating that concrete words presented in the RVF were better recognized than any of the other three

treatment combinations.

Hypothesis 4:

As an extension of the two previous hypotheses, it was postulated that lateralization effects would follow a predictable pattern, with abstract stimuli displaying greater lateralization effects by virtue of their limited potential for processing into both a verbal and a visual code.

The results of this study do not support this position in the case of the drawings, as there was no difference in laterality effects in relation to design type. These results are nevertheless consistent with past studies indicating no VFAs using either abstract forms or picture objects (Bryden & Rainey, 1963; Hines, 1978; Birkett, 1978; Nieto, Hernandez, Gonzalez-Feria, & Barroso, 1990; Christianson, Nilsson, Saisa, & Silfvenius, 1992).

For words, the opposite effect was demonstrated, as concrete words displayed the greatest VFAs. A RVF advantage was only observed for concrete words, a finding that runs contrary to the predicted trend. Although unusual at first glance, these results are similar to those reported by Christianson, Nilsson, Saisa, & Silfvenius (1992) for their normal control group. In spite of their finding that

words were significantly better recognized in the RVF overall, these authors reported a borderline significant interaction between visual field and word type, with concrete words presented in the RVF also being better recognized than all other groups.

The above findings are somewhat puzzling in light of neuropsychological findings suggesting that injury to the left hemisphere is followed by difficulty in dealing with abstract words (Christianson, Nilsson, Saisa, & Silfvenius, 1992; Coltheart, Patterson, & Marshall, 1980). However, it must be noted that in normal subjects access to both intact hemispheres would serve to minimize this difficulty, even when words are flashed in the LVF. One possible explanation for the above findings may lie in the "additive" nature of the verbal and visual codes in concrete words.

As predicted by the dual-coding theory, concrete words are best remembered because of easier access to both a verbal and a visual code. Initial presentation to the RVF may reinforce this advantage due to the preferential presentation of a verbal stimulus to the left hemisphere. Recall that memory retrieval based on semantic processing was also promoted by using different letter types (upper and lower case) in the encoding and recognition phases. As abstract words are not as easily encoded because of the lack

of an "additional" easily available visual code, they are generally not expected to be recognized as well as concrete words. In short, this type of explanation deals well with how a concrete word initially presented in the RVF would lead to better recognition.

Why then, are abstract words presented in the LVF recognized as well as concrete words? The answer may be two-fold. First, as mentioned previously, the task was biased towards a semantic retrieval strategy due to the different letter type used during the recognition phase. Increased semantic processing enhances the likelihood that memory for a predominantly verbal item (i.e., an abstract word) would be increased. Second, our findings seem to support the notion that increased delay in normal subjects may decrease lateralization effects, while at the same time increasing the effect due to word type. It is interesting to note that the study most closely resembling our own (Christianson, Nilsson, Saisa, & Silfvenius, 1992) reported a significant effect of visual field but not of word type, whereas the present study suggested the opposite trend. As well, both studies suggested at least a borderline significant interaction between visual field and word type, with concrete words presented in the RVF being better recognized than all other groups. The only obvious methodological difference between these two studies was the

addition of a delay in the present study, suggesting that the addition of a delay may have diminished lateralization effects while increasing the effect of word type.

Conclusions

The major aim of this study was to investigate the possible hemispheric asymmetries in delayed recognition memory using the lateralized presentation of lists of words and designs. The effects of other intervening factors such as sex and stimulus type on memory lateralization were also assessed.

Results revealed no clear visual field effects for either verbal or nonverbal stimuli, with the exception of a significant RVF advantage for concrete words. These results contradict predictions of a significant RVF advantage for words and LVF advantage for designs. However, there was a significant effect of stimulus type that seemed to support the dual-coding hypothesis. Concrete items were generally found to be better recognized than abstract ones, particularly in the case of drawings. However, the prediction that abstract drawings and words would show the greatest lateralization effects was not borne out. In fact, the opposite trend was found for words, with concrete words showing greater lateralization. No effect of sex on lateralization was found, but there was a non-significant

trend for males to perform better than females in the recognition of drawings.

There are a number of methodological factors that could have affected these findings. In particular, the addition of a substantial delay between the encoding and recognition stages may have attenuated any possible lateralization effects. Comparison with a similar study that used a much shorter delay suggested that a longer delay decreases lateralization effects while increasing the effect of stimulus type (abstract or concrete).

Evidence from patients with cerebral dysfunction using traditional memory paradigms has provided much clearer results suggesting lateralization of memory functioning in the two hemispheres. This study provided an attempt to mimic these findings in neurologically intact individuals using a comparable memory measure. The lack of clearly lateralizing findings would seem to suggest that hemisphere-specific memory functioning occurs in the earlier stages of processing, as increased delay in normal subjects resulted in decreased, and not increased, memory lateralization. Although studies using DVF techniques have proven relatively effective at identifying memory lateralization in brain-injured patients, they have not had the same success with neurologically intact subjects. Future investigations

should continue to investigate the relative importance of factors such as length of delay, recall vs. recognition paradigms, and stimulus type in normal subjects in order to better understand the effects of unilateral brain damage on memory.

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APPENDIX A

List of abstract and concrete words

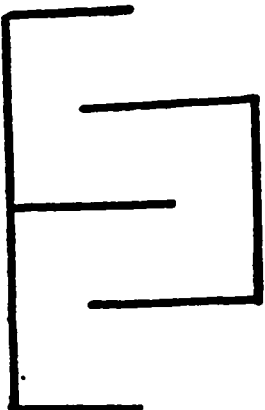
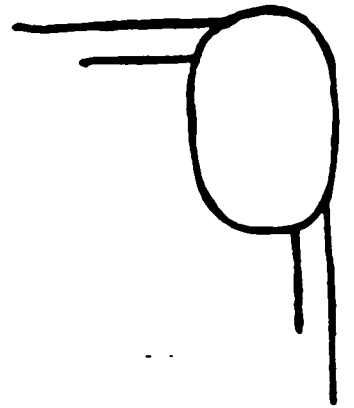
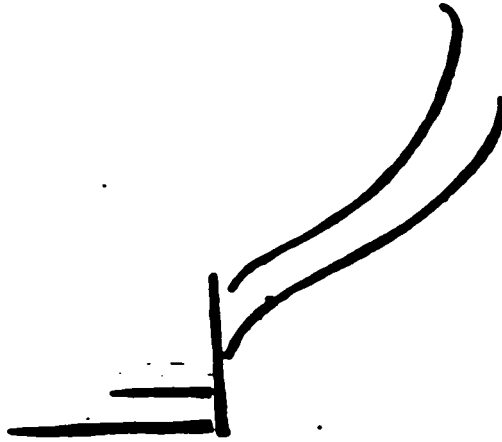
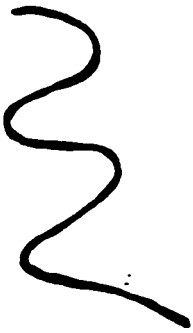
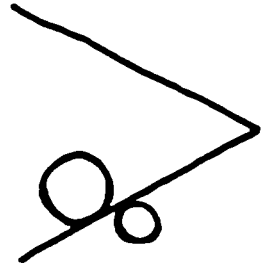
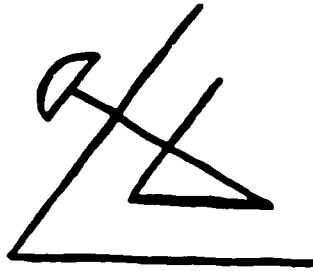
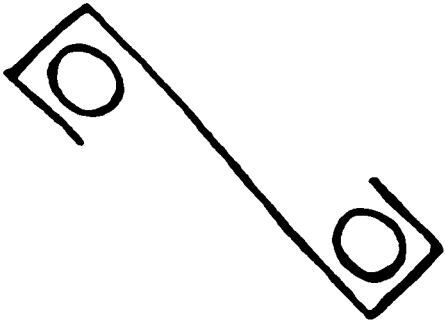
Abstract (Low-Imagery)
Words:

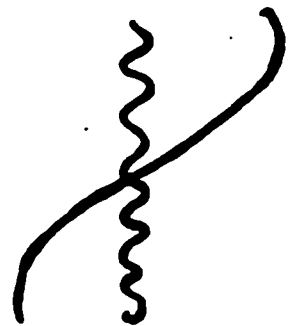
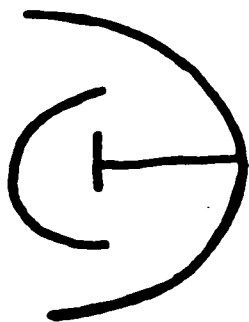
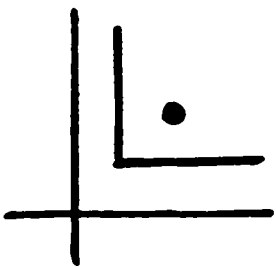
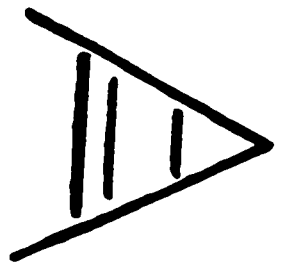
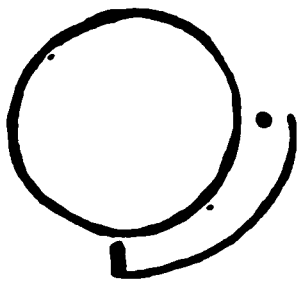
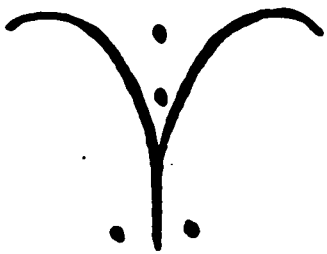
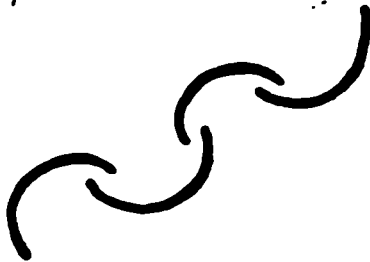
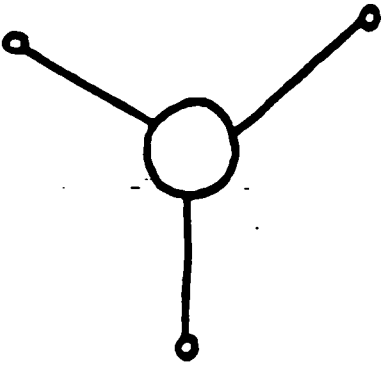
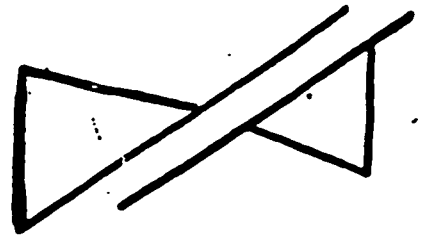
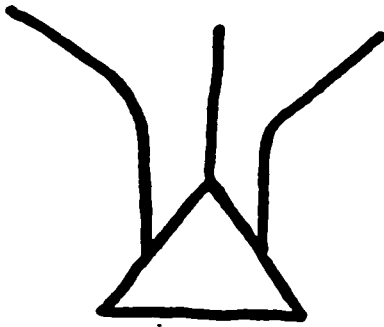
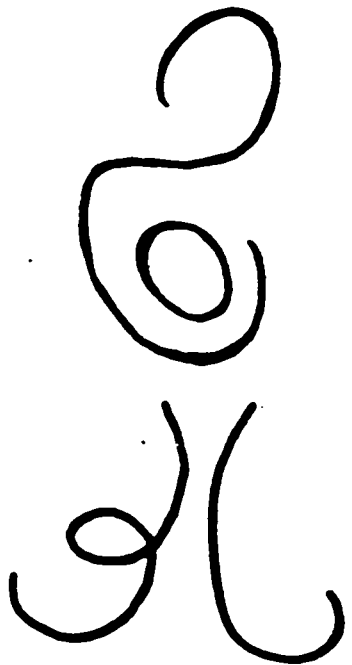
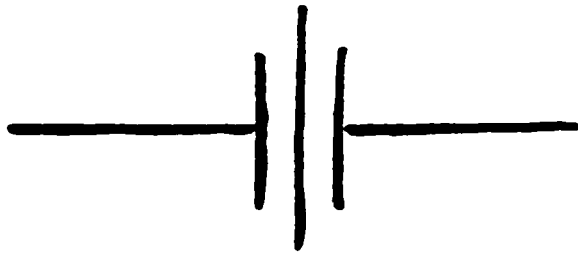
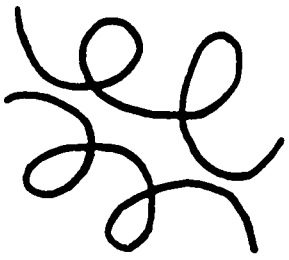
ADVICE
AMOUNT
ANSWER
BELIEF
CHANCE
COST
CUSTOM
DUTY
EFFORT
EVENT
FACT
FATE
HISTORY
HONOR
HOPE
HOUR
IDEA
JUSTICE
LAW
LENGTH
METHOD
MIND
MOMENT
OPINION
QUALITY
SILENCE
SOUL
SPEECH
SPIRIT
THOUGHT
TROUBLE
TRUTH

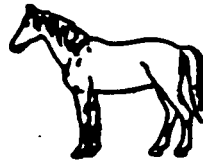
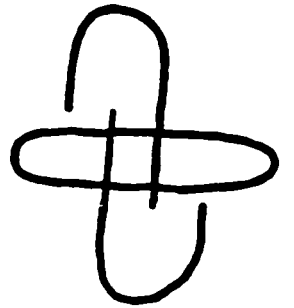
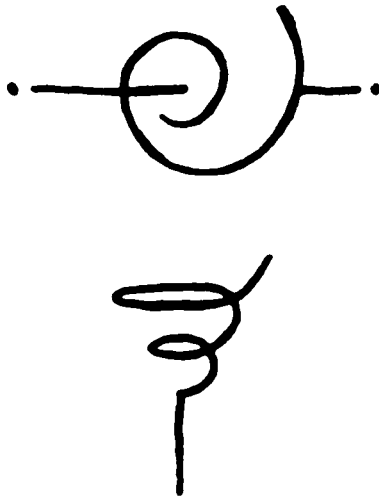
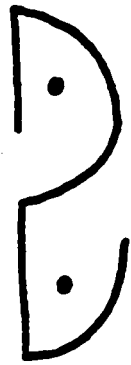
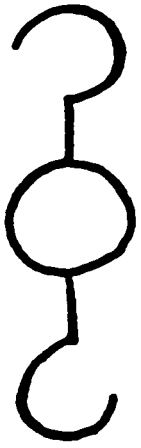
Concrete (High-Imagery)
Words:

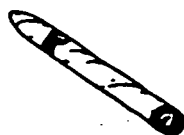
ACROBAT
ALCOHOL
BARREL
CAR
CORNER
ELBOW
ENGINE
FACTORY
FLASK
GALAXY
GARDEN
GIRL
HALL
HARP
HOTEL
HURDLE
INSECT
JOURNAL
LETTER
NAIL
PERSON
PIPE
POSTER
PROFILE
REPTILE
ROCK
SEAT
SKIN
STRING
TRIPOD
VEST
VILLAGE

APPENDIX B
List of abstract and concrete drawings









APPENDIX C

Table 4:

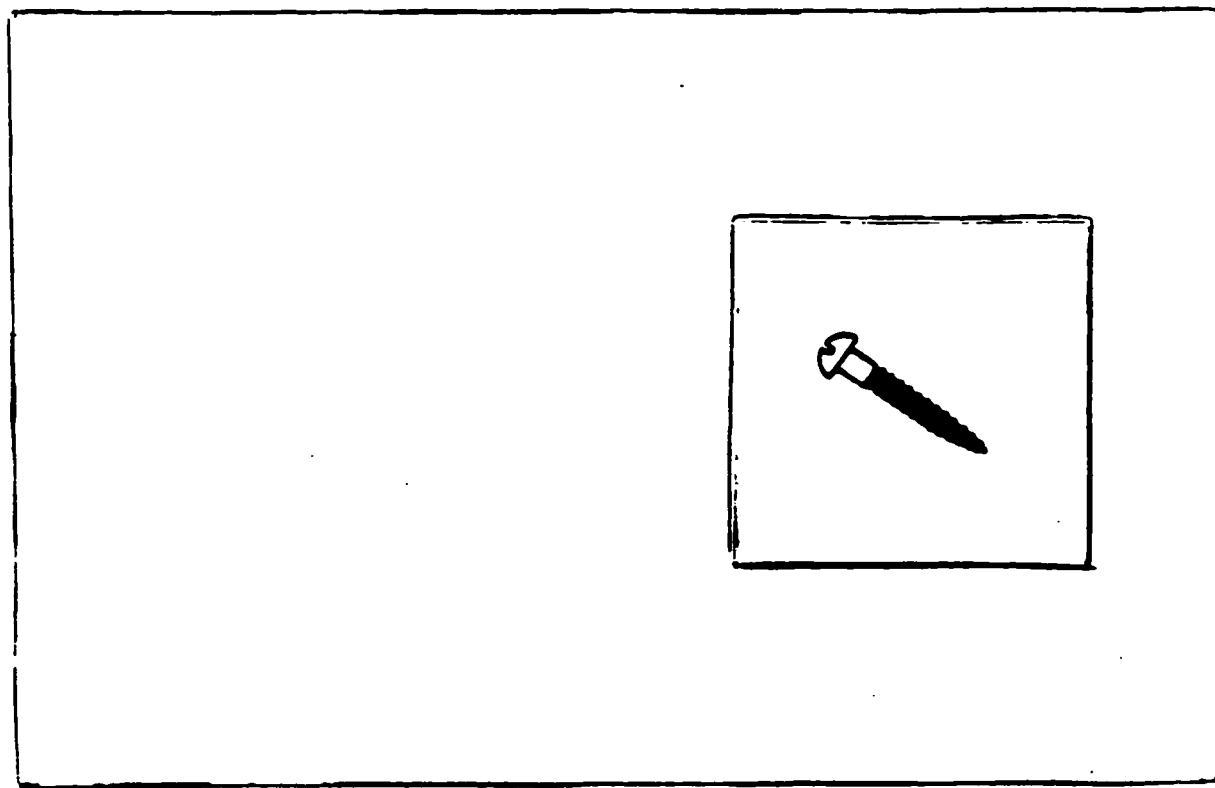
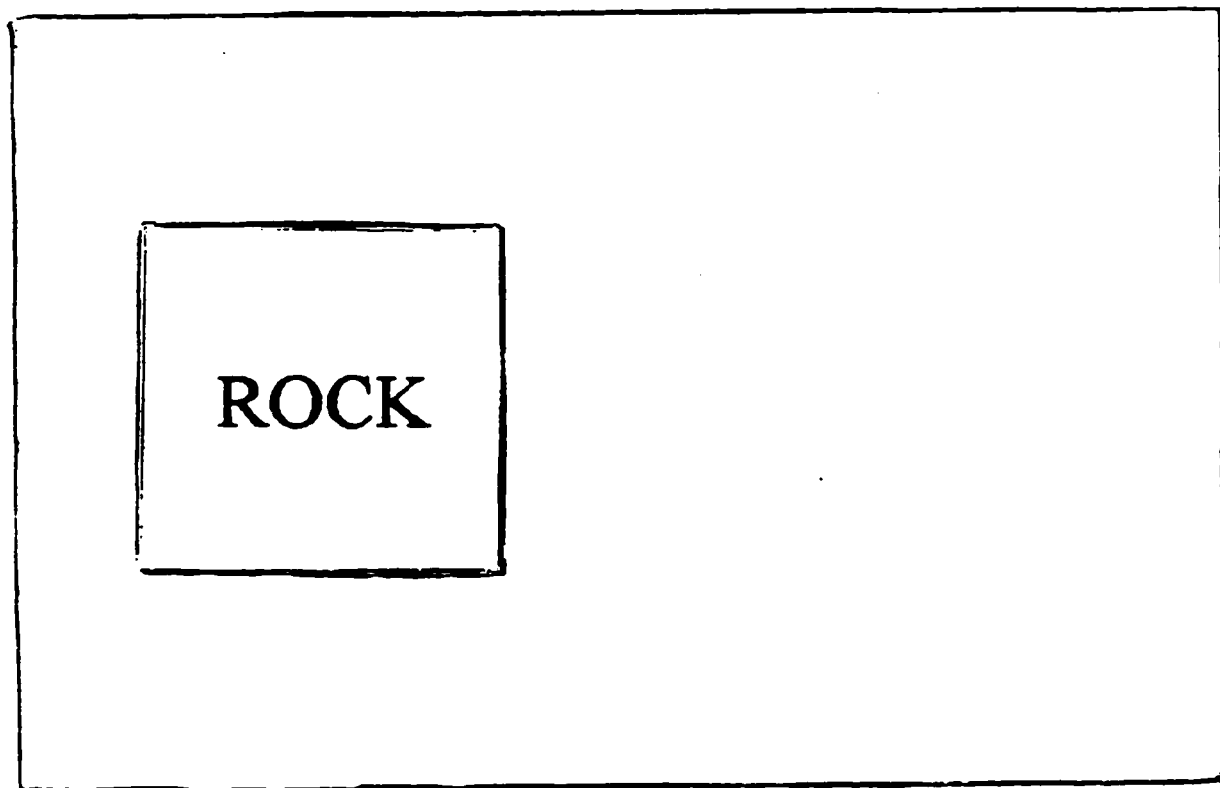
Effect on Performance due to Use of Hand for Button Press

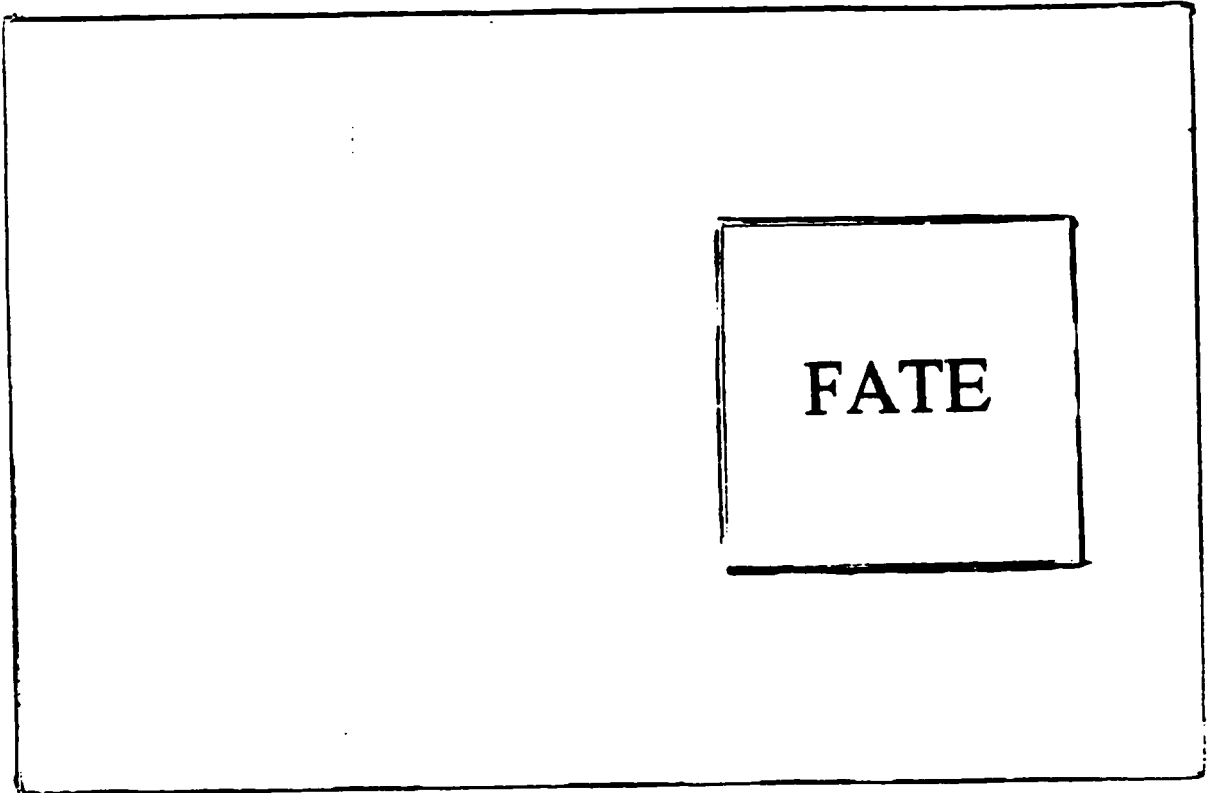
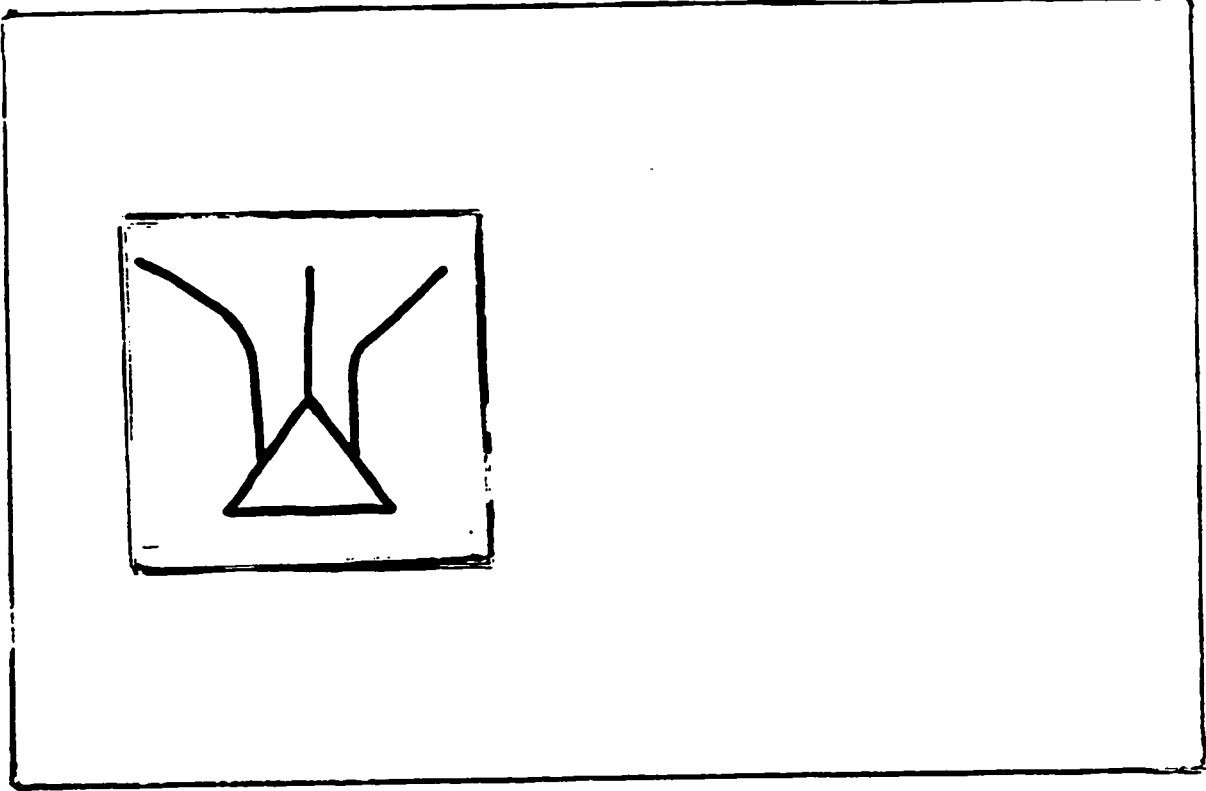
Hand for Button Press

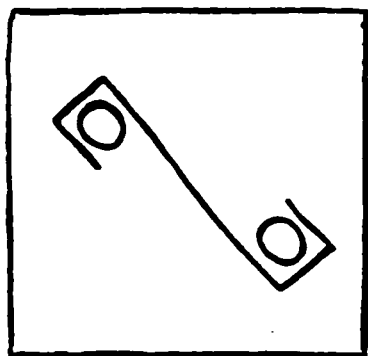
	Left Hand	Right Hand	F	p
<u>M</u>	76.48	75.42	0.28	0.598
<u>SD</u>	12.54	14.00		

Note. The values represent mean percentages of recognition discriminability of targets from distractors.

APPENDIX D
Examples of stimulus cards







history

APPENDIX E

Example of the Calculation and Plotting of the Recognition
Discriminability Index (A_g)

Calculation of A_g :

$$\begin{aligned}
 A_g = & ((x_1 * y_1) / 2) + (x_1 * y_2) + ((x_2 * y_2) / 2) + \\
 & ((x_1 + x_2) * y_3) + ((x_3 * y_3) / 2) + ((x_1 + x_2 + x_3) * y_4) \\
 & + ((x_4 * y_4) / 2) + ((x_1 + x_2 + x_3 + x_4) * y_5) + \\
 & ((x_5 * y_5) / 2)
 \end{aligned}$$

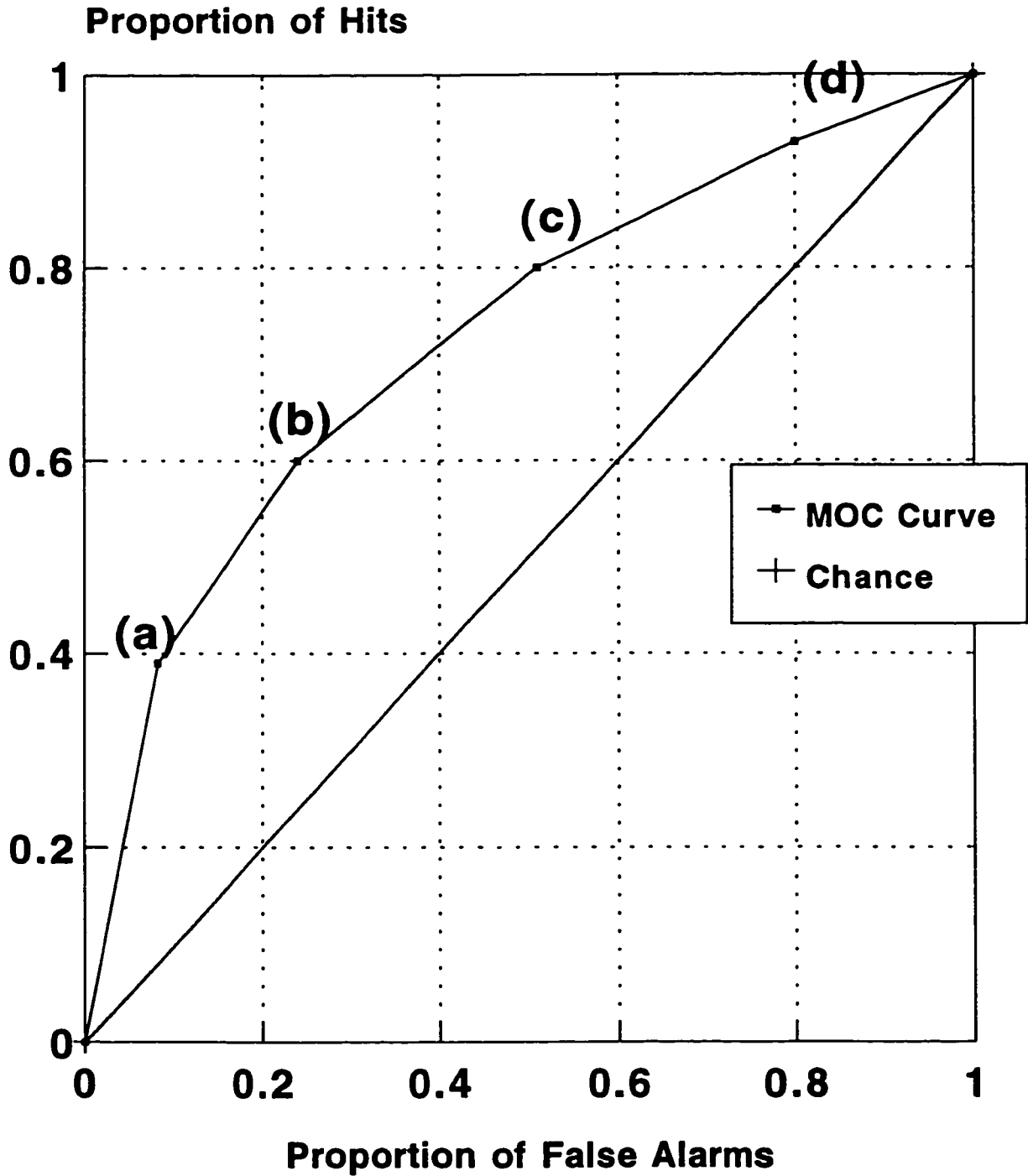
$$\begin{aligned}
 A_g = & ((0.39 * 0.08) / 2) + (0.39 * 0.16) + \\
 & ((0.21 * 0.16) / 2) + ((0.39 + 0.21) * 0.27) + \\
 & ((0.20 * 0.27) / 2) + ((0.39 + 0.21 + 0.20) * 0.29) + \\
 & ((0.13 * 0.29) / 2) + \\
 & ((0.39 + 0.21 + 0.20 + 0.13) * 0.20) + \\
 & ((0.07 * 0.20) / 2)
 \end{aligned}$$

$$\begin{aligned}
 = & 0.0156 + 0.0624 + 0.0168 + 0.1620 + 0.0270 + \\
 & 0.2320 + 0.0189 + 0.1860 + 0.0070
 \end{aligned}$$

$$= \mathbf{0.7277}$$

Figure 8:

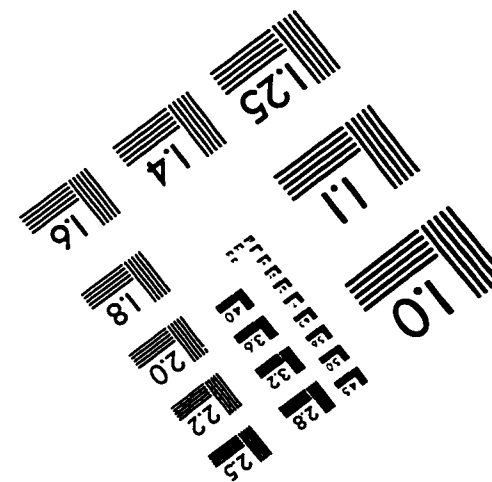
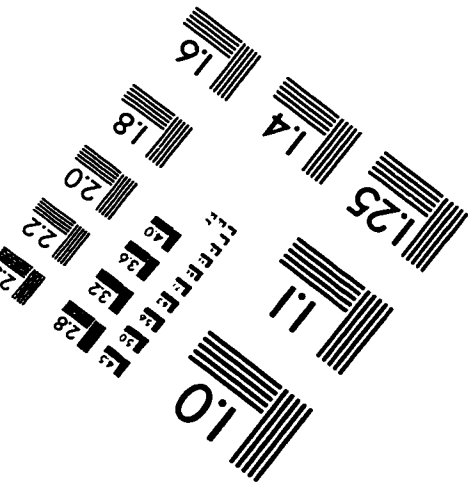
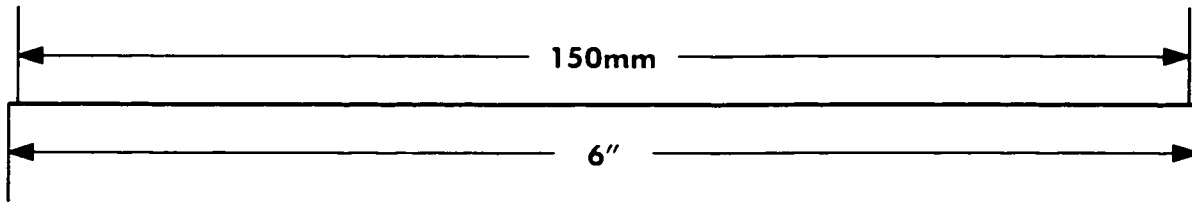
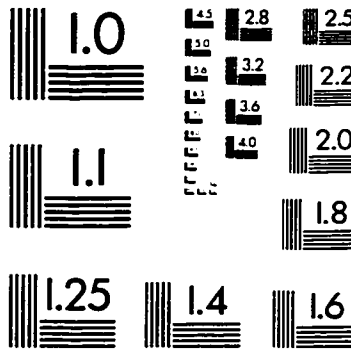
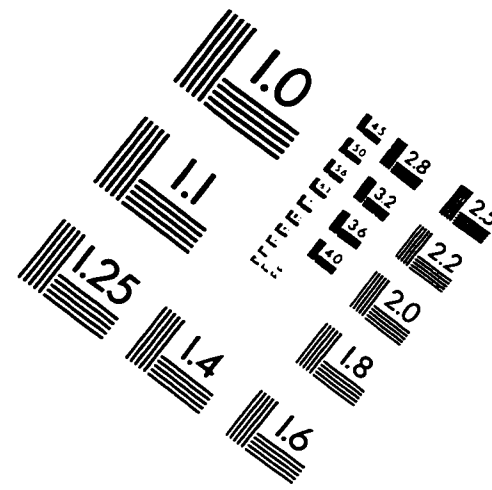
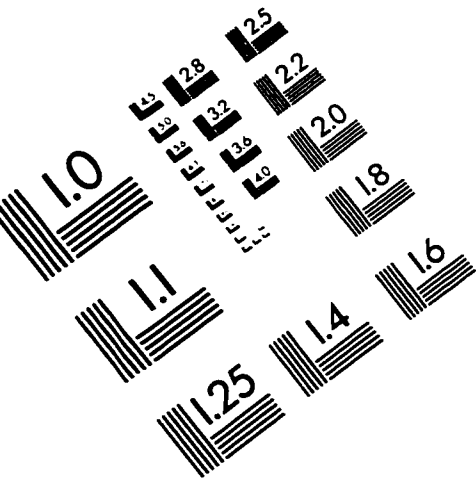
Example of the Isomnemonic Function Plotting the MOC Curve



VITA AUCTORIS

Stephan Kennepohl was born on October 28th, 1969 in Scarborough, Ontario. In 1986, he graduated from College Beaubois in Montreal, Quebec. He completed his DEC in Pure and Applied Sciences from John Abbott College in 1988. Following this, he attended McGill University, where he first developed and fostered an interest in neuropsychology. He graduated from McGill with a B.Sc. in Psychology in 1991, and for the next three years divided his time between two of his primary interests: neuropsychological research and travel. In 1994, he began his postgraduate degree in psychology at the University of Windsor. He is currently a candidate for a Master's degree in Clinical Neuropsychology, and hopes to complete his doctoral degree in neuropsychology at the University of Windsor.

IMAGE EVALUATION TEST TARGET (QA-3)



APPLIED IMAGE, Inc
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