MODIFICATION OF THE COMPLEX FIGURE TEST
AND THE EVALUATION OF AGE AND SEX DIFFERENCES IN VISUAL MEMORY

By

Philip Stephen Fastenau

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Psychology

1993

ABSTRACT

MODIFICATION OF THE COMPLEX FIGURE TEST AND THE EVALUATION OF AGE AND SEX DIFFERENCES IN VISUAL MEMORY

By

Philip Stephen Fastenau

Recognition and matching trials were designed for the Rey-Osterrieth Complex Figure Test (CFT) to help clinicians differentiate construction, perception, encoding, consolidation, and retrieval functions in visual-spatial memory performance. The trials were used to examine age and sex differences in visual memory using 90 community-dwellers (equal numbers of men and women in all but one quinquennium, ages 30 to 80). Alpha was set at .001 for all analyses to control experimentwise Type I error.

The Recognition Trial has 30 multiple-choice items for different elements of the figure. Alpha reliabilities were .84, .61, .59, and .66 for the Total, Global, Left Detail, and Right Detail scales, respectively. Total Score correlated .71-.74 with CFT recall and .50-.57 with Visual Reproductions (VR). Subscale design was confirmed by factor analysis, and Total Score loaded on visual-spatial memory factors. Scores distributed normally with strong item-total correlations and item difficulties.

The Matching Trial has 10 multiple-choice matching-to-sample items. Alphas were .58, .40, and .08 for the Total, Right Detail, and Left Detail scales. Total Score correlated .39 with VR Matching and .46 with Judgment of Line Orientation. Zero-variance items precluded analysis of the subscale structure. Total Score loaded on broad cognitive factors which included visual-spatial perception. Test scores were skewed

negatively, and item difficulty indices were low; corrected item-total correlations were moderate.

These tests and others helped determine whether reduced attention capacity explains age-related decline in secondary memory. On auditory-verbal memory, no age effect was observed on consolidation; encoding/storage varied by age, but the effect was due entirely to attention deficits; only retrieval showed age differences that could not be explained by attention. On visual-spatial memory, no age effects were observed in encoding/storage, consolidation, or retrieval after perception and construction were controlled. Consequently, older memory may best be sharpened by increasing attention capacity and using visual imagery.

Finally, men outperformed women on CFT Immediate recall only ($\underline{r}^2$=.09). This result adds to many inconsistent and small sex differences in visual-spatial memory research.

DEDICATIONS

This work is dedicated to the glory of God in the name of my Lord and Savior Jesus Christ. I also dedicate this to my parents, Doris P. Fastenau and the late Rev. Emmett H. Fastenau, who have always encouraged me to learn and grow, and to my brothers and sisters who have supported me in every possible way throughout my graduate training. This is further dedicated to my wife, Dana Atkinson Fastenau.

Finally, this dissertation is dedicated to all of my many mentors in life, but especially James F. "Mr. D" DeBruhl, E. Keith Bramlett, Michael J. Fimian, Kenneth D. Jenkins, Norman Abeles, and Lauren Julius Harris.

ACKNOWLEDGMENTS

I recognize Alexander A. Manning and the staff/administration of Broughton State Hospital, Morganton, North Carolina, for their support in the pilot study; Jane Holmes Bernstein for her review of the original recognition items; Natalie L. Denburg for her close collaboration on this study and on related projects; Norman Abeles, Lauren Julius Harris, Neal Schmitt, and Bertram Karon for their invaluable contributions to the design of the standardization study and the interpretation of these results; Lidia A. Domtrovic and Michael J. Finton for testing some of the subjects in the standardization sample; Linda E. Sloan, Eric A. Fertuck, and Jennifer Winer who provided substantial clerical assistance in the standardization study; the APA Science Directorate for partially funding the standardization study with a research award; Aaron Beck, The Psychological Corporation, and Consulting Psychologists Press for subsidizing the testing materials; and Roger Halley for his resourcefulness in supporting this research. I also appreciate the participation of the members of Holt Church of the Nazarene, Holt, MI; Our Savior Lutheran Church, Lansing, MI; Saint Luke Lutheran Church, Haslett, MI; and the Shaarey Zedek Congregation, East Lansing, MI. Finally, I am indebted to my wife, Dana Atkinson Fastenau, for her loving support and encouragement.

TABLE OF CONTENTS

LIST OF TABLES

FIGURE

INTRODUCTION

Although there are many clinical instruments for assessing visual-spatial memory, all of them have limitations. In this investigation, I modify one of those tests, the Complex Figure Test (CFT), to be a more comprehensive tool for clinical assessment and for the theoretical investigation of memory functions. This project had three purposes. First, I designed supplementary trials for the CFT and examined their psychometric properties using a sample of 90 healthy, community-dwelling adults ages 30-80.

Second, as an application of the modified instrument, I used it to test a hypothesis about memory decline in advanced age. It has been observed that the ability to learn new information (secondary memory) declines with age, beginning in the 50s and becoming more evident in the 60s (Albert, 1984; Poon, 1985). This decline in secondary memory parallels age-related decline on some measures of attention. Because secondary memory involves effortful processing, it was hypothesized here that age-related decline in secondary memory is mediated, at least in part, by age-related declines in attentional resources. After controlling for age-related decline in other cognitive abilities that contribute to memory performance (perception and production), I used the modified CFT to decompose secondary memory performance into three putative processes (encoding/storage, consolidation, and retrieval) in each of two modalities (auditory-verbal and visual-spatial).

Finally, because some sex differences have been observed on some visual-spatial tasks, the performances of men and women were compared on the CFT data. The measurement of age and sex differences was also used to guide stratification of norms for the extended CFT for clinical use.

RATIONALE FOR MODIFYING THE CFT

The Complex Figure Test (CFT; Rey, 1941; Osterrieth, 1944) was designed to measure both perceptual organization and visual memory in brain-injured persons (Lezak, 1983). It is a standard component in many neuropsychological batteries (Kaplan, 1988; Lezak, 1983; Squire, 1986; Weintraub & Mesulam, 1985). In the administration of this test, individuals are asked to copy a complex geometric stimulus (Figure 1) on a blank sheet of white paper using five or six colored pens, which are presented one at a time by the examiner. The examiner can track the subjects' constructional approach by listing the sequence of lines as they are drawn; perceptual organization is inferred from the type of constructive procedure employed by the subjects during the copy production. The examiner also notes the time that lapsed between start and finish. Immediately following the copy trial, the stimulus and copy are removed. The examiner provides a new blank sheet and asks the subjects to draw the image from memory (immediate recall). After 20 to 60 minutes, the memory trial is repeated (delay recall); the length of the delay is inconsequential within these limits (Lezak, 1983).

Research and clinical applications of the CFT have shown it to be sensitive to certain neuropsychological functions. For example, Waber and Holmes (1985, 1986) used the instrument with children to describe developmental patterns in organization and construction. The CFT has also been used with adults, not only to differentiate brain-injured

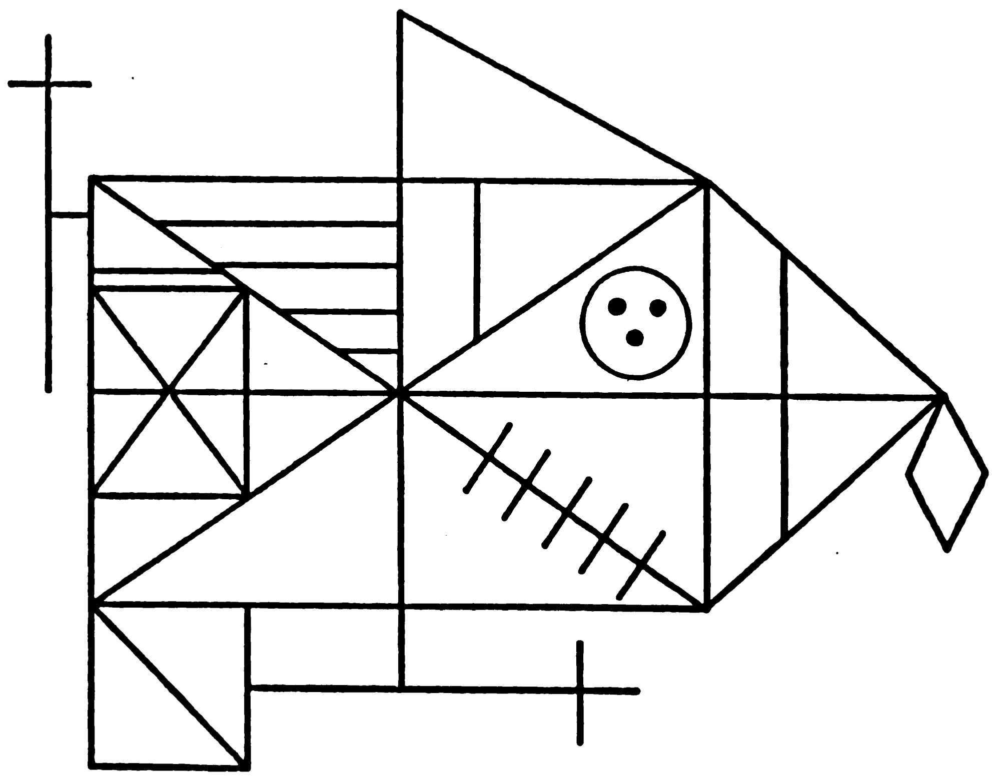


Figure 1. Complex Figure Test stimulus. Reproduced with permission of Swets & Zeitlinger BV, The Netherlands.

groups from nonimpaired comparison groups but also to differentiate between groups with different pathologies. Such studies have demonstrated some correspondence between the location/type of neurological insult and certain characteristic patterns of fragmentation, neglect, rotation, and distortion on this task (Binder, 1982; Brouwers, Cox, Martin, Chase, & Fedio, 1984; Kaplan, 1988; Lezak, 1983; Milberg, Hebben, & Kaplan, 1986).

Limitations of the CFT

Although the CFT can be an invaluable tool in the neuropsychologist's repertoire, it has limitations. First, its dependence on constructional ability can confound interpretations regarding memory. Individuals who have trouble drawing the figures in the copy trial are destined to score low on the immediate and delay memory trials. For example, among neurological patients with hemiparesis or with apraxia, low memory scores may be indicative of drawing or construction limitations only, thereby masking intact visual memorization skills. To circumvent these obstacles, supplementary measures of visual memory should be included that are independent of complex motor responses; alternative approaches should allow for a pointing or even spoken response.

Second, in its present use, the test does not discriminate between encoding and post-encoding deficits. For patients with low memory scores, the problem may be getting information into memory (encoding/storage) or making the memory trace more permanent (consolidation) or accessing it later (retrieval). There is evidence that the encoding and post-encoding processes are independent of one another or that they at least operate upon different types of information (Craik, 1979). This has been observed in developmental research comparing the efficiencies of these processes at different ages (Craik & McDowd, 1987; Howe & Hunter, 1985) and in research with learning disabled children (Howe, O'Sullivan, Brainerd, & Kingma, 1989). Because a recognition task provides additional cues to facilitate retrieval, comparisons between free recall and recognition performances clarify the relative contributions of encoding and post-encoding processes to total memory performance. Consequently, it is important to include a measure of recognition as well as a measure of free recall.

Jacoby (1984) argued against separate assessment of the three processes (encoding, storage, and retrieval), proposing instead that there are no differences between stages with regard to the <u>type</u> of processing; strategies, if employed, are active and elaborative irrespective of the stage at which they are invoked. Differences in types of amnesias, he claims, are due to whether the patient engages such processing at one or all stages. This explanation supposedly casts the focus away from individual stages and onto a comprehensive metamemory (that is, the executive regulation of memory processes). However, Jacoby's argument is deceptive; although his revised paradigm looks parsimonious, the fact that some patients spontaneously apply elaborative processing at one stage and not another underscores the necessity for examining each of the stages.

In addition to its theoretical significance, the assessment of processes at different stages has clinical relevance. First, in rehabilitation settings, the specific nature of the deficiency--encoding versus post-encoding--can have important implications for intervention.

Second, including both recall and recognition measures increases the diagnostic sensitivity of the memory test:

> Failure to recognize words [or figures, in the case of nonverbal memory] as having been previously presented is a more reliable sign of memory disorder than failure to recall, and recognition failure denotes a more severe disorder as well. The use of recall and recognition tests together makes it possible to detect subtle, early signs of impairment (Squire, 1986, p. 280).

Clinical Remedies

Alternative Measures of Visual Memory

To address these problems of visual memory, clinicians may use nonverbal memory tests other than the CFT. These measures, however, have their own shortcomings when sensitive memory evaluation is the goal. One of these measures was devised by Kimura (1963). The task effectively discriminated left- from right-temporal patients. Unfortunately, the nature of this task (purely a recognition measure) precludes an assessment of recall, without which the relative efficiencies of encoding and post-encoding processes cannot be compared.

Another recognition task, originally developed for non-human primates, was modified for clinical use with dementing patients. The Delayed Recognition Span Test (DRST) measures recognition across five types of stimuli: verbal, spatial, color, pattern, and faces (Moss, Albert, Butters, & Payne, 1986). Despite the advantages of testing so many relevant stimulus domains, this instrument--like the Kimura test--does not include a recall component.

The Benton Visual Retention Test (BVRT; Benton, 1974) is similar to the CFT. Like the CFT, however, it measures only recall and requires the subjects to draw their responses. The BVRT has also been criticized for the simplicity of its stimuli (Hemsley, 1974; Lezak, 1983). It has been found that simple visual images are frequently encoded in verbal concepts (Reed, 1974). Many investigators have argued that the BVRT stimuli, in particular, are susceptible to verbal encoding so that recall performance on this task is not necessarily a pure measure of visual memory. In fact, BVRT scores improve with language recovery in aphasics (indicative of verbal mediation); in addition, performance on this test correlates more with measures of constructional ability than with measures of memory (Erickson & Scott, 1977; Lezak, 1983). Consequently, although this test is not without diagnostic utility, evidence that it can measure and differentiate visual memory processes is equivocal.

Finally, the most widely used measure of visual memory besides--or in addition to--the CFT is the Wechsler Memory Scale. The revised form (Wechsler, 1987) contains two subtests of visual memory. The Visual Reproductions subtest (VR) involves studying geometric stimuli and then recalling (i.e., drawing) them from memory. There is no recognition component for this subtest. A second subtest, Figural Memory (FM), uses abstract stimuli in a recognition paradigm but without a measure of recall. Ideally, however, one would like to know, for a given stimulus, how much is available for recall and how much can then be recognized; when the two tasks are conducted on separate stimuli, the two processes cannot be analyzed in relation to one another.

Kaplan (1988) designed an unpublished recognition task to be a supplement for the Visual Reproductions subtest. That task was intended to accomplish the same objectives of the present study, except by modifying the WMS rather than the CFT:

> Examining a patient's visual reproductions in this manner obviously can be very helpful in determining the impact that such factors as

> encoding, retrieval, visuomotor ability, and perceptual functioning have on performance. Thus if a patient fails to adequately reproduce a design that he or she has just seen but can recognize it and has no problem copying the design except for a segmented approach, a retrieval problem secondary to deficient encoding may be postulated. If a patient's impaired recall, copy, and delayed recall are all comparably flawed, but both multiple choice recognition tests [one following immediate recall and one following delayed recall] are unimpaired, one may assume that visuomotor dysfunction is implicated rather than a memory problem (Kaplan, 1988, p. 146).

The WMS-VR, however, is inadequate, even when the unpublished recognition items are added. First, the stimuli are too simple. Consequently, they are likely to be coded verbally (Reed, 1974); it is not surprising, therefore, that this subtest has consistently loaded on a factor with two verbal tasks in the battery, Logical Memory and Paired Associates (Wechsler, 1987), possibly reflecting patients' tendency to use verbal labels. The simplicity of the figures may further compromise the usefulness of these tests by insufficiently taxing the upper range of visual memory capacities. Palmer (1977) reported that

> with more complex figures and/or more demanding tasks, many more levels [of perceptual organization and processing] may be required. The requirement of multiple levels of structural units rules out standard template or iconic forms of representation, since only one level of functional unit is defined for a pattern. It also rules out any feature-list representation that has only one level of structural features (p. 469).

Gazzaniga and LeDoux's (1978) evaluation of clinical data echoed Palmer's conclusions. "The interpretation here would seem to be that both the left and right half-brains have substantial capacities for visual recognition, with the right excelling mainly where the upper perceptual limits are tested" (p. 68). Therefore, with simple stimuli, processes in the left hemisphere may compensate for, and thereby disguise, any impairment of the right hemisphere.

Other findings confirm these speculations. King (1981) found very modest relationships between "percent recall" scores (% recall = delay recall score / copy score x 100) for the WMS-VR and the CFT (*r* = .22). This supports the hypothesis that the two instruments measure the domain differently, most likely because of the difference in stimulus features (i.e., the complexity of the CFT figure).

A second weakness of the WMS-VR is the small number of items in Kaplan's unpublished recognition task; there are only four items for immediate recall and four for the delay trial. Although this may suffice as a rough screening, it may be insufficient for diagnosis and treatment planning.

Inferences from Other Memory Tests

Another way to address issues of visual encoding and post-encoding processes is to draw inferences from tests other than visual memory measures. This can often be inconclusive, however, particularly if the measures of retrieval deficits are designed for verbal stimuli. The reason is that memory for verbal material (processed primarily by the language-dominant hemisphere of the cerebral cortex, usually the left) is largely dissociated from nonverbal memory (which appears to be localized predominantly in the opposite hemisphere, usually the right). Although some language functions are subserved by the right hemisphere, testing with commissurotomy patients reveals short-term verbal memory deficits when information is presented only to the right hemisphere (Zaidel, 1985). In addition, research with epilepsy patients undergoing unilateral temporal lobectomies indicates that left temporal damage selectively impairs verbal memory whereas right-temporal damage impairs nonverbal memory (Milner, 1971, 1975, 1978; Rausch, 1985; Taylor, 1969).

This suggests that strengths or weaknesses in verbal learning and/or retrieval may be unrelated to nonverbal memory functions.

Furthermore, the study by Moss et al. (1986), cited earlier, demonstrated how memory dysfunction can be quite modality-specific, beyond simple auditory-verbal and visual-spatial distinctions. On the DRST, Huntington's disease patients were unimpaired on measures of verbal material despite memory loss across four types of nonverbal stimuli; this feature, in fact, distinguished this form of dementia from Alzheimer's and alcoholic Korsakoff's syndrome. Consequently, assessment across modalities is paramount for sensitive neurodiagnostics, and nonvisual measures cannot be used to describe processes of visual memory.

Extended CFT: A Synthesis of Assets

This discussion has demonstrated that any neuropsychological battery needs a test of visual-spatial memory that: (1) is modality-specific, (2) employs a complex stimulus, (3) includes not only a measure of free recall but also a recognition task with enough items to be discriminating, and (4) includes a matching trial to verify accurate perception of the memory stimuli. In this project, recognition and matching trials were developed to supplement the Rey-Osterrieth CFT. Because the design of these instruments and their validation derive from a neuropsychological model, a brief description of neuroanatomical correlates follows.

NEUROANATOMICAL CORRELATES OF RELEVANT COGNITIVE BEHAVIORS

Neuropsychologists attempt to relate behavior to neurological substrates. The data come from clinical, developmental, and animal neurosciences, with ongoing efforts to integrate these areas (e.g., Heilman & Valenstein, 1993; Mesulam, 1985b; Olton, Gamzu, & Corkin, 1985; Squire & Butters, 1985). More and more efforts are underway to compile findings from <u>all</u> domains in which memory phenomena are studied, not only from the neurosciences but also from cognitive, developmental, and social psychology (Solomon, Goethals, Kelley, & Stephens, 1989).

The recognition and matching tasks under development are intended for use with neurologically impaired patients as well as for understanding memory changes in older adulthood. The rationale for designing these two tasks derives predominantly from neuropsychological models of cognition and from research with clinical populations. Consequently, a review of that research will be included here, even though hypotheses with neurological patients will not be tested here.

The brain is divided into many anatomical regions based on topographical features, histological distinctions, and functional relationships. Some of these regions are specialized; that is, they exercise primary control over certain behaviors and process certain kinds of information more efficiently than other regions. The following review is not intended to be an exhaustive account of functional neuroanatomy. Rather, it encompasses those findings that are relevant to the threefold purpose of this project: developing recognition and matching trials for the CFT, assessing the role of attention in age-related memory decline, and examining sex differences on the CFT.

Performance on the CFT involves attention, perception, construction, and memory (encoding/storage, consolidation, and retrieval processes of secondary memory). Because language mediation has been implicated in the memorization of simpler visual stimuli, it too is described in the model that follows.

Perception

Perception is the interpretation of a sensation, the ascription of meaning or identity to a sensory stimulus. Each of the senses has a discrete unimodal locale in the cortex where sensory data from that modality are first processed consciously (usually after coursing from the sensory organ through relay nuclei in the thalamus). For each of the senses, there are unimodal primary and secondary areas and a unimodal association area on the cortex. Primary and secondary areas register the physical attributes of the stimulus (e.g., wavelength, amplitude), and the unimodal association area for that sense attaches meaning to the pattern of firing (e.g., "blue," "bright"). In addition, there are multimodal areas where perceptual data from several unimodal association areas are integrated (Barr & Kiernan, 1988; Mesulam, 1985b).

Visual sensation is represented in V1 and V2 (Brodmann areas 17 and 18, respectively) along the calcarine sulcus of the occipital lobe; visual perception is achieved by the adjacent visual association cortex (VA, area 19). Somatosensory information is first registered in S1 and

S2 (areas 1, 2, and 3), just posterior to the Rolandic sulcus in the anterior parietal lobe; interpretation of those sensory data is achieved in SA (area 5). Auditory data are first consciously recorded among the cells of the anterior transverse temporal gyrus (Heschel's gyrus, A1 and A2, areas 41 and 42) and interpreted in Wernicke's area on the planum temporale (AA, Area 22). Primary gustatory information projects to orbitofrontal cortex, just anterior to the insula, and olfaction projects to the piriform cortex. Both of these senses have association cortex in the paralimbic regions (Barr & Kiernan, 1988; Mesulam, 1985b).

In addition to the unimodal association areas that correspond with each of the primary sensory areas in neocortex, there are two prominent heteromodal association areas where information from several unimodal association areas is exchanged and integrated with other forms of processing such as language, memory, and motor movement. One of these areas is located at the juncture of the temporal and parietal lobes, primarily comprised of the angular and supramarginal gyri (areas 39 and 40, respectively). Another prominent multimodal area lies in the prefrontal cortex and encompasses Brodmann areas 8, 9, 10, 11, 12, 45, 46, and 47. This area integrates perceptual, motor, and processing functions to achieve the higher-order intellectual behaviors characteristic of humans (Barr & Kiernan, 1988; Mesulam, 1985b).

As a final organizational principle, visual and somesthetic sensation and perception are represented contralaterally on the cortex. Stimuli in the right visual field of each eye project to V1 and V2 in the left hemisphere, whereas stimuli in the left visual fields project to the right hemisphere. Similarly, somesthesis from the right side of the body projects to S1 and S2 in the left hemisphere; left-side afferents cross to the right hemisphere. Audition is less lateralized, due to substantial bilateral projections and to commissural connections between the inferior colliculi (Barr & Kiernan, 1988; Mesulam, 1985b).

A lesion anywhere in the circuit between the sense organs and the primary sensory area can result in unawareness of contralateral sensation despite appropriate reactivity by the sense organ itself. In vision, this is sometimes called "cortical blindness." A lesion of the unimodal association area or of the projections between unimodal and heteromodal association areas ("disconnection") may result in some forms of agnosia, an inability to identify the stimuulus or to appreciate its significance despite an accurate description of the physical properties of that stimulus (Bauer, 1993). Lesions involving the temporo-parietal heteromodal association area can result in a variety of disorders of perception and orientation (Mesulam, 1985b; Damasio & Anderson, 1993).

The integrity of these primary, secondary, and association areas is critical to effective performance on the CFT. Pillon (1981; in Lezak, 1983) reported that individuals with parietal-occipital pathologies displayed profound deficits in spatial organization, which were ameliorated by the provision of reference points to guide their drawings. There remains a question as to whether such deficits in perception and organization (manifest not only in the copy trials but also in the recall trials) hinder encoding of the stimulus in memory. This issue may be better addressed with the use of a recognition task.

Attention

Two theories of attention based on clinical case studies and experimental animal research have converged on a coherent, albeit gross, neuropsychological model of attention. A third theory, which derives from cognitive neuroscience, leads to a rather different model. Similarities between the models suggest that there are some reliable principles to the organization of attention; the many differences in definitions and substrates demonstrate that our conceptualization of these phenomena is still very primitive.

As described above in the "Perception" section, visual, auditory, and somatosensory inputs project via thalamic nuclei to the primary sensory cortices, then to unimodal association cortex, and finally to multimodal association cortices in the temporoparietal and prefrontal regions. These multimodal association areas, in turn, have extensive connections to the inferior parietal lobule and the cingulate gyrus. Heilman, Watson, and Valenstein (1993), who developed the first model to be presented here, proposed that the same sensory inputs that stimulate thalamic and cortical centers simultaneously stimulate the cholinergic tracts arising from the mesencephalic reticular formation (MRF). These neurons synapse on the nucleus reticularis in the thalamus to inhibit its inhibitory influence over the other thalamic nuclei, thereby facilitating transmission of sensory information through the relay nuclei within the thalamus. The ascending MRF neurons also project diffusely to the cingulate and to neocortex, including all of the primary sensory cortices and the unimodal and heteromodal association areas. These cholinergic tracts appear to desynchronize electrical activity in these regions, thereby potentiating transmission of the sensory signals.

Mesulam (1985a) constructed a very similar model. He called the MRF-nucleus reticularis-neocortex component of attention the "matrix or state" function, or "tonic attention." The other network, which involves the sensory relays and specific cortical projections, controls what he called the "vector or channel" function, or "selective attention." Tonic attention appears to be maintained primarily by the MRF with some executive regulation by the frontal lobes; injury to the MRF produces a disruption of overall attentional tone (e.g., a delirious state). Selective attention appears to involve an interchange (via thalamic and striate connections) between the sensory information of the primary sensory cortex, the motivational information of the cingulate (e.g., the emotional and adaptive relevance of the stimulus), and the motor control of the posterior frontal cortex (e.g., orientation to the stimulus by the frontal eye fields, area 8). Lesions in any of these areas can produce inattention to part of the perceptual field (Mesulam, 1985a).

A third and quite different model has been proposed by Posner and his colleagues (Posner & Peterson, 1990; Posner & Presti, 1987). Posner divides attention into three functions. The first component of atttention, "alerting" or vigilance, is similar to Mesulam's tonic attention. However, Posner proposes that this is a function of a noradrenergic pathway that arises out of the locus ceruleus at the level of the midbrain and pons. This pathway courses through frontal areas and then projects caudally to the posterior attention system that serves visual orienting; these tracts are more lateralized to the right cerebral cortex.

Posner's second component, "orienting," corresponds to Mesulam's selective attention, but Mesulam and Posner emphasize different subsystems. Mesulam subdivides this function into sensory information processing (a function of sensory cortex), motivational processing (cingulate gyrus), and motor movements (posterior frontal cortex). Posner defines orienting in terms of three other functions (and different structures): (1) disengaging from the present focus (a function of the parietal lobe), (2) shifting attention to a new location (a function of the midbrain), (3) and registering the contents of the new location (mediated by the pulvinar nucleus of the thalamus). Finally, Posner's third component is "target detection"; research with both auditory-verbal and visual-spatial stimuli has implicated the anterior cingulate gyrus as a common substrate for this function (Posner & Peterson, 1990).

All of these theorists state that visual attention, like visual and somesthetic sensation and perception, is lateralized. That is, there is a functional asymmetry between the left (LH) and right (RH) cerebral hemipheres. However, only the LH follows the contralateral principle described above; the RH processes stimulation bilaterally. According to Heilman and Mesulam, the LH controls attention to the right visual fields; the RH, on the other hand, controls attention to stimulation arising from <u>either</u> hemispace (Heilman & Van Den Abell, 1979, 1980; Mesulam, 1985a). Therefore, LH lesions impair attention to the right hemispace, but this is partially compensated by ipsilateral projections to the RH. By contrast, RH lesions impair attention to the left hemispace, with no compensatory ipsilateral projections to the LH.

These hemispheric differences are believed to account for the clinical finding that left neglect syndromes are both more severe and more enduring than right neglect syndromes (Cummings, 1985). Past research has indicated that in addition to being more severe and enduring, left neglect syndromes are also more <u>common</u> than right neglect. However, this claim has been challenged. Ogden (1987) found that just as many left-brain-damaged (LBD) patients as right-brain-damaged (RBD) patients experienced contralateral neglect.

Ogden (1987) proposed that the relative incidence rates were misconstrued for several reasons. First, it appears that patients with anterior left lesions frequently experience concomitant aphasia; investigators tended to exclude these subjects from their studies. Secondly, some researchers focused on large figural units for evaluating neglect, but they ignored omissions of smaller details (which are more common in LBD patients). In addition, many tests are more sensitive to left neglect than to right neglect, perhaps because of the difference in severity. Finally, because neglect in the left side of visual space does tend to be more enduring, the rate of left neglect may appear higher with greater time intervals between injury and assessment.

When these problems were controlled, Ogden (1987) found that on some measures there were as many patients with right neglect as there were with left neglect. The former patients typically suffered anterior LH lesions, whereas the latter typically suffered posterior RH lesions. Consequently, it can be expected that, if the instrument is sensitive enough, anterior LBD and posterior RBD will result in equal frequencies of neglect. In spite of this qualification for the frequency of the two syndromes, it is still maintained that left neglect is typically more severe and more enduring than right neglect.

Other aspects of attention are also believed to be lateralized. Heilman, Watson, and Valenstein (1993) argue that the RH may play more of a role in arousal than does the LH. As mentioned earlier, Posner and

Peterson (1990) concur, pointing to evidence that the noradrenergic innvervation of the posterior attention systems is itself more lateralized to the RH. In addition, Posner and his colleagures posit that the RH may be more specialized for attending to global features of a stimulus (e.g., gestalt, contours, or melodies) and that the LH may be more specialized for attending to local, or detail, elements (e.g., individual line segments or musical notes).

These three models differ in how they subdivide attention; they also differ in some of the substrates they implicate. Nonetheless, some common principles emerge. First, attention involves a general arousal function that maintains attentional tone across the cortex and "alerts" or potentiates specific regions for special processing of incoming nervous signals. This function appears to have its center in the mesencephalon and is achieved either via ascending noradrenergic tracts or via cholinergic innervation. Second, at the cortical level there are several component processes involved in directing attention to a specific input for priority processing. However these functions are defined, they are sure to involve the posterior right hemisphere, especially for processing bilateral visual stimuli and gestalt features, and the left hemisphere, especially for processing right-side visual stimuli and detail features. Third, there appears to be a motivational component achieved by the cingulate gyrus and its connections to limbic structures. Finally, there is a motor component to selective attention that is served by motor and premotor cortex in the posterior frontal lobes.

From these models of attentional representation, it could be predicted on the CFT that RBD would more likely result in neglect of the left side of the constructions, and LBD would be manifest to a lesser degree in the right side, if at all. In fact, this has been observed in CFT copy and recall drawings (Kaplan, 1988; Milberg, Hebben, & Kaplan, 1986). Patients with RBD neglect the left side of the figure in their copy and recall drawings, whereas left-lesioned patients frequently show a progressive loss of detail (not a total neglect) in the right side of their drawings. Among stroke patients, Binder (1982) discovered that left cerebrovascular accidents (CVAs) resulted in right-side hemi-inattention. Patients with right CVAs neglected the left side of the figure and produced more severe spatial distortions.

Construction

Construction, or constructional praxis, is the ability to assemble materials into a whole object. This term is used to refer to a diversity of tasks, ranging from two-dimensional pencil drawings to jigsaw puzzles to three-dimensional block configurations. Assessment of the construction function itself assumes the integrity of component functions such as perception, attention, and motor control. Construction ability is the actual synthesis process. Benton and Tranel (1993) argue that this concept has been applied too broadly to be clinically useful. They demonstrate that a plethora of studies localize "construction" to many different parts of the brain, depending on the response required (especially two-dimensional versus three-dimensional), how the stimulus was presented (two-dimensional versus three-dimensional model), and the difficulty of the task (especially the complexity of the stimulus). Studies of laterality are difficult to compare because they use different tasks and they do not control for location or severity of injury. Benton and Tranel's (1993) review and Mesulam's (1985b) review suggest a convergence of localization findings: There is substantial agreement that posterior lesions are more devastating than anterior lesions, and a preponderance of the evidence implicates the right parietal region in more severe cases of constructional apraxia.

Investigators using the CFT with frontal lobe patients have observed that planning and organizational processes controlled by the frontal lobe also play a role in construction for this two-dimensional task. Bennett-Levy (1984) reported that, during the CFT copy and recall administrations, frontal patients exhibited a loss of programming and lack of organization yielding poor recall scores. Klicpera (1983) used the CFT with dyslexic children and concluded that visuomotor and visuospatial anomalies in this population appear to be less of a function of lateralization than of the overall integrity of the frontal lobes. Compared with normal controls, his sample of learning disabled children produced the copy and recall trials with very poor organization and a less systematic approach. Therefore, problems on the constructive trials of the CFT may have reflected poor organization of both the stimulus and the response.

There is little consensus on how construction should be subclassified and what that might mean for localization. This discussion has shown that constructional disability has been correlated with both left and right pathology and with both anterior and posterior lesions. Regardless of the cerebral substrate, it is reasonable to assume that how the CFT copy is organized and synthesized into a picture is likely to have an impact on the encoding/storage and retrieval of the memory trace. Therefore, it is possible that the extent to which these deficits actually impair encoding of the memory trace can be examined with the use of a recognition task.

Language

Language is significantly lateralized. In virtually all right-handed individuals and in the majority of left-handers (about 70%), the left hemisphere exercises substantially more control over language functions and is therefore called the "language-dominant" hemisphere. People who sustain brain damage early in life are much less homogeneous with respect to lateralization of language functions; in this group, up to 30% of right-handers and 80% of left-handers are right-dominant or bilaterally represented for language (Springer & Deutsch, 1985).

It should be noted that dominance does not mean exclusive control. Although most major language functions are controlled by the language-dominant hemisphere, language processing is represented to some degree in <u>both</u> hemispheres (Benson, 1985; Zaidel, 1985). This point has been argued in a banter of polemics revolving around the split-brain findings of the '60s and '70s (Gazzaniga, 1983a, 1983b, 1984; Levy, 1983; Myers, 1984; Zaidel, 1983). Challenges to the conclusions of those early studies have hinged on issues such as: the extent to which the measures that were used effectively circumvented intact communication circuits between hemispheres (e.g., bilateral audition); bias in subject selection, namely, choosing to study those commissurotomy patients who <u>did</u> show right-hemisphere language <u>because</u> they exhibited that presumably uncommon characteristic; the extent of surgical sectioning and, more specifically, the role of the often-spared anterior commissure; and definitions of "linguistic competence." The consensus of this sample of critical scholarship appears to be that (1) any linguistic skills that exist in the language-nondominant hemisphere are rudimentary at best and that (2) whatever skills that can be described reliably and validly in these early patients can be generalized only with extreme caution because of the limited number of cases and because of their idiopathic histories.

A recent review of lexical processes was conducted to further elucidate the role of each hemisphere in language. To avoid the interpretive pitfalls of research employing split-brain and other neurological samples, Chiarello (1988) focused exclusively on normal, right-handed adults who were neither bilingual nor reading-disabled. The strategy most frequently employed with the normal population is the manipulation of word presentations using a visual half-field technique. Based on her thorough examination of this research base, she concluded that lateralization is manifested in different ways and to varying degrees at each of three stages of lexical processing. The most substantial differences exist in prelexical operations (encoding). At this stage, if the letters are presented in the normal reading format, the left hemisphere perceives the stimuli (i.e., words) in a very rapid, automatic process whereas the right hemisphere employs a slow, serial analysis; however, the relative efficiency of the right hemisphere increases when the words are presented in an unusual format (e.g., in a vertical array). In actual lexical access, the second stage of this model, lateralization effects were not observed; there is no evidence that the right hemisphere is limited in the size of "its" word stores, nor is the right hemisphere less efficacious in its access (relative to left-hemisphere processing). Finally, postlexical processing, like prelexical processing, contains some cortical asymmetries; however, these lateralized differences interact with the demands of the task and with the type of lexical information involved and cannot be easily distilled into interpretable generalizations.

In conclusion, for the majority of the population the LH excels in processing most verbal stimuli. Although the RH exercises some control over some language functions, the LH appears to be more skilled and is used preferentially, especially for verbal stimuli presented in standard language form (e.g., left-to-right arrays for English-speaking people). With regard to memory performance, therefore, verbal codes for visual stimuli could implicate LH functioning instead of the RH patterns described below.

Memory

The investigations cited thus far support a model of complex interaction between the hemispheres in the processing of language and spatial information. Nonetheless, when we examine our present body of memory data, the generalizations of left language dominance and right spatial dominance seem to prevail (Delaney, Rosen, Mattson, & Novelly, 1980; Kaplan, 1988; Kimura, 1963; Milberg, Hebben, & Kaplan, 1986; Milner, 1971, 1978; Rausch, 1985; Squire, 1982, 1986; Taylor, 1969; Zaidel, 1977, 1985).

Generally stated, patients with left brain dysfunction (LBD) experience impairments of verbal memory even when nonverbal memory is completely spared; individuals who suffer right brain dysfunction (RBD) display more deficits of figural memory, that is, when the visual material is complex enough to preclude verbal mediation. Although King

(1981) found no differences on the CFT when comparing patients with left hemisphere lesions and those with right hemisphere lesions (both groups equally impaired relative to noninjured controls), other evidence suggests that this task is very sensitive to hemispheric differences, both quantitatively (in terms of the amount recalled) and qualitatively (how the figure was drawn during recall).

Milner (1971, 1978) found that, across a variety of tasks, patients with right temporal lobe epilepsy who subsequently had partial lobectomies experienced impaired visuospatial memory compared to their counterparts with partial lobectomies of the left temporal lobe. Taylor (1969) demonstrated this with the CFT among patients who had left- and right-temporal excisions.

Kaplan (1988; Milberg, Hebben, & Kaplan, 1986) uses the CFT as part of her "process approach" to assessment. As would be predicted from the above-described behavioral geography of the brain, LBD patients experienced less impairment on this spatial memory task than RBD patients. The drawings by the two patient groups also differed qualitatively. The RBD patients' figures typically lacked proper contours, integration, and organization, whereas the LBD patient's figures were typically drawn in segmented fashion and were more likely to lack internal detail.

Certain subcortical regions have also been implicated in memory processes, although it is difficult to be specific because a lesion of one of these areas is typically accompanied by damage to its neighboring structures (Barr & Kiernan, 1988). Nonetheless, some patterns have emerged in clinical neuropathology and in animal science to elucidate the relative contributions of some of these deep nuclei.

Squire (1982, 1986) proposed that there are two types of subcortical amnesias. Patients with "diencephalic amnesias" (those involving the mammillary bodies and dorsomedial thalamic nuclei) exhibit a normal rate of forgetting, which suggests that theirs is an encoding deficit; retention is relatively unimpaired, however, such that information that can be acquired can also be retained. Patients with "bitemporal amnesias" (hippocampal and amygdaloid lesions), by contrast, exhibit an abnormally rapid rate of forgetting, which implicates deficient post-encoding processes of consolidation and/or elaboration, which are critical for effective retrieval. These findings are limited to declarative knowledge (information); procedural knowledge, or perceptual-motor ability, is not affected by these local pathologies.

A review of clinical human studies and experimental animal research (Winocur, 1984) supports the conclusions that thalamic damage affects encoding whereas hippocampal injury affects consolidation and subsequent retrieval. Furthermore, hippocampal lesions may contribute to interference effects observed in memory processing.

Summary

All of these findings help describe the organization of salient cognitive functions from a neuropsychological frame of reference. Throughout this discussion I demonstrated the importance of assessing cognitive processes through at least two modalities, auditory-verbal and visual-spatial. This discussion also revealed the diagnostic implications for differentiating among attention, perception, construction, and memory deficits. Finally, I argued that it can be useful to distinguish between encoding and post-encoding processes in memory functioning. Adding recognition and matching trials to the Rey-Osterrieth Complex Figure Test can be an invaluable asset to extant neuropsychological batteries. The additional trials will enable neuropsychologists to rule out perceptual and constructional confounds to the memory assessment, and comparisons between free recall and recognition performance can help distinguish between encoding and post-encoding deficits.

To make future clinical investigations and applications meaningful, this project will lay the psychometric groundwork for the new recognition and matching trials and provide age-appropriate norms. Furthermore, this project will explore the interplay of sex and age on the different trials of the CFT (i.e., Copy, Immediate Recall, Delay Recall, Recognition, and Matching), in hopes of shedding light on developmental differences among the various memory processes for males and females. In the sections that follow, I review the literature on memory differences that have been observed between different age groups and between males and females, with emphasis on visual memory and its measurement. The specific predictions of this project are embedded in those discussions.

AGE DIFFERENCES IN VISUAL-SPATIAL MEMORY AND IN RELATED VARIABLES

Developmental changes in memory are receiving more and more attention in the research literature for several reasons. First, complaints of memory difficulties are common among older adults, beginning in the 50s and becoming especially frequent after age 60 (Albert, 1984). (In this discussion, "older adults" refers to people in their late 50s and older unless otherwise indicated.) This has led many investigators to examine the validity of subjective reports and to determine the nature and extent of reported age-related memory impairments. Second, pattern of memory loss in older adulthood has proven to be diagnostically useful, for example, differentiating dementia (organic memory loss) from pseudodementia (temporary memory loss secondary to depression). Consequently, there has been an increasing need for sensitive measures of memory processes and for age-appropriate norms, especially as more and more people thrive beyond the seventh decade.

In this section, I present a cognitive model of memory that has been frequently applied to explain memory phenomena. The discussion begins with four theoretical memory stores (sensory memory, primary memory, secondary memory, and tertiary memory) and the putative information processes that act upon the memory traces within and between those stores (selective attention, encoding/storage, consolidation, and retrieval). Then I address variables that affect memory performance: attention, perception, production, health, depression, and anxiety. Research findings on age differences are documented throughout the discussion. Finally, I relate these findings to the study at hand, the development of recognition and matching trials for the CFT.

Memory Stores

Since the early information-processing theories in the 1960s, models of memory have incorporated putative storage cells of varying capacities and functions. The smallest store holds sensory stimuli in close-to-original form for a very brief time; it is frequently labeled "sensory memory" or the "sensory register." It is engaged unconsciously, has a fixed storage capacity, and is further characterized by rapid decay of the stimuli. The memory traces are called "echoes" when they derive from auditory stimuli and "icons" when the stimuli are visual-spatial. These traces are maintained for only a few seconds at most, until the individual can selectively attend to a subset of stimuli that require further processing. These processes proceed more-or-less automatically and at an unconscious level.

The next store is called "working memory," "short-term memory," or "primary memory." Like the sensory register, primary memory has a relatively fixed capacity; in contrast to the sensory register, primary memory involves conscious processing, and traces can be maintained as long as they are active in the store. It is postulated that primary memory serves as a workbench where new memories are maintained until they are no longer needed; the traces may then be displaced by new incoming material or encoded for longer storage and for later retrieval. Primary memory can hold approximately seven "chunks" of information, although each chunk can represent many smaller units of data; for example, the numbers 1, 4, 9, 16, 25, 36, and 49 could be rehearsed as one chunk, "perfect squares." Traces can be held in this store as long as the individual consciously maintains them, such as through rehearsal.

More permanent storage conventionally has been called "long-term memory (LTM)." This storage is believed to have infinite capacity and can maintain at least some memories for an indefinite period of time. Memory traces are encoded here and are stored, becoming more and more consolidated (that is, resistant to forgetting) with time. Retrieval processes make these memories accessible to primary memory for future re-use. Encoding and retrieval both demand substantial attentional resources, whereas consolidation appears to proceed automatically. Forgetting from LTM appears to be due, at least in part, to improper encoding and/or inefficient retrieval; whether LTM traces are subject to decay is still a subject of debate.

Since the original models were proposed, LTM has been subdivided. A classification scheme has been introduced that distinguishes between long-term memories that are more contemporary ("recent memory" or "secondary memory") and memories that comprise one's personal archives from the distant past ("remote memory" or "tertiary memory"). An example of secondary memory would be a newly learned list of words or story; tertiary memory, on the other hand, would house autobiographical information (name, birthdate, etc.) and overlearned material (e.g., the alphabet or nursery rhymes). Whether these two "types" of memory actually represent different stores or whether they are simply anchors on either end of a consolidation gradient has yet to be determined.

Nonetheless, inasmuch as they are affected differently by pathological processes and by aging, the distinction would appear to be warranted.

In a recent review of age differences in memory, Poon (1985) summarized findings that had addressed the relative capacities of each of these stores across the lifespan. He concluded that age-related impairments in sensory, primary, or tertiary stores are negligible or absent altogether. However, in secondary memory, older adults performed significantly worse than younger adults. Differences in this domain implicate deficiencies in encoding and/or retrieval processes. These processes have been investigated at length, especially using auditory-verbal stimuli.

Memory Processes

Consolidation. Consolidation is the unconscious, automatic process that transforms secondary memory traces into tertiary memories by making the traces more resistant to disruption. Because there are no age differences in tertiary memory (Poon, 1985) and because consolidation is largely automated thereby requiring fewer attentional resources, it seems probable that consolidation is not affected by the aging process. This hypothesis is reflected in the following prediction:

Prediction 1: When the variance associated with consolidation in secondary memory is isolated, age will not explain a significant portion of that variance.

Encoding and retrieval. The bulk of research has attempted to compare encoding and retrieval efficiencies across the age span. The findings of many studies suggest that attentional resources are central to understanding age differences.

Smith (1977), manipulated cues in an auditory-verbal learning task in an attempt to investigate the effectiveness of different cues to ameliorate age differences in memory performance. When appropriate cues were provided at input, thus facilitating encoding, older adults performed as well as younger adults did. By contrast, providing cues at retrieval benefitted all age groups equally. These results suggest that memory decline in older adults is due to faulty or incomplete encoding.

In a later paper, Smith (1980) reviewed the literature and found other evidence for encoding deficits. Older adults were impaired across three different modes of processing (organization, elaboration, and imagery); however, they differed from younger adults not in their <u>ability</u> to process the stimuli but instead in their <u>spontaneous use</u> of such strategies. This was also the finding of Perlmutter and Mitchell (1982), based on their own data and based on a review of 12 other studies. Unfortunately, the present research design does not lend itself to the isolation of encoding functions; consequently, a prediction will be made about only retrieval mechanisms:

Prediction 2: Age will explain a significant portion of variance in retrieval operations of secondary memory.

Craik and his colleagues (Craik & Byrd, 1982; Rabinowitz, Craik, & Ackerman, 1982) explored these encoding deficits further. They found that older adults tend to encode core semantic (general) features rather than distinct characteristics of stimuli. The former is believed to involve more automated processing, whereas the latter is assumed to require more effortful processing. Therefore, the investigators concluded that memory differences are due to the reduction in processing resources with increasing age. This is consonant with other findings indicating that automaticity is spared in aging and that effortful processing declines (Hasher & Zacks, 1979).

Waugh and Barr (1982) also found evidence for an attentional deficit hypothesis. Specifically, older adults registered less information than younger adults and failed to encode specific details valuable for later retrieval. Thus, it appeared that older adults encode more selectively and less efficiently, attending to some items at the expense of others.

Although most of these studies employed auditory-verbal material, similar investigations used visual-spatial stimuli. Craik's (1977) review of the literature indicated that visual-spatial memory is susceptible to the same processing deficits as auditory-verbal memory and may be even more compromised than memory for auditory-verbal material. One reason may be that auditory-verbal input can be processed with less effort and more automaticity. "When the input is visual, however, attention is required; older subjects have less processing capacity to spare in the divided attention situation, thus their performance on visual memory tasks is especially poor" (Craik, 1977, p. 392). Findings by Winograd and Simon (1980) support this conclusion. They found that older adults did worse in forming and/or retrieving pictorial codes as opposed to auditory-verbal encoding/retrieval. Craik (1977) also reported that comparisons between recall and recognition with visual-spatial stimuli (geometric designs) are similar to such comparisons with auditory-verbal stimuli. Specifically, recognition, although impaired with aging, is more resistant to decline than is recall. This suggests that auditory-verbal and visual-spatial retrieval are similarly facilitated by the decreased processing demands of a recognition format.

Some investigators have used the Complex Figure Test with older adults. Tombaugh and his colleagues (Tombaugh, Hubley, Faulkner, & Schmidt, 1990) administered the test in a modified fashion; they instructed subjects to memorize the figure during a timed exposure (intentional learning, viewing the stimulus rather than drawing it) and they administered the copy trial last, following the immediate and delay recall trials. They recruited a large community-dwelling sample that had equal numbers of subjects in each 10-year age band from 20-79. These investigators found that adults in their 60s scored lower than younger adults on immediate and delay trials, despite equivalent performance on the copy trial; adults in their 70s scored even lower than adults in their 60s on those same trials. These findings were corroborated by Berry, Allen, and Schmitt (1991), who used the standard administration of the test with healthy, community-dwelling adults ranging from age 50 to age 79. This is further evidence that the secondary memory deficits observed with auditory-verbal material affect visual-spatial material in a similar way.

Read (1987) suspected that the original stimulus was too difficult for the older adults to draw and that difficulty on the copy trial resulted in poor recall. (No data were reported to support this proposition.) Consequently, he presented individual elements of the design in a structured, sequential manner so that the subjects could copy the figure effectively. Cues were provided at the time of retrieval in a similar fashion. Copy reproductions and recall improved substantially. Nonetheless, even with the modified administration and equivalent copy performance, older adults performed worse on recall than did their younger counterparts. Facilitating encoding and retrieval, and thus reducing the attentional resources required, failed to eliminate all age differences, suggesting that age-related changes in attention capacity play a significant but not solitary role in age-related memory decline. Again, because the present research design does not permit the dissection of encoding processes, I proffer a prediction about only retrieval mechanisms:

Prediction 3: After controlling for the effects of attention, age will explain significantly less variance in retrieval operations of secondary memory.

In summary, sensory memory and tertiary memory operate mostly at an unconscious level by very automated processes (selective attention and consolidation); these are unaffected in healthy aging. Primary memory is also virtually unaffected in healthy aging. By contrast, secondary memory ability declines significantly with healthy aging. The two main information manipulations in this store, encoding and retrieval, are engaged with substantial effort. For older adults, an age-related decline in attention capacities has been consistently observed, especially in tasks where attention is divided between two or more activities. This pattern of attentional decline closely coincides with the pattern of decline in secondary memory. It seems plausible, therefore, that impairment of encoding and retrieval in secondary memory is due, at least in part, to limited attentional resources and that attentional decline is the primary mediating agent of memory decline among older adults. Because visual-spatial processing is more effortful than auditory-verbal processing, the attentional deficit may disadvantage visual-spatial memory even more than auditory-verbal memory.

Variables that Affect Memory Performance

Memory performance is dependent on other cognitive abilities: attention, perception, and production. Individuals must attend to the specific stimulus in their environment and then accurately perceive it in order to encode and store it as a memory trace. They also must be able to verbally or graphically report the memory trace upon retrieval. Because these skills decline with age, they must be considered as potential confounds to analyses of aging memory. In addition, many health conditions are known to impair memory performance, and some of these occur with greater frequency among older adults such that pathological memory decline might be misattributed to normal, healthy aging. Finally, clinical levels of depression and anxiety have been shown to impair performance on memory tests; therefore, the relationship between age and these emotional states is also salient to this investigation.

Attention. Attention for effortful processing was shown to decline with age in a classic study by Hasher and Zacks (1979). More recently, Stankov (1988) examined 11 different tests of attention as part of an extensive battery of other cognitive measures. These 11 measures formed three attentional factors; performance on all factors declined with age (*r*s ranged from -.43 to -.48). Furthermore, these changes in attention explained most of the variance in the fluid intelligence factor and in the crystal intelligence factor in that study.

Craik and Byrd (1982) reviewed several lines of evidence for compromised attention in older adults, including studies of divided-attention, depth of processing, and automaticity. They concluded: "We postulate that reduced attentional resources lead to an attenuation or shrinkage in the richness, extensiveness, and depth of processing operations at both encoding and retrieval" (p. 208).

Most of the research evidence for age decline comes from cross-sectional studies, which means that the differences may represent cohort and time-of-measurement effects in addition to or possibly even instead of aging per se. Crossley, Hiscock, and Beckie (1991) conducted a longitudinal follow-up to a cross-sectional analysis and found age-related decline in multi-task processing across the adult lifespan. The longitudinal findings, in conjunction with cross-sectional evidence, indicate that these differences are indeed a product of aging, independent of cohort and time-of-measurement effects.

<u>Perception and production</u>. Perception and production also decline with age; the age effect increases with the complexity of the stimuli. In the auditory-verbal domain, perception (language comprehension for sentences) declines mildly with aging. Production also changes, with significant declines in the number of words generated during fluency (or listing) tasks and with significant increases in repetition, redundancy, and personalization during discourse (La Rue, 1992).

In the visuospatial domain, simple perceptual skill (e.g., judgments of line angles) begins to decline in the fourth decade, but even in the ninth decade performance is only marginally lower than that in the sixth decade. The decline in the performance of complex tasks (facial recognition and embedded figures) is more substantial. Similar declines occur on tests of visual-spatial production. For example, older adults can accurately copy simple two-dimensional designs but they experience more difficulty with complex two-dimensional tasks and with three-dimensional stimuli (La Rue, 1992, chapter 3). Although the CFT is a relatively complex stimulus, testing of adults ages 20 to 79 (Tombaugh, Hubley, Faulkner, & Schmidt, 1990) and of adults ages 50 to 79 (Berry, Allen, and Schmitt, 1991) failed to identify any age differences on the copy trial. Therefore, in this study I expect the following outcomes:

Prediction 4a: Attentional skill and perceptual accuracy will correlate negatively with age in both auditory-verbal and visual-spatial modalities.

Prediction 4b: Production ability will correlate negatively with age in the auditory-verbal modality but will not correlate with age in the visual-spatial modality.

Health factors. Memory also depends on the physical integrity of the central nervous system. Age-related changes in brain structure, metabolism, and neurotransmission have been studied extensively, and correlations between biological indices and cognitive performance in older adulthood have also been documented (for review, see La Rue, 1992, chapter 2). Because no biological measures of brain structure and function were used in this study, this body of research will not be presented here. However, many medical conditions can compromise nervous system efficiency and impair cognitive performance; in the current study, these conditions were grossly measured through a structured interview.

A variety of direct insults to the brain can affect cognition. In the current study, questions were asked about loss of consciousness (LOC) following traumatic head injury, cerebrovascular disease (CVD; ischemia and cerebrovascular accidents [CVAs or "strokes"]), hydrocephalus, and epilepsy. The structured interview also inquired about a variety of systemic factors that are known to impair cognition. These include heavy alcohol use, smoking, hypertension (HTN), coronary heart disease (CHD), diabetes mellitus (DM), pulmonary insufficiency, renal insufficiency, and hepatic dysfunction. Several of these same variables are more likely to show up in older adults' histories for three reasons: (1) Older adults have lived longer and thus have longer histories to report. (2) Physical decline and vulnerability to disease increase from young adulthood to older adulthood. Finally, (3) older cohorts did not have the benefit of contemporary health care, preventive education, and nutrition when they were younger.

Vascular disorders are more common among older adults than among younger adults and have been shown to impair some elements of cognition. HTN has been diagnosed in 60 percent of non-Hispanic white Americans who are over 60 years old (National High Blood Pressure Education Program, 1992). HTN alone has been shown to affect attention and memory and possibly perception and constructional ability (Waldstein, Manuck, Ryan, & Muldoon, 1991). In addition, HTN substantially increases risk for CHD, CVD, and renal disease (National High Blood Pressure Education

Program, 1992), which also increase with age and which also have detrimental effects on cognition.

The prevalence of ischemic heart disease increases with age, rising to 50 percent among people over age 60 (Bienenfeld, 1990a). Neuropsychological impairment has been unequivocally demonstrated in patients with CHD, at least for those with disorders severe enough to warrant surgical intervention (Bornstein & Kelley, 1991).

CVA is more frequent in older adults, occuring in 5.1 percent of Americans over the age of 65, compared to 1.0 percent between the ages of 46 and 65 and only 0.7 percent below age 45. In 47 percent of these CVA patients, intellectual impairment is observed; in 50 percent of these patients, cognitive decrements are severe enough to fulfill criteria for dementia (Cummings & Mahler, 1991).

In addition to HTN, CHD and CVD, non-insulin dependent diabetes mellitus (DM) increases in frequency with age as glucose uptake by target organs diminishes (Bennett, 1990; Bienenfeld, 1990a). Prevalence begins to increase around age 40 and reaches 15 to 20 percent after age 65 (Davidson, 1991). DM predisposes individuals to much higher rates of HTN, CHD and CVD as well as higher rates of acute fluctuations in mental status secondary to metabolic instability. Cognitive consequences of the vascular complications (HTN, CHD, CVD) were described above. Cognitive sequelae due to DM itself have not been conclusively demonstrated; research in this area has been virtually nonexistent until recently, and studies so far have been limited to people under age 45 (Bornstein & Kelly, 1991).

In contrast to these other risk factors, use of alcohol and illicit substances (both frequency and amount) decreases with age, especially after age 70 (Bienenfeld, 1990b). The proportion of current drinkers in 1990 declined across cohorts, from 68.8 percent in 25-44 year-olds to 57.6 percent in 45-64 year-olds to 41.4 percent in adults 65-and-older (U. S. Department of Health and Human Services, 1993). In addition, alcohol use is not so predictive of cognitive impairment as is long-standing alcohol abuse. Chronic substance abusers are underrepresented in older community-dwelling adults because of early mortality and high comorbidity of conditions leading to institutionalization (Bienenfeld, 1990b; National Institute on Alcohol Abuse and Alcoholism, 1990).

Cigarette smoking is also observed least among older Americans (age 65 and older; 12-15 percent) compared to other adult cohorts (25-34, 35-44, and 45-64 year-old cohorts range 25-33 percent; U. S. Department of Health and Human Services, 1993). Related to cigarette smoking is hypoxemia (pulmonary insufficiency). Even though current smoking may decline with age, residual pulmonary disease may continue to impair cerebral oxygenation. In a review of two major investigations of chronic obstructive pulmonary disease, Bornstein and Kelley (1991) concluded that severity of cognitive impairment is related to the severity of hypoxemia. Chronic obstructive pulmonary disease is most frequently identified in the seventh decade.

Epilepsy can also contribute to cognitive impairment. It is estimated that 10 percent of the population has a seizure at some time in their lives. The age of onset for seizures is linked to the etiology. Among older adults, it is not uncommon for CVA patients to develop seizures; CVA is the most common cause after age 50. However, prevalence of seizures is much less common in older adults than among younger adults and children. Approximately 50 percent of persons who experience epilepsy have their first seizure before age 20; most people have one or a few seizures without recurrence (Epilepsy Foundation of America, 1992; National Institutes on Health Consensus Development Conference, 1990).

Prediction 5a: The frequency of HTN, CHD, CVD, DM, and pulmonary disease will correlate positively with age.

Prediction 5b: Current alcohol and tobacco use will correlate negatively with age.

Prediction 5c: Nonsignificant correlations are expected between age and hydrocephalus, renal disease, hepatic disease, seizures, and LOC that follows traumatic head injury.

Emotional influences. Finally, an inventory of depression and an inventory of anxiety were included in the battery. Clinical levels of depression can compromise memory performance (Fisher, Sweet, & Pfaelzer-Smith, 1986; Fromm & Schopflocher, 1984); this effect appears to be due to a cerebral mechanism rather than motivation deficits (Richards & Ruff, 1989). However, depression is not expected to confound age comparisons in this study because clinical depression is no more prevalent among noninstitutionalized older adults than among younger adults (Nakra & Grossberg, 1990).

Anxiety, also, can adversely affect cognitive test performance (King, Hannay, Masek, & Burns, 1978; Wrightsman, 1962). Clinical levels of anxiety are no more frequent among older adults than among younger adults (Ruskin, 1990), and adults ages 50-69 have even been shown to have slightly less reactive ("state") and chronic ("trait") anxiety than adults ages 19-39 (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983, p. 5). In testing situations, however, older adults are more prone to reactive anxiety due to repeated confrontation with failure on tasks that they could perform better at a younger age. Also, older cohorts tend to be more intimidated by testing because they have less formal education than younger cohorts (Albert, 1988, pp. 62-63).

Prediction 6a: Depression scores and trait anxiety scores will not correlate with age in this community-dwelling sample.

Prediction 6b: State anxiety scores will correlate positively with age.

SEX DIFFERENCES AND VISUAL-SPATIAL MEMORY

Harris (1978, 1981, 1985) documented the history and findings of sex differences across cognitive domains. Although many of the data are inconsistent and controversial, some differences have been more robust: Males tend to excel in spatial tasks, and females tend to excel in verbal fluency tasks (Harris, 1978, 1981, 1985). Even here, there is substantial variation within each group and considerable overlap between groups, indicating that the differences reflect "sex-related variability" rather than "sexual dimorphisms" (Harris, 1985, p. 296). Harris (1978, 1981) concluded that this sex-related variability may have several foundations, both physiological and environmental in nature.

As a clue to a possible physiological mechanism, there is some evidence for sex differences in the strength of lateralization of function. Although sex differences often do not appear, where they do occur it is such that males are more lateralized than females. Specifically, males show more right-hemisphere (RH) specialization for spatial tasks and more left-hemisphere (LH) specialization for linguistic tasks, whereas females exhibit more bilateral representation of these same skills. Witelson (1976) has reported differences of this sort in childhood, already at age six. Others have found that the differences endure into adulthood (e.g., McGlone, 1978). However, the lateralization data are inconsistent and controversial (see commentaries in McGlone, 1978).

There is some evidence for environmental influences. Hyde (1990) conducted two meta-analyses on research that examined sex differences in verbal and visual-spatial functioning. Comparing results from the first meta-analysis, which used studies published before 1973, to results from the second meta-analysis, which used studies published after 1973, she found a decline in the magnitude of sex differences in the later study. She suggested as one explanation that this trend may reflect changes in sex roles.

It is probable that both physiological factors and environmental factors contribute to sex differences in the facility and manner of spatial processing. As one possible scenario, Harris (1978, 1981) speculated that because females acquire language earlier than males, they may come to rely on verbal mediation to a greater extent than males do and, thus, may develop an approach to memory and problem-solving that draws more heavily on verbal mediation. If so, a preference for verbal strategies, linked to maturation and molded by environmental forces, may account for many observed individual and sex differences.

Mixed results have emerged from sex comparisons on the Complex Figure Test, but some findings suggest that intricate processing differences may play a role. Waber and Holmes-Bernstein have investigated sex differences in CFT performance among children. With regard to copy scores, Waber and Holmes (1985) found no sex differences on accuracy or organizational approach in a large sample (ages 5 to 14). Memory performance was examined in a much smaller sample of 5th- and 8th-grade children (Waber, Bernstein, & Merola, 1989). In that study, the encoding condition (i.e., whether the child simply viewed the figure or copied the figure during exposure to the stimulus) affected some features of recall, but this effect depended on the child's sex and age. In general, older children, especially older boys, benefited from copying the stimulus as opposed to simply viewing it. These findings require replication because of the limited sample size (approximately 10 per cell). Nonetheless, they raise several questions. First, are measures of memory that require visual encoding (e.g., the WMS-R, Wechsler, 1987) comparable to those whose administration involves motor encoding (e.g., the CFT)? Second, how do age and sex interact throughout the lifespan on measures of visual memory?

With factory line workers ranging in age from 17 to 49 ($\underline{M}$ = 29), Bennett-Levy (1984) found significant differences between men and women. Men exceeded women on measures of symmetry, good continuation, strategy (an organizational score derived from both symmetry and continuation), and recall. However, subsequent multiple regression analyses showed that sex did not make an independent contribution to the total variance in recall; rather, strategy, copy score, and age were the best predictors.

A thorough examination of the data presented by Bennett-Levy (1984) suggests that the relationship between strategy use and sex was very salient to the interpretation of these results. Given that sex did not make an independent contribution to recall, its effect must be mediated by another variable. Three variables predicted recall: the copy score, age, and the strategy score. The copy score and age were found to be sex-independent, whereas the strategy score (reflective of good organization) was significantly related to sex ($\underline{r}$ = -.28).

Consequently, it seems that differences in recall were best explained not by sex per se but by strategy differences. That is, sex affected the level of organization such that many (but not all) men organized their copies better than many (but not all) women. Those subjects who organized their drawings better (a mixed-sex group composed of more men than women) went on to recall more components of the figure on later trials ($\underline{r}$ = .65 or .69, depending on the stringency of the scoring rules applied). This re-evaluation supports Harris' (1985) conclusion that sex differences are sex-related and not dimorphic; furthermore, it is consistent with Harris' (1978, 1981) proposal that sex differences, at least in visual memory, might be mediated through different processing mechanisms.

In study using college students, Snyder (1993) found that men's memory constructions were superior to women's but only on the delay recall trial. This difference accounted for less than two percent of the total variance.

With older adults, Read (1987) also found that men performed slightly better than women on delay recall. He also found that women performed slightly better than men on the copy trial. In his study, the examiner provided sequential cues on the copy trial to facilitate organization; consequently, the results are not representative of performance on standardized administrations. As in Snyder's study, sex differences were very small, accounting for less than two percent of the total variance. In another study with older adults, Berry, Allen, and Schmitt (1991) found no evidence for sex differences. These results suggest that even if sex differences persist throughout adulthood, they do not account for much of the variance in visual memory performance.

In summary of the CFT data, children show a complex interaction between sex, age, and format of stimulus presentation; when given the opportunity to draw the stimulus and not just view it, pubescent children improved whereas younger children did not, and boys improved more than the girls in the pubescent group (Waber, Bernstein, & Merola, 1989). With adults, men tended to outperform women on the delay memory trial only, but differences were minimal when they appeared at all (Bennett-Levy, 1984; Berry, Allen, & Schmitt, 1991; Read, 1987; Snyder, 1993). These differences in memory performance may be mediated by organizational style and other intervening variables, and the form and degree of mediation may change across the lifespan. A study that spans adulthood to provide age- and sex-appropriate norms seems critical.

Prediction 7: The only sex difference on the CFT will be on the delay recall trial, where men will outperform women.

DEVELOPMENT OF THE NEW MEASURES

Item Construction

A set of 20 recognition items were initially designed based on findings in the literature and using patient test protocols in the neuropsychology department of a North Carolina psychiatric hospital. Each item was classified by two descriptors: the part of the figure used (constructional element) and the type of error that was predominant among the distractors, that is, the incorrect choices in the array (constructional error).

Constructional elements. Waber and Holmes (1985, 1986) described developmental changes in the production of the CFT and quantified organization and style. In doing so, they classified the original 18 scoring units (Lezak, 1983) into four groups. This system guided the design of test items for the recognition instrument under construction here. The base rectangle (BR) and main substructure (MS) contain the more global elements of the figure: the large rectangle, the diagonal cross, and the horizontal and vertical midlines. More specific elements comprise the outer configuration (OC; e.g., cross at far left, diamond at far right) and internal detail (ID; e.g., circle with three dots, five horizontals in upper left quadrant).

Constructional errors. The distractors for the original items were derived using types of errors that have been frequently observed during the construction of the complex figure and similar stimuli (Binder, 1982; Kaplan, 1988; Koppitz, 1964; Waber & Holmes, 1986). <u>Rotation</u> (R) items contain choices that are rotated varying numbers of degrees (90, 180, 270) from the accurate orientation as well as one choice that is a mirror image. The choices on <u>integration</u> (I) items lack connections at intersections, lack good continuation, and lack closure. Choices on other items are characterized by errors of <u>distortion</u> (D) such as malalignment, disproportion, and misplacement. Finally, some items were designed to be more sensitive to <u>neglect</u> (N). The responses on these items were arranged in a vertical array; the features that discriminated the correct choice from incorrect choices were concentrated on one side of all the choices in order to evaluate the extent to which the subject could attend to that side of the page and to that side of each drawing.

By recording the sequence of the lines drawn during the copy and memory administrations of the CFT, some investigators have observed that after age 13 the base rectangle and main substructure become increasingly salient as organizational units. These units are typically copied and recalled first, and then the more specific elements are added (Milberg, Hebben, & Kaplan, 1986; Waber & Holmes, 1985, 1986). For this reason, the items of the recognition task were arranged so that the global parts are presented first (BR and MS items) followed by items that incorporate the specific parts (OC and ID, except number 14). In addition, within each half of the test, different constructional elements were alternated as much as possible; that is, the first items were in the sequence BR, MS, BR, MS, etc., and the latter items were arranged OC, IC, OC, IC, etc. This was intended to guard against comparisons across consecutive items and to limit the extent to which previous choices could provide cues in successive responses. Where it became necessary to place two OCs or two IDs together, stimuli were chosen that contained different detail features, again to prevent comparisons across items. This ordering is reflected in the final set of items (Table 1).

Pilot Study

Using the 20 items described above, Fastenau and Manning (1992) conducted a pilot study to examine the psychometric properties of the new recognition items. The sample consisted of 42 adult volunteers on staff at a North Carolina state psychiatric hospital. These subjects were employed full-time, most in skilled positions. Education varied from 12 to 18 years with a mean of 13.6 (SD = 1.6), age ranged from 18 to 55 with a mean of 32.5 (SD = 12.2), and the mean estimated IQ based on a demographic formula (Wilson, Rosenbaum, & Brown, 1979) spanned the Average-High Average range (91 to 116) with a mean of 104.5 (SD = 5.0).

Based on the preliminary data collected in that pilot study, the recognition task merited continued use and further development. The test data yielded point-biserial correlations that were mostly in the range of .300 to .600. The coefficient alpha was .68 ($p < .001$). Raw scores distributed fairly normally between 12 and 20 (M = 16.2, SD = 2.2), with a slight ceiling effect.

Some revisions were made based on the point biserial correlations and based on other research. Specifically, one item was dropped because the point biserial correlation was negative, indicating that those subjects with good overall performances tended to fail that item. In addition, the first item was correctly completed by virtually all subjects; nonetheless, this item was retained to orient subjects to the task. Finally, right neglect items were added based on Ogden's (1987)

Table 1

Classification of Recognition Items by Element and by Quadrant.

Item No.	Element[a]	Quad[b]	Item No.	Element[a]	Quad[b]
1	BR	NS	16	ID	RI
2	MS	NS	17	ID	RS
3	BR	NS	18	ID	LS
4	MS	NS	19	OC	RG
5	OC	NS	20	ID	LI
6	MS	NS	21	OC	RI
7	BR	NS	22	ID	RS
8	MS	NS	23	OC	LS
9	OC	NS	24	OC	LI
10	ID	LS	25	ID	RI
11	OC	LG	26	ID	RS
12	ID	RI	27	OC	LI
13	OC	RS	28	OC	RG
14	ID	LS	29	ID	NS
15	OC	LI	30	OC	RG

[a]BR=Base Rectangle, MS=Main Substructure, ID=Internal Detail, OC=Outer Configuration

[b]LS=Left Superior Quadrant, LI=Left Inferior Quadrant, LG=Left Global (Both Left Quadrants), RS=Right Superior Quadrant, RI=Right Inferior Quadrant, RG=Right Global (Both Right Quadrants), NS=Nonspecific

findings, cited previously, that after controlling for speech impairments in studies of neglect, right hemisphere neglect was as frequent as left hemisphere neglect, although the latter tended to be less severe. Because the recognition task can circumvent language deficits, it seemed especially important to design right neglect items into the task. These revisions expanded the set to 27 items.

The constructional error labels were modified after the pilot study because it was difficult to classify some items as exemplifying purely one error in the absence of another error (e.g., rotated but not distorted). Neglect was an exception because the items that were classified this way met a reliable, objective construction criterion. Specifically, all of the stimuli for a given item were identical on one side of the midline. In the 27-item set, there were equal numbers of left- and right-neglect items (six each) and these were equally distributed between BR (one each), MS (one each), OC (three each), and ID items (one each). The results of the pilot study are reported elsewhere (Fastenau & Manning, 1992).

Expert Appraisal

Dr. Jane Holmes Bernstein of Children's Hospital, Boston, has used the CFT extensively with children (Waber, Bernstein, & Merola, 1989; Waber & Holmes, 1985, 1986). She reviewed the 27 items generated from the pilot study and suggested modifications based on her experience with the CFT and based on her research in visual memory. Her first recommendation was that I design the neglect items to allow for more systematic examination of the different quadrants. Her second recommendation was based on informal observations in her clinical work with children with a variety of medical conditions. She observed that the children occasionally shifted the left and right halves vertically along the vertical midline. They also tended to separate the two halves horizontally to leave a narrow alley in the center of their drawings, which then was often left devoid of detail. Based on this information, I modified several items to include distractors with empty alleys and midline shifts. Finally, the items were revised to better reflect the errors committed by the normal pilot group. It was expected that this would eliminate the ceiling effect observed in the pilot study.

Final Revision

The final revised set contains 30 recognition items (Appendix A). Four items were designed for each of the four constructional quadrants (left superior, left inferior, right superior, and right inferior); these account for 16 of the 30 items. Three additional items reflect gross right-side features (i.e., specific to the right side of the figure but not to one quadrant or the other); another item contains gross left-side features. Ten other items lack lateralization qualities in their design. The proportions of Base Rectangle items (.10), Main Substructure items (.13), Outer Configuration items (.40), and Internal Detail items (.37) were made to match the same proportions in the criteria used for scoring copy and recall constructions (.06, .17, .44, and .33, respectively; derived from Taylor's criteria reported in Lezak, 1983, p. 400). The classification of each item by constructional element and constructional error is depicted in Table 1.

The matching items are reproduced in Appendix B. The matching set includes one base rectangle item and one main substructure item. The other eight consist of two items from each of the four quadrants. This representative sample of the different quadrants was meant to provide an additional means for assessing visual neglect. During testing, each matching item is placed one at a time beside its corresponding recognition stimulus card.

The new recognition and matching trials are expected to be reliable and valid. Repeated testing for temporal consistency (test-retest reliability) will not be conducted as part of this study. Because the recognition and matching trials are scored objectively, interrater indices will not be necessary. In addition, only one form of each trial has been developed, so alternate-form reliability (consistency across forms) will not be presented. The only measure of reliability will be homogeneity of content, or internal consistency. This should be high for the Total Scale and moderate for the subscales, which will have fewer items and thus limit the size of Cronbach's alpha coefficient.

Convergent validity will be demonstrated by significant correlations with analogous measures and by confirmatory factor loadings with tests of similar taxonomy (that is, visual-spatial secondary memory and perception for recognition and matching respectively). Construct validity will be evidenced by confirmatory factor loadings of each item on its respective scale (Global element, Left Detail, and Right Detail). Exceptions are Items 5, 9, and 29 which are specific to neither the left side nor the right side of the stimulus. On the Matching Task, two items (Items 1 and 6) are global-element items but these are too few to construct a scale. Consequently, these two items will be omitted from the factor analysis; the other eight items are expected to load onto one of two factors, Left Detail and Right Detail.

For the recognition task, I expect this healthy sample to produce a normal distribution of scores, with no floor or ceiling effects. For the matching task, however, simplicity of the items for healthy persons is expected to produce a negatively skewed distribution with a substantial ceiling effect. A broad range of item difficulties is expected by design: Some items were created to be mastered by neurological patients so as to foster some degree of self-esteem and a sense of competence within a potentially discouraging examination; these should be answered easily by most or all healthy subjects. Other items were intentionally designed to discriminate among higher functioning individuals and, therefore, to be difficult even for healthy subjects. Good discrimination will be measured for each item by a corrected item-total correlation, the correlation between that item and the Total Score after correcting for the direct contribution of the item to the Total Score. A high item-total coefficient is expected on most items; modest coefficients, however, are expected on items with low item difficulties because success on an item by all subjects restricts the range of the point-biserial. These expectations are summarized below.

Prediction 8a: The CFT Recognition Task will have homogeneous content, as indicated by a strong Total Scale alpha reliability and by moderate subscale alpha reliabilities.

Prediction 8b: The CFT Recognition Total Score will have good convergent validity, that is, will correlate positively with the WMS-R Visual Reproductions recognition score.

Prediction 8c: The CFT Recognition Total Score will have good construct validity in that it will load on a factor with other visual-spatial secondary memory test scores.

Prediction 8d: As further evidence of construct validity, each item of the CFT Recognition Task will load on the a priori scale for which it was designed (Global, Left Detail, or Right Detail), except items 5, 9, and 29.

Prediction 8e: CFT Recognition Total Scores will distribute normally with no ceiling or floor effects.

Prediction 8f: Most items on the CFT Recognition Task will have significant, positive corrected item-total correlations.

Prediction 9a: The CFT Matching Task will have homogeneous content, as indicated by a strong Total Scale alpha reliability and by moderate subscale alpha reliabilities.

Prediction 9b: The CFT Matching Total Score will have good convergent validity, that is, will correlate positively with the WMS-R Visual Reproductions matching score and with the Judgment of Line Orientation test score.

Prediction 9c: The CFT Matching Total Score will have good construct validity in that it will load on a factor with other visual-spatial perception tests, and not with auditory-verbal perception tests or with memory tests.

Prediction 9d: As further evidence of construct validity, each item of the CFT Matching Task will load on the a priori scale for which it was designed (Left Detail or Right Detail), except items 1 and 6.

Prediction 9e: CFT Matching Total Scores will be negatively skewed with a prominent ceiling effect.

Prediction 9f: Most items on the CFT Matching Task will have significant, positive corrected item-total correlations.

METHOD

Subjects

The normative sample consisted of 90 healthy community-dwelling adults. These individuals reported no active central nervous system conditions and were living independently in the community at the time of testing. Volunteers with uncorrectable visual impairment, uncorrectable hearing impairment, or impaired use of the preferred hand were excluded from the sample.

Subjects were solicited from three churches and one synagogue in and near East Lansing, Michigan. Participating organizations received a cash donation for each of the participants from their group. In addition, participating organizations were provided a financial incentive to recruit equal numbers of men and women from each of 10 5-year age bands (30-34, 35-39, ... , 70-74, 75-and-over). With this incentive, I created an age- and sex-stratified sample and minimized socioeconomic bias within the age and sex groups. That is, because each organization is equally represented among men and women and across age groups, potential differences between organizations in socioeconomic status are unlikely to confound age and sex analyses.

The total sample consists of 38 men and 52 women, fairly equally represented (approximately 58% women) from age 30 through age 79+, except in the 60-64 age group where the number of women far exceeded the number of men (82% women). Efforts to remedy this disparity were unsuccessful. In at least one large church, review of the census indicated that men in their early 60s were very disproportionately underrepresented. This same age-sex cell was difficult for all of the groups to fill; therefore, this may reflect a broader cohort bias. Based on 1990 census data, females consistently comprise 48.7 percent of the population among the 1966 and 1990 birth-cohorts (0- and 24-year-olds in 1990) and those in between. From the 1965 cohort backward, the proportion of women increases curvilinearly across the seven successive 10-year age bands (49.6, 50.0, 50.7, 52.3, 55.9, 62.6, and 72.5, respectively; U.S. Department of Health and Human Services, 1993). Although no data are available for the specific 1929-1933 birth-cohorts that were underrepresented here, the steady increase across the lifespan and the relatively modest disproportion of women in this cohort in 1990 (52.3 percent) renders it unlikely that selective mortality could account for the huge disparity (82 percent women) observed in this sample. The reason for this bias is uncertain. Demographic data and health data for the 90 subjects are presented in Tables 2 and 3, respectively.

Instruments

The following descriptions are arranged by instrument. Some of the instruments (for example, the Wechsler Memory Scale-Revised) contain multiple subtests, each of which may test different functions from the other subtests. It is parsimonious to discuss different tests within these batteries within the same section, even though separate subtests may measure very different processes. As an aid to the reader, Table 4 lists each test under the construct it is supposed to measure; Table 5 depicts the order of the tests within the testing sequence. The reader

Table 2

Demographic Data for the Sample, by Age Group.

Variable	Mean	Median	Mode	SD	Min	Max
			Total Group (N = 90)			
Age	55.9	54.5	----	14.1	29	88
Education	15.2	15.0	16	3.0	8	25
Vocabulary	12.5	12.5	12	2.3	5	19
Percent Women	57.8					
			Younger Adults (n = 47)			
Age	43.5	43.2	----	7.4	29	54.9
Education	15.7	16.0	16	2.9	12	25
Vocabulary	12.3	12.0	12	2.6	7	19
Percent Women	55.3					
			Older Adults (n = 43)			
Age	67.5	66.6	----	7.4	55	88
Education	14.6	14.0	12	3.1	8	21
Vocabulary	12.7	13.0	12	2.1	6	17
Percent Women	60.5					

Note. Education is reported in number of years completed. Vocabulary scores are age-corrected scale scores from Wechsler (1981).

Table 3

Frequency of Health Risks, by Age Group.

	Percentage of Group		
	Total	Younger[1]	Older[2]
History of . . .	N=90	n=47	n=43
Intracranial Conditions			
Loss of consciousness following a blow to the head	16	17	14
Unexplained loss of consciousness	8	6	9
Cerebrovascular accident or transient ischemic attack	4	0	9*
Seizures	1	2	0
Neurosurgery (intracranial)	1	2	0
Hydrocephalus	0	0	0
Systemic Conditions			
Hypertension	31	23	40
Heart Disease	18	9	28
Diabetes	10	4	16
Renal disease	16	13	19
Hepatic disease	2	2	2
Pulmonary disease	10	9	12

[1] Younger subjects ranged from 30 to 55 years old.

[2] Older subjects ranged from 55 to 80+ years old.

* $p < .001$. All other comparisons, $p \geq .005$.

Table 4

Listing of Tests by the Constructs They Purportedly Measure.

Affective States
- Beck Depression Inventory ("BDI")
- State Trait Anxiety Inventory ("STAI"; State scale only)

Perception
- Speech Sounds Perception Test ("SSPT"; Series A, B, and C only; AV)
- Judgment of Line Orientation ("JOLO"; VS)
- CFT Matching (VS)
- WMS-R Visual Reproductions ("VR") Matching (VS)

Response Speed
- WMS-R Alphabet Recitation (AV)
- Counting 1-20 (AV)
- Gross Letter Cancellation (VS)
- Gross Symbol Cancellation (VS)

Attention and Concentration
- Discriminative Letter Cancellation (AV)
- Discriminative Symbol Cancellation (VS)
- WMS-R Digit Span ("DS") Backward (AV)
- WMS-R Visual Memory Span ("VMS") Backward (VS)
- Phoneme Matching (AV)
- Shape Matching (VS)

Production
- Letter Fluency: C, F, L (AV)
- Category Fluency: Animal, Fruit, Vegetables (AV)
- CFT Copy (VS)
- WMS-R Visual Reproductions ("VR") Copy (VS)

Primary (Working) Memory and Simple Attention
- WMS-R Digit Span ("DS") Forward (AV)
- WMS-R Visual Memory Span ("VMS") Forward (VS)

Secondary (Recent Long-Term) Memory, Immediate Free Recall
- WMS-R Logical Memory I ("LM-I"; AV, Intentional)
- Cowboy Story (AV, Incidental)
- WMS-R Visual Reproductions I ("VR-I"; VS, Intentional)
- CFT Immediate Recall (VS, Incidental)

Secondary (Recent Long-Term) Memory, Delay Free Recall
- WMS-R Logical Memory II ("LM-II"; AV, Intentional)
- Cowboy Story Delay Recall (AV, Incidental)
- WMS-R Visual Reproductions II ("VR-II"; VS, Intentional)
- CFT Delay Recall (VS, Incidental)

Secondary (Recent Long-Term) Memory, Delay Recognition
- WMS-R Logical Memory Recognition (AV, Intentional)
- Cowboy Story Recognition (AV, Incidental)
- WMS-R Visual Reproductions Recognition (VS, Intentional)
- CFT Delay Recognition (VS, Incidental)

Note. AV=Auditory-Verbal modality; VS=Visual-Spatial modality. Abbreviations in quotation marks are provided for cross-reference; these are conventions used in the field and/or abbreviations used in the text.

Table 5

Sequential Ordering of Tasks and Approximate Number of Minutes Required.

Tasks	Time
Intro, Consent, Neuropsychological Questionnaire	10
CFT Segment (65 minutes)	
Cowboy Story Immediate Free Recall	3
CFT Copy and Immediate Free Recall	10
HRB Speech-Sounds Perception Test	15
Judgment of Line Orientation	5
Cowboy Story Delay Free & Cued Recall, Recognition, Reading)	2
Symbol Cancellation (Gross and two different shapes)	5
CFT Delay Recall, Recognition, Matching	15
RAVLT (one trial only), 7/24	5
Category Fluency (Animals, Fruits, Vegetables)	5
Break (15 minutes)	
Beck Depression Inventory	5
State Trait Anxiety Inventory	10
WMS-R Segment (65 minutes)	
Logical Memory I (Immediate Free Recall)	10
Visual Reproductions I (Immediate Free Recall)	5
Digit Span (Forward & Backward)	5
Visual Memory Span (Forward & Backward)	5
Count 1 to 20	1
Alphabet tasks (Recitation, Phoneme Matching, Shape Matching)	3
Letter Cancellation (Gross, "E," "H")	6
Logical Memory II (Delay Free & Cued Recall, & Recognition)	5
Visual Reproductions II (Delay Free Recall)	6
Visual Reproductions Recognition, Matching, & Copy	6
WAIS-R Vocabulary	10
Letter Fluency ("C," "F," and "L")	3
Total Time	155-180

Note. Most subjects completed the testing in 150 minutes. Total Time ranged from 120 minutes to 180 minutes, with a few exceptions: Three of the oldest subjects required two 2-hour sessions.

may find it useful to consult these tables while reading the following descriptions.

Neuropsychological Questionnaire. Appendix C contains a copy of the survey that was used to collect demographic and medical information for the study. Questions address the participant's sex, age, educational background, and medical history. Age was computed in years (from birth date to testing date); computations used ages that were rounded to the nearest one-thousandth of a year. Education was recorded in whole years completed, beginning with 1st grade. A graduation equivalency diploma (GED) was recorded as 12 years. College and technical training were recorded in full-time, academic-year equivalents; for example, half-time attendance for four semesters was recorded as one year. Sex was coded 0 for men and 1 for women.

Medical history variables were also derived from questions on the questionnaire. Hypertension (HTN) was assessed by the question, "Have you ever had high blood pressure?"; coronary heart disease (CHD), "Have you ever had a heart attack, heart disease, or any other heart problems?"; diabetes mellitus (DM), "Have you ever had diabetes?"; pulmonary disease, "Have you ever had problems with your lungs?"; renal disease, "Have you ever had problems with your kidneys?"; and hepatic disease, "Have you ever had problems with your liver?" Cerebrovascular disease (CVD) was assessed by the question "Have you ever had a stroke or a transient ischemic attack (sometimes they're called TIAs or mini-strokes)?"; hydrocephalus by the question "Have you ever had hydrocephalus (too much fluid in the brain)?"; seizures, "Have you ever been treated for seizures or seizure prevention?"; and loss of consciousness (LOC) following traumatic head injury, "Can you remember the <u>WORST</u> time that you hit your head or suffered a blow to your head? [If yes] Were you unconscious?"

Current alcohol use was assessed by the question "On average, how many alcoholic drinks do you have <u>PER WEEK</u>?" Follow-up inquiries translated the subjects' responses to a standard drink size of approximately 0.6 ounces of pure alcohol (12 ounces of beer = 5 ounces of wine = 3 ounces of port = 1.5 ounces of liquor; Albert, 1988, p. 78). Current tobacco use was assessed by the question "Have you ever smoked cigarettes? [If yes] At <u>present</u>, how many packs do you smoke <u>PER WEEK</u>?"

<u>WAIS-R Vocabulary</u>. As an index of broad intelligence, examiners administered the Vocabulary subtest of the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981). This subtest is desirable because of its ease of administration and because of its high correlation with the Full Scale IQ ($\underline{r}$ = .85). It was also selected because it is the most robust measure of intelligence across the lifespan and is stable even following many forms and locations of neurological insult (Russell, 1987; Wechsler, 1958); thus this provides an IQ index that can be compared across normal and neurological groups in different studies.

<u>Letter Fluency and Category Fluency</u>. As a measure of language production skills, subjects were asked to say as many words as possible that begin with a designated letter of the alphabet or within a given category. Three trials were conducted using different stimulus letters (C, F, L); another three trials used different stimulus categories (animals, fruits, vegetables). A one-minute time limit was imposed. More information about these tasks is available in Lezak (1983, pp. 329 ff).

<u>HRB Speech-Sounds Perception</u>. Auditory-verbal perception was assessed using the Halstead-Reitan Battery Speech-Sounds Perception Test (Reitan & Wolfson, 1993). This measure was chosen because it provides an auditory analogue that is close to the visual measures of perception. Specifically, in the Speech-Sounds test, a tape-recorded nonsense word is presented, and the subject is to identify that word from four choices. The test score is the number of errors; only three of the six 10-item trials were administered so the total possible score was 30.

This test was chosen because the multiple-choice match-to-sample format parallels that used in all three of the visual-spatial perception measures included here (CFT Matching, WMS-R VR Matching, and JOLO). Also, this task uses verbal stimuli instead of tones or rhythms; this was important for verifying the ability to perceive similar verbal stimuli used in the auditory-verbal memory tasks. The Seashore Rhythm Test (Reitan & Wolfson, 1993) and the Woodcock Johnson-Revised Sound Patterns (Woodcock & Johnson, 1989) are nonverbal and are therefore less appropriate. Furthermore, Woodcock Johnson-Revised Sound Blending and Incomplete Words (Woodcock & Johnson, 1989) lack the matching-to-sample format desired for this study.

<u>Judgment of Line Orientation Test (JOLO)</u>. This is a well-standardized and validated measure that measures perception for the orientation of lines in two-dimensional space (Benton, Hamsher, Varney, & Spreen, 1983). In this test, subjects are shown two cards. The top card contains two stimulus lines; each line lies on the card in one of 11 angles, varying from 0° to 180° from the edge of the card. On the bottom card are 11 sample lines radiating from a common vertex, spaced equally from 0° to 180° from the bottom edge of the card. The subject

is instructed to choose the two lines on the bottom card that point in the same direction as the two stimulus lines on the top card. There are 30 items; the score is the number of completely correct items (i.e., both lines matched correctly). This matching-to-sample format parallels the administration of the CFT and VR matching tasks.

Alphabet tracking. The examiners administered two attention tasks used by Coltheart, Hull, and Slater (1975) in their first experiment. These investigators employed two simple tasks to measure relative efficiencies of verbal and visual tracking:

> For the verbal task, subjects were asked to proceed mentally through the alphabet from A to Z, counting the number of letters containing the sound "ee," including E. No external aids such as speaking or writing were permitted. The subjects were asked to perform as rapidly as possible and the time between the beginning of the task and the utterance of the solution was measured. The visual task, performed under the same conditions, was to proceed mentally through the alphabet from A to Z, counting the number of letters containing a curve in their upper-case form. Since no information about the shape of a letter could assist in deciding whether its name contains the sound "ee," and since no information about the sounds constituting the name of a letter could assist in deciding whether its printed form contains a curve, we considered that these tasks were to a sufficient degree purely verbal and purely visual (Coltheart et al., 1975, p. 439).

These two alphabet tracking tasks were modified by DeLuca and Cicerone (1991). In the revised administration, subjects first proceeded through the alphabet silently and counted every letter containing the sound "ee" (silent phoneme). Then they repeated the task, saying each letter aloud as they proceeded (voiced phoneme). Next, subjects silently counted all the curved letters (silent shape). They then repeated the task vocally (voiced shape). A speeded recitation of the alphabet was also administered.

Because silent phoneme and silent matching do not permit analysis of the number of errors, these two trials were not analyzed in this study. For the recitation and two voiced trials, speed and accuracy were combined into a single variable, "seconds per target" (SPT):

$$SPT = \frac{\text{Time}}{\text{Number Correct}}$$

Recitation SPT served as an index of response speed. Phoneme Tracking SPT and Shape Tracking SPT measured verbal and visual attention, respectively.

<u>Counting 1-20</u>. As another measure of verbal response speed, examiners asked the subjects to perform a presumably automated function, similar to the alphabet recitation. Subjects were instructed to count from one to 20 as fast as possible. Counting SPT will be computed as described above.

<u>Letter Cancellation</u>. The examiners administered six timed trials of a letter cancellation task, similar to tasks described by Lezak (1983, chapter 17) as measures of attention. Stimuli were large print prose paragraphs (Appendix D). For the first two trials, the subjects crossed out every letter on the page (gross cancellation). On the next two trials, the subjects crossed out all of the e's on the page. On the last two trials, the target letter was "h." The two "e" trials

contained equal numbers of targets, and the two "h" trials also had equal numbers of targets. In addition, each trial had equal numbers of silent and pronounced targets.

Speed and accuracy were combined into a single variable, "seconds per target" (SPT), computed by applying the same formula used "Alphabet Tracking." SPTs were computed for each trial. SPTs for the first two trials were summed to provide an index of manual response speed (Gross Letter SPT). SPTs for the four discriminative trials were summed to provide a measure of attention in the auditory-verbal modality (Letter Tracking SPT).

Symbol Cancellation. As a visual-spatial analogue to the letter cancellation tasks described above, I designed three timed cancellation trials using three pages of geometric symbols as stimuli (Appendix E). The examiners administered three timed trials of symbol cancellation, similar to the tasks described in the "Letter Cancellation" section above. For the first trial, the subjects crossed out every symbol on the page (gross cancellation). On the next trial, the subjects crossed out every occurrence of a specific symbol that the examiner circled in a key at the top of the page. On the last trial, a different symbol in the key was circled as the target.

Speed and accuracy were combined into a single variable, "seconds per target" (SPT), computed by applying the same formula for "Alphabet Tracking." SPTs were computed for each trial. SPT for the first trial provided an index of manual response speed (Gross Symbol SPT). SPTs for the two discriminative trials were summed to provide a measure of attention in the visual-spatial modality (Symbol Tracking SPT).

CFT. The Complex Figure Test (CFT) has been described already. The original copy trial, immediate recall trial, and delay recall trial (20-minute delay) were supplemented by the recognition (Appendix A) and matching trials (Appendix B) that were developed as part of this project. Because of the unreliability of other scoring systems, I developed my own scoring criteria (Appendix F) for the free recall and copy drawings by modeling the criteria for WMS-R Visual Reproductions (Wechsler, 1987). The interrater reliability on 23 complete protocols spanning a wide range of ability was very good for the copy drawings ($r = .90$) and exceptional for immediate and delay recall drawings ($r = .97$ for both; Fastenau & Denburg, 1994).

WMS-R. Several subtests from the Wechsler Memory Scale-Revised were administered; psychometric information for this battery is documented in the manual (WMS-R; Wechsler, 1987). Digit Span and Visual Memory Span assessed verbal and visual attention, respectively; however, these attention skills appear to be synonymous with primary memory.

There are four measures of secondary memory. Two are auditory-verbal in nature: Logical Memory I (LM-I) for immediate recall and Logical Memory II (LM-II) for delay recall. I wrote 10 multiple-choice questions for each of the two LM stories to measure auditory-verbal recognition memory. These questions were modeled after questions written by Edith Kaplan (formerly of Boston Veteran's Administration Medical Center) in her "Process Approach" to the original version of the Wechsler Memory Scale (Wechsler, 1945). The distractors for my set of questions were designed using the scoring criteria (frequently occurring incorrect responses) for LM in the WMS-R manual.

Two other measures of secondary memory are visual-spatial in nature, using simple geometric designs for stimuli: Visual Reproductions I (VR-I) for immediate recall and Visual Reproductions II (VR-II) for delay recall. VR-II was followed by a recognition trial and a matching trial; Hanger and his colleagues recently developed these stimuli (Hanger, Montague, & Smith, 1991) and provided the items for inclusion in this study (Appendix G). Subjects then copied the VR stimuli as a demonstration of constructional ability (Fastenau & Sloan, 1993).

Digit Span Backward (DS-B) and Visual Memory Span Backward (VMS-B) were included as measures of verbal and visual attention, respectively. The use of these as attentional indices is based on a discussion by Lezak (1983, pp. 550-551).

Finally, I had the subjects recite the alphabet as quickly as possible, using the instructions from the Mental Control subtest of the WMS-R. This overlearned and automated recitation served as a measure of simple verbal response speed. Prorated time (SPT) was computed.

<u>Cowboy Story</u>. This memory task has been used in mental status exams for many decades (Franz, 1919; Talland, 1965, ch. 9). Originally, it was administered in a procedure very similar to WMS-R LM-I, as an intentional memory task for aurally presented material; that is, the patients were told in advance to try to remember the story and then they listened to the story as it was read to them. However, in the present study the subjects themselves silently read the passage from an 8 1/2" x 11" white page with large black print. The examiner gave the subjects no indication that they should remember it. Immediately afterward, the examiner removed the stimulus and asked the subjects to recall as much

as possible. After a delay of no fewer than 20 minutes, subjects were asked again to recall as much of the story as possible. Thus, the presentation was modified from an intentional aural administration to an incidental reading administration, as an auditory-verbal analogue to the ECFT.

I designed criteria for scoring the free recall reports, modeling my criteria after the LM system in the WMS-R manual (Wechsler, 1987). In addition, ten multiple-choice recognition items recorded in Talland's chapter were modified to more contemporary language. The story and questions are appended (Appendix H). Some psychometric data are presented in Talland (1965). Talland, however, used the standard procedure (intentional, aural presentation of the story); there are no data for the visual, incidental presentation used in this study.

Rey Auditory Verbal Learning Test (RAVLT). In the standard administration of the RAVLT (Rey, 1964, cited in Lezak, 1983; Taylor, 1959), subjects are read a list of 15 words and are asked to repeat as many as words as possible. The first trial was believed to measure immediate memory span, similar to other primary memory tasks like the WMS-R and WAIS-R Digit Span subtests (Lezak, 1983, pp. 426-427). Additional trials provide information about rate of learning and interference. However, in this study, only one trial was administered. The examiner first said, "I am going to read a list of words. Listen carefully, for when I stop you are to say back as many words as you can remember. It doesn't matter in what order you repeat them. Just try to remember as many as you can" (Lezak, 1983, p. 423). The following words were then read to the subject at a rate of one per second, in accordance with the standardized administration: Drum, Curtain, Bell, Coffee, School, Parent, Moon, Garden, Hat, Farmer, Nose, Turkey, Color, House, River. Because this measure exceeds the primary memory span and shows primacy and recency effects in recall (indicative of mixed primary and secondary memory involvement), these data will not be analyzed in this study. It is described here so that the reader will know what other tasks the subjects completed as part of the battery.

7/24. Barbizet and Cany (1968; reported in Lezak, 1983, p. 456-459) developed a measure of visual memory that was modified by Rao, Hammeke, and Huang (1982; also reported in Lezak, 1983) to be analogous to the RAVLT. As with the RAVLT, recall on the first trial of 7/24 was originally believed to represent the immediate memory span, but for visual material. The white stimulus card contains a 4 x 6 rectangular checkerboard with black dots in seven of the 24 squares. The examiner says, "in a moment, I'm going to show you a card that looks like this," placing a blank 4 x 6 checkerboard answer sheet in front of the subject, "only there will be black dots in some of the spaces. You will have 10 seconds to look at the card. Then I will take it away and let you fill in this blank one from memory. Try to remember which squares have dots in them so that, afterwards, you can place each dot in the correct square on the blank card. Don't begin to draw it until I say 'Go.' Ready?" The examiner reveals the stimulus card for 10 seconds and then removes the card saying, "Now mark the boxes that had circles in them."

Beck Depression Inventory. In addition to the cognitive measures described thus far, two instruments were administered to assess emotional states that are reportedly salient to memory performance. The Beck Depression Inventory (BDI; Beck, 1978) is a standardized and well-validated self-inventory of depression. It includes four statements of hierarchical intensity for each of 21 depressive symptoms. Subjects are asked to indicate which one of the four statements best describes how they have been feeling over "the past week, including today." The weights of all the endorsed statements are summed for a Total Score, which can be compared to normative data. A recent meta-analysis of research with this instrument indicated that the BDI correlates well with other inventories of depression and with physiological and behavioral symptoms of depression. Furthermore, BDI Total Scores effectively discriminate psychiatric from nonpsychiatric patients (Beck, Steer, & Garbin, 1988). These findings were corroborated by other reviews (Rehm, 1988).

State Trait Anxiety Inventory. Another emotional measure used was the State Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Like the BDI, this is a standardized and well-validated self-report inventory. Each anxiety scale, State and Trait, consists of 20 statements accompanied by four-point intensity rating scales. The State scale assesses how subjects feel "right now, at this moment"; the Trait scale assesses how they "generally feel." This instrument is reported to have strong psychometric properties (Chaplin, 1984).

Procedure

Recruitment

The investigator contacted five Christian churches and one synagogue to solicit participation for the study. The purpose of the study and the need for healthy adults living in the community were described. Also explained were the testing (two and one-half hours of pencil-and-paper tests of memory and related skills such as attention, hearing, and drawing); the assurance of confidentiality; and the subject's right to decline any part of the testing and to withdrawal from the project. Volunteers with uncorrected vision, uncorrected hearing, or impaired use of their preferred hand were excluded from participation. I offered each organization $10 for each volunteer who completed testing; in addition, there was a $50 bonus for every 20 volunteers who matched the minimum age-sex distribution (i.e., 1 man and 1 woman in each of 10 5-year age bands). One church declined to participate and another declined to coordinate the volunteer sign-up based on their opposition to "fund-raising" in the church. Three organizations generated 18 to 20 volunteers each, and another generated 33 volunteers; prorated bonuses were awarded to each organization for having carefully attended to the age-sex criteria. Appended is the confirmation letter that was mailed to the contact person at each organization to be distributed to interested persons (Appendix I).

Scheduling and Everyday Memory Questionnaires

Subjects' names and phone numbers were provided to me by the coordinator at each organization. I or one of the research assistants called the subjects, explained the project to them, answered any questions, scheduled an appointment at the MSU Psychological Clinic, and then administered the Subject's Everyday Memory Questionnaire. If the subject gave permission, the investigator phoned the designated informant for the Relative's Everyday Memory Questionnaire.

Introduction

All subjects were tested individually. Most subjects came to the MSU Psychological Clinic for testing, and testing was conducted in quiet, private testing rooms. Five subjects with limited mobility were tested in their homes; steps were taken to maintain the same quiet, private testing conditions created at the Clinic.

Most subjects completed the testing in one session, lasting from two to three hours. Three older subjects required two sessions for optimal testing; in each case, the subject completed one full section ("CFT" or "WMS-R") followed by the "Break" section during the first visit; this ensured that depression and anxiety measures immediately followed the first section of testing for all subjects.

The following description of the testing session is also outlined in Table 5. When subjects arrived for testing, the examiners introduced themselves. They then presented the consent form, which explained in writing the nature of the study, the confidentiality of the data, and the subject's right to terminate participation at any time (Appendix J). After the consent form was signed, the examiner asked a standard set of questions regarding the subject's neuropsychological history (Appendix C). These preliminary steps helped establish rapport with the subject before formal testing began.

The examiner prefaced the actual testing by saying, "We'll work for about one hour. Then, we'll have a break before we begin again. Would you like to get some water or use the bathroom now, before we get started?" When the subject was ready to begin, the examiner said, I'm going to ask you to do a lot of things today. Some of them may seem very easy to you, perhaps even silly. Other tasks may challenge you a bit. There may even be some things that you can't do at all. On every task, just do your best, and then we'll move on to the next one."

CFT Segment

The CFT segment and the WMS-R segment were counterbalanced. That is, some subjects took the CFT segment before the break, followed by the WMS-R segment (Table 5). The other subjects took the WMS-R segment first, followed by the CFT segment. The assignment to these two conditions was stratified within age-sex cells.

Cowboy Story, Immediate Recall. The CFT segment began with the Cowboy story. The examiner said, "Take a moment and read this story to yourself. Tell me when you are done." This was not introduced as a memory task. After the subject finished, the examiner removed the stimulus page from view and said, "Now what did you just read? Tell me everything and begin at the beginning." The examiner recorded the subject's report verbatim. Then the examiner asked the subject to tell the story one more time to verify that nothing was omitted. The examiner would not change or delete anything from the first record but would only add material that had not been recorded in the first report. Using the WMS-R Logical Memory scoring criteria as a model, I developed scoring criteria for the Cowboy Story; these criteria were used for delay recall also (Appendix H).

CFT, Copy. The examiner placed a clean 8 1/2 x 11 sheet of white paper (marked with a "C" and the subject number in one corner) on the table in front of the subject and said, "I have something I want you to copy VERY CAREFULLY. As you work, I will hand you different colored pens. When I hand you a new pen, place the other pen aside and continue with the pen I hand you." The examiner handed the subject the first pen, turned the stimulus card over, and said, "Draw this picture as

ACCURATELY as you can. Try to make your drawing look identical to the picture in every way."

A stopwatch, visible to the subject but not emphasized, was then started and stopped when the subjects gave clear indication that they were finished. If subjects indicated that they could not draw (e.g., "I'm no artist"), the examiner responded, "Do your best. Draw it as accurately as you can." If the subject expressed concern about being timed, this same examiner response was provided. Examiners changed pens at approximately 20-30 second intervals. The new pens were introduced smoothly but assertively when the subject lifted his or her hand/pen between lines. If the subject ignored the new pen for more than five seconds, the examiner said, "Now take this pen." The examiner recorded the subject's hand preference, the color sequence of the pens, and the time to completion. Drawings were scored only for accuracy (Appendix F), not for organizational style.

CFT, Immediate Recall. Following the copy trial, the examiner removed the stimulus card and the copy drawing and placed them out of sight. Then, the examiner laid down a new, clean sheet of paper (marked with an "I" and the subject number in one corner). Handing the subject the first pen, the examiner said, "Now draw as much of it as you can from memory. Draw the picture as ACCURATELY as you can." Pens were introduced at approximately 15-20 second intervals initially, and then the timing was gauged by the subject's speed. Color sequence was recorded by the examiner after each pen was introduced. Again, a timer was started. When the subject finished, the examiner said, "I always tell people to take another moment in case something else comes to mind." The time was recorded at the second indication that the subject had finished. The subject was not told that there would be another memory trial. A delay was then imposed by the administration of the following tasks.

Speech-Sounds Perception Test. This test was administered and scored in standardized fashion (Reitan & Wolfson, 1993, pp. 267-271) but using only the first three trials instead of all six. Consistent with the manual and with other studies using this measure, scores on this task reflect the number of errors, with 30 points possible.

Judgment of Line Orientation. This test was also administered and scored in standardized fashion (Benton, Hamsher, Varney, & Spreen, 1983, ch. 5). Scores reflect the number of items that are completely correct, with 30 points possible.

Cowboy Story, Delay Recall. The examiner said, "Do you remember the little story you read a few minutes ago? Now I want you to tell me that story again. Tell me everything; begin at the beginning." If the subject could not remember the story, the examiner said, "The story was about a cowboy." However, no credit was given for the first phrase ("A cowboy") if the reminder was required. The examiner recorded the subject's report verbatim and then asked the subject to tell the story one more time to verify that nothing was omitted. The examiner did not change or delete anything from the first record but only added material that had not been recorded in the first report. Finally, the examiner handed the original Cowboy stimulus to the subject again and said, "Okay, now I would like you to read this story again, but this time read it out loud." While the subject read, the examiner noted any errors. When scoring memory trials, the recall was compared to what was actually read.

Rey Auditory Verbal Learning Test. The examiner introduced the next task by saying, "I am going to read a list of words. Listen carefully, for when I stop you are to say back as many words as you can remember. It doesn't matter in what order you repeat them. Just try to remember as many as you can." The following words were read at a rate of one word per second, and not one second between words: drum, curtain, bell, coffee, school, parent, moon, garden, hat, farmer, nose, turkey, color, house, river. The examiner recorded the order in which the words were repeated and wrote any intrusions verbatim. Plurals were accepted for credit; intrusions and omissions were scored as errors.

Gross Symbol Cancellation. The examiner placed the stimulus sheet (SC-1) and a pencil in front of the subject and said, "This is a test to see how quickly you can draw a line through each symbol on this page, like this." Then, the examiner drew a line through each symbol in the "Key," from left to right. "When I tell you to start, you do the rest of them. Begin here (pointing to the top left) and draw a line through every symbol as quickly as you can, one after the other, without skipping any. Make sure that your line touches one and only one symbol. When you finish this line (sweeping finger across the top line), go on to the next one (pointing). Keep working until you reach the end (pointing). Work as quickly as you can without making mistakes. Ready. Go!" Timing was started immediately and was stopped as soon as the subject cancelled the last symbol (bottom right) or gave clear indication of being finished. If subjects asked whether they could sweep left-to-right down one line and then right-to-left down the next, the examiner repeated the corresponding direction with emphatic sweeping gestures; however, if subjects used such a zigzag motion during the timed trial, they were not interrupted. The time to completion was recorded; later a template was used to count omissions. Omissions were scored if there was no line present for a target or if less than 50% of the line closest to a target was within the box of that target; a line that touched two targets received credit for only one target.

Discriminative Symbol Cancellation. SC-1 was removed immediately so that subjects could not review their performance. SC-2 was then placed on the table. "Good. Let's try another one. This time, I'm going to circle one of the symbols in the key. I want you to go across the page, same as before, but this time cross through only the symbol I circle. Make sure that your line touches one and only one symbol. Begin here (pointing to the top left) and draw a line through that symbol each time you see it. When you finish this line, go on to the next one. Keep working until you reach the end. You are looking for this symbol (circling #2 in the Key: the horizontal with a dot underneath). Work as quickly as you can without making mistakes. Ready. Go!" The time to completion was recorded; later a template was used to count omissions.

SC-3 was presented in similar fashion. "Good. Let's try one more. This time, I'm going to circle a different symbol in the key. You are looking for this symbol (cIrcling #5, the center symbol, in the Key: the "T" that is turned clockwise 90°). Work as quickly as you can without making mistakes. Ready. Go!" Time and omissions were recorded. For all three symbol cancellation trials, time and omissions were combined into a summary score, "Seconds Per Target" (SPT), described earlier ("Instruments" section).

CFT, Delay Recall. At this point, the examiner placed the color markers on the table with a clean sheet of white paper and said, "Do you remember that picture you copied for me? I want you to draw as much of it as you can from memory. Draw the picture as ACCURATELY as you can." Again, a timer will be started. Pens were changed at approximately 10-15 second intervals initially; the timing was then gauged by the subject's speed. The sequence of the pens was recorded. When the subject finished, the examiner said, "Take another moment and see if anything else comes to mind." The time was recorded at the second indication that the subject is finished. Scoring was described earlier.

CFT, Recognition. The examiner presented the first recognition item and said, "Which one of these was part of the ORIGINAL picture, which you copied a little while ago? Point to the right one." If the subject was correct ("a" is correct), the examiner said, "That's right. Of these five, this one looks most like the original picture," and then recorded the response. If the first response was incorrect (any R except "a"), the examiner said, "No, that's incorrect. Do you remember the card that was lying on the table? If the card were sitting on this page facing you (here, the examiners outlined the imaginary card with their fingers, above the page), how would the picture look to you?" If the subject was correct on the second attempt, the examiner said, "That's right. Of these five, this one looks most like the original picture," and continue with Number 2. If incorrect again, the examiner said, "No, the picture on the card had this shape" (pointing to the correct answer). If the subject appeared confused, the examiner elaborated as necessary but without describing any more elements of the stimulus. This was to make sure that the subject understood the task and to ensure that the subject was correctly oriented to the layout of the drawings. Whether or not the confusion cleared, the examiner continued with #2, offering no more help.

The examiner presented the second test item saying, "Which one of these was part of the original picture, which you copied a little while ago? Point to the right one." The examiner recorded the response but provided no feedback. These instructions were repeated as necessary for each item, abbreviating or eliminating the directions as the subject became more familiar with the task.

Each item answered correctly received one point credit, with all 30 items contributing to the Total Scale. Items 1-4 and 6-8 comprise the Global Scale. Items 5 and 9-30 comprise the Detail Scale. The Right Neglect Scale consists of Items 5, 12, 13, 16, 17, 19, 21, 22, 25, 26, 28, and 30. The Left Neglect Scale consists of Items 10, 11, 14, 15, 18, 20, 23, 24, and 27.

<u>CFT, Matching</u>. The first matching stimulus card was placed alongside the corresponding multiple-choice array (identical to the array used in the recognition task), and the examiner said, "Which one of these (pointing to multiple-choice array) looks like this (pointing to stimulus) picture? Point to the right one." If the subject was correct, the examiner said, "That's right. Now try this one." If the subject was incorrect on the first item, the examiner said, "No, <u>THIS</u> one (pointing to the correct response) looks the most like this (pointing to the stimulus) picture. Try this one. Which one of these looks like this picture (pointing)?" Feedback was not provided on any remaining items.

Each item answered correctly received one point credit, with all 10 items contributing to the Total Scale. The Right Neglect Scale consists of Items 4, 5, 9, and 10. The Left Neglect Scale consists of Items 2, 3, 7, and 8.

7/24. The examiner then placed a blank checkerboard answer sheet (with an asterisk in the upper right hand corner) in front of the subject and said, "In a moment, I'm going to show you a card that looks like this, only there will be black dots in some of the spaces. You will have 10 seconds to look at the card. Then I will take it away and let you fill in this blank one from memory. Try to remember which squares have dots in them so that, afterwards, you can place each dot in the correct square on the blank card. Don't begin to draw it until I say 'Go.' Ready?" Then the examiner revealed the design on the stimulus card by turning the card so that the asterisk was in the subject's upper right hand corner. After 10 seconds, the stimulus card was removed and the subject was instructed, "Now mark the boxes that had circles in them. Go." Any mark was scored; a circle was not necessary for credit. Omissions and commissions were recorded separately.

Letter Fluency. Finally, the examiner said, "I'm going to say a letter of the alphabet and then I want you to tell me all of the words you can think of that begin with that letter, as fast as you can. But proper names are not allowed, so if the letter were 'B' you would NOT say 'Boston' or 'Bob.' (After a pause) The letter is 'C.' Now tell me all the words you can think of that begin with the letter 'C.' Ready. Begin!" The examiner recorded every word produced for one minute, noting each 15 second interval with a hash mark.

At the end of the first trial, the examiner said, "Okay. Now we're going to do the same thing again, but this time tell me all the words you can think of that begin with the letter 'F.' Do it as fast as you can. Ready. Begin!" Again, the examiner recorded the responses for one minute, noting each 15 second interval with a hash mark.

The third trial was introduced in similar fashion: "Good. Now, we'll do it one more time, but this time tell me all the words you can think of that begin with the letter 'L.' Do it as fast as you can. Ready. Begin!" Responses were recorded as before. On all three trials, each accurate response received one point credit.

Break Between Segments

Between the CFT segment and the WMS-R segment, irrespective of the order of the segments, we gave the subject a break and asked them to complete the State-Trait Anxiety Inventory (STAI) and the Beck Depression Inventory (BDI). "Now you can take a brief break. Then take a few minutes to complete these two questionnaires. Be sure to complete both sides of each one. Notice that this one (BDI) asks about how you've been feeling over 'THE PAST WEEK, INCLUDING TODAY' (underlining that phrase in the directions). This one (STAI) is different on each side. On this side, describe how you feel 'RIGHT NOW, ... AT THIS MOMENT' (underlining). On the other side, describe how you 'GENERALLY FEEL' (underlining). Please don't write your name on either of these forms." Both instruments were scored in accordance with their manuals. When the subject was ready, testing resumed.

WMS-R Segment

Logical Memory I. The WMS-R segment began with Logical Memory (LM) I, immediate free recall for paragraph-length stories, in strict adherence to the directions and scoring criteria in the manual (Wechsler, 1987).

Visual Reproductions I. Visual Reproductions (VR) I, immediate free recall drawings for geometric designs, followed LM I and were administered and scored as instructed in the manual (Wechsler, 1987).

Digit Span. Digit Span, repetition of numerical strings, was administered next in standardized fashion (Wechsler, 1987).

Visual Memory Span. Visual Memory Span followed (Wechsler, 1987).

Count 1-20. The next task was introduced as follows: "I want to see how quickly you can count from 1 to 20, like this--1, 2, 3, all the way to 20. Go ahead!" The timer was started immediately after the directions were concluded. Time, omissions and commissions were recorded; time and omissions were combined into the summary score, "Seconds Per Target" (SPT), described earlier in this chapter ("Instruments" section).

Alphabet Recitation. Then the examiner said, "Now I want to see how quickly you can say the alphabet for me, like this--A, B, C. Go ahead!" The timer was started immediately. Time, omissions and commissions were recorded, and SPT was computed.

Silent Phoneme Matching. The examiner then said, "Now I want you to silently think of the alphabet and, without saying anything, count every letter that contains the sound 'ee.' As quickly as you can, tell me how many letters contain the sound 'ee.' Go ahead!" The timer was started immediately and stopped when the subjects gave their answers. Time and the subject's response were recorded. This format only permits a dichotomous score on accuracy, that is, whether or not the response matches the correct answer.

Voiced Phoneme Matching. The examiner continued, saying, "Now we'll do it again, only a little differently. This time, I don't want you to count the letters. Instead, start from the beginning and tell me every letter that contains the sound 'EE' as you go. Do it as quickly as you can without any mistakes. Go ahead!" The timer was started immediately and stopped when the subjects provided the first indication of being finished (e.g., looking up at the examiner or dropping the pitch in their voices) OR as soon as they reach "Z" (if they recited in order). Time, omissions, and commissions were recorded, and SPT was computed.

Silent Shape Matching. The next task was introduced. "Now we'll do a different exercise. Once again silently think of the alphabet, but this time picture it typed in upper-case form--that is, all capital letters. Without saying anything, count every letter that contains a curve. As quickly as you can, tell me how many letters contain a curve. Go ahead!" The timer was started immediately after saying "Go ahead" and stopped when the subjects gave their answers. Time and the subject's response were recorded. Again, this format permits only dichotomous scoring on accuracy.

Voiced Shape Matching. The examiner continued, saying, "Now we'll do it again, only a little differently. This time, I don't want you to count the letters. Instead, start from the beginning and tell me every letter that contains a curve as you go. Do it as quickly as you can without any mistakes. Go ahead!" The timer was started immediately and stopped when the subject provided the first indication of being finished (e.g., looking up at the examiner or dropping the pitch in their voices). Every response was recorded, together with the total time.

Subjects were not penalized for reporting letters out of order. Time, omissions, and commissions were recorded, and SPT was computed.

Gross Letter Cancellation ("LC-1" and "LC-2"). Next, the examiner placed the stimulus marked "LC-1" in front of the subject with a pencil and said, "This is a test to see how quickly you can draw a line through each letter on this page, like this (drawing a line through each letter in the key words above the paragraph, from left to right). When I tell you to start, you do the rest of them. Begin here (pointing to the top left) and draw a line through every letter as quickly as you can, one after the other, without skipping any. When you finish this line, go on to the next one (pointing). As soon as you get to the end, cross through the word 'FINISHED' here (pointing). Make sure that your line touches one and only one letter. Work as quickly as you can without making mistakes. Ready. Go!"

The examiner started timing immediately and stopped timing as soon as the subjects canceled the word "Finished" (bottom right) or gave clear indication that they were finished. If necessary, the following prompts were used to redirect the subject: "Do them in order. Don't skip any. Do this one next" (pointing to the item omitted), or "Make sure that your line touches one and only one letter." Time was recorded and a template was used to count omissions (absence of a unique line for one of the targets). Time and omissions were combined into a summary score, "Seconds Per Target" (SPT), described earlier in this chapter ("Instruments" section).

Removing LC-1 and placing LC-2, the examiner said, "Good. Let's try another one. You'll do this one the same way as the last one. Begin here; as soon as you get to the end, cross through the word

'Finished.' <u>Make sure that each line touches one and only one letter</u>. Work as <u>quickly</u> as you can without making mistakes. Ready. Go!" Timing and scoring were the same as on LC-1.

<u>Discriminative Letter Cancellation</u>. The examiner then exchanged LC-2 for LC-3 and said, "Okay. Let's try another one. This time, I'm going to write a letter at the top of the page. I want you to go across the page, same as before, but this time cross through only the letter I write. Begin here (pointing to the top left) and draw a line through that letter each time you see it. As soon as you get to the end, cross through the word 'Finished' here (pointing). You are looking for the letter 'E' (writing 'E/e' at the top of the page). Work as <u>quickly</u> as you can without making mistakes. Ready. Go!" Timing and scoring were the same as on LC-1.

Upon completion of LC-3, the examiner introduced LC-4, saying, "Good. Let's try another one. You'll do this one the same way. You are looking for the letter 'E' (writing 'E/e' at the top of the page). Work as <u>quickly</u> as you can without making mistakes. Ready. Go!" Timing and scoring were the same as on LC-1.

The examiner then exchanged LC-4 for LC-5 and said, "Okay. Let's try another one. This time, I'm going to write a different letter at the top of the page. I want you to go across the page, same as before, but this time cross through only the letter I write. You are looking for the letter 'H' (writing 'H/h' at the top of the page). Work as <u>quickly</u> as you can without making mistakes. Ready. Go!" Timing and scoring were the same as on LC-1.

Upon completion of LC-5, LC-6 was introduced saying, "Good. And now I have just one more. You'll do this one the same way. You are looking for the letter 'H' (writing 'H/h' at the top of the page). Work as quickly as you can without making mistakes. Ready. Go!" Timing and scoring were the same as on LC-1.

Logical Memory II. Delay free recall for the LM stories was administered according to the directions in the manual and scored by the criteria in the manual (Wechsler, 1987).

Visual Reproductions II. Delay free recall for the VR designs was administered according to the directions in the manual (Wechsler, 1987). The drawings were scored using the manual's criteria.

Visual Reproductions, Recognition. The examiner presented the first recognition item and said, "Which one of these was the original picture which you copied a little while ago? Point to the right one." The first response was recorded and then feedback was provided. If the subject was correct (correct R is "d"), the examiner said, "That's right. Of these five, this one looks most like the original picture."

If the first response was incorrect (any R other than "d"), the examiner said, "No, that's incorrect. Do you remember the card that was lying on the table? If the card were sitting on this page facing you (the examiner outlining an imaginary card with his or her finger, above the page), how would the picture look to you?" If the subject was correct on the second attempt, the examiner said, "That's right. Of these five, this one looks most like the original picture." If the subject was incorrect again on the second attempt, the examiner said, "No, the picture on the card had this shape (pointing to the correct answer)."

If the examinee appeared confused, the examiner elaborated as necessary in order to help the subject understand the task and to ensure that the subject was correctly oriented to the layout of the drawings. Whether or not the confusion cleared, the response was recorded and the examiner continued with Item 2. No further help was offered.

In presenting Item 2, the examiner said, "Which one of these was the original picture which you copied a little while ago? Point to the right one." Instructions were abbreviated as subject became familiar with the directions. Response were recorded without providing feedback. Each correct response received one point credit, and item scores were summed for a maximum Total Scale score of 5.

Visual Reproductions, Matching. Then, the first matching stimulus card (Card A from the WMS-R Kit) was placed alongside of the corresponding multiple-choice array (identical to the array used in the recognition task), and the examiner said, "Which one of these (sweeping finger across the multiple-choice array) looks like this picture (pointing to the stimulus)? Point to the right one."

The response was recorded, and feedback was provided on the first item. If correct, the examiner said, "That's right. Now try this one." If incorrect, the examiner said, "No, this one (pointing) looks the most like this picture (pointing). Try the next one. Which one of these looks like this picture (point)?" No further feedback was provided. Response were recorded without providing feedback. Each correct response received one point credit, and item scores were summed for a maximum Total Scale score of 5.

Visual Reproductions, Copy. The examiner placed the blank "VR-II Copy" sheet, unfolded, on the table in front of the subject. The first Visual Reproduction card ("Flags") was placed above the top of the page. The examiner instructed the subject, "Copy this picture as accurately as you can. Try to make your drawing look identical to the picture in every way." Draw it here (pointing to the first blank space on the record sheet). If subjects indicated that they could not draw (e.g., "I'm no artist"), the examiner responded, "Do your best. Draw it as accurately as you can." The subject was permitted to erase.

This procedure was repeated for each of the other three stimulus cards ("Circles," "Windows," and "Rectangles/Semicircle"), with the examiner emphasizing accuracy on <u>every</u> stimulus. The drawings were scored using the WMS-R Visual Reproduction criteria (Wechsler, 1987).

<u>WAIS-R Vocabulary Subtest</u>. This test was administered and scored according to the manual (Wechsler, 1981).

<u>Category Fluency</u>. The examiner introduced the next task saying, "I want to see <u>how many</u> different animals you can name. Any animals will do; they can be from the farm, from the jungle, from the ocean or even house pets. For instance, you can start with 'dog.' You have one minute. Try to say as many as you can until I tell you to stop. Ready. Begin!" The examiner recorded every word produced for one minute, noting each 15 second interval with a hash mark.

At the end of the first trial, the examiner said, "Good. Now we're going to do the same thing again, but this time I want to see how many different <u>fruits</u> you can name. Any fruits will do. You have one minute. Try to say as many as you can until I tell you to stop. Ready. Begin!" Again, the examiner recorded the responses for one minute, noting each 15 second interval with a hash mark.

The third trial was introduced in similar fashion: "Okay. Now, we'll do it one more time, but this time I want you to name as many different <u>vegetables</u> as you can. Do it as fast as you can. Ready.

Begin!" Responses were recorded as before. On all three trials, each accurate response received one point credit.

Debriefing. At the end of the testing session, the examiner handed subjects the debriefing form (Appendix K) and asked them to read it. Upon indication that they had read the debriefing sheet, the examiner encouraged the subjects to take the form with them and then thanked them for their participation.

RESULTS

Correlations were used to describe bivariate relationships. Pearson product-moments were used when both variables were continuous and interval in nature; point-biserials were computed when one variable was continuous and interval and the other was discrete and nominal. For all predicted relationships, the direction was specified so one-tail tests were applied; when no relationship was expected, two-tail tests were applied. Because of the excessive number of analyses being performed on this data set (9 predictions involving multiple analyses each), a stringent cutoff for Type I error was applied to guard against alpha inflation. Following the Bonferroni convention (recommended by Cohen & Cohen, 1983, p. 504), I divided the desired alpha, .05, by the expected number of significance tests (approximately 55) for a stringent alpha of .001. At an experimentwise error rate of approximately 1 - (1-alpha) $^{g-1}$, where g is the number of comparisons or significance tests to be performed, an alpha of .001 over 55 significance tests keeps the experimentwise Type I error rate at .05. In addition, I collapsed across trials and across variables to create summary variables wherever it was prudent, in order to minimize the number of independent variables (e.g., combining error scores and time into a "Seconds Per Target" score on Letter Cancellation and taking the mean of all equivalent trials; Cohen & Cohen, 1983, chapter 4).

In the conventional, "variance decomposition" model, $\underline{r}^2$ best estimates the percentage of variance in the dependent variable that is explained by the independent variable (Cohen & Cohen, 1983, p. 100; Ozer, 1985). In "variance partitioning" models, however, the correlation itself best estimates the variance explained. This model applies in several situations, including the determination of measured variables by a latent trait. In concurrent validity, for example, two tests are assumed to measure the same construct; $\underline{r}$, and not $\underline{r}^2$, can be interpreted as the amount of variance in those tests that is explained by that construct (Ozer, 1985). In addition to its use for estimating variance explained, some advocate that $\underline{r}$, rather than $\underline{r}^2$, is a better indicator of effect size (Gorsuch, 1991; Nelson, Rosenthal, & Rosnow, 1986; Rosnow & Rosenthal, 1988). Both $\underline{r}$ and $\underline{r}^2$ will be reported.

The predictions in this study were numbered according to their appearance in the literature review. However, for the purposes of describing the results, another ordering seemed more logical. Consequently, the results and the discussion begin with Predictions 4, 5, and 6, followed by Predictions 1, 2, and 3. Predictions 7, 8, and 9 complete the results and discussion chapters.

Prediction 4a: Attentional skill and perceptual accuracy will correlate negatively with age in both auditory-verbal and visual-spatial modalities.

Correlations with age were computed for the summary attentional and perceptual measures in each modality. Attention in the auditory-verbal domain was measured by Discriminative Letter Cancellation (the mean seconds-per-target [SPT] for trials 3 through 6), Digit Span Backward (raw score), and Voiced Phoneme Matching (SPT). Visual-spatial attention was measured by Discriminative Symbol Cancellation (the mean SPT for trials 2 and 3), Visual Memory Span Backward (raw score), and Voiced Shape Matching (SPT).

Perception in the auditory-verbal modality was measured by SSPT (number of errors). Visual-spatial perception was measured by JOLO (number correct), CFT Matching Total Score, and VR Matching Total Score. The correlations between age and all of these variables are tabulated below (Table 6). For eight of the 10 tests, an age-related decline in skill was observed ($p \leq .001$). Contrary to the prediction, however, two measures did not correlate with age: Digit Span Backwards ($p = .01$) and CFT Matching ($p = .01$).

Prediction 4b: Production ability will correlate negatively with age in the auditory-verbal modality but will not correlate with age in the visual-spatial modality.

Correlations with age were computed for the summary production measures also. Auditory-verbal production was measured by Letter Fluency (the sum of all three trials) and Category Fluency (the sum of all three trials). Visual-spatial production was measured by CFT Copy and VR Copy scores. This prediction was not well supported. Performance on Category Fluency and Visual Reproductions Copy Trial declined with age ($p < .001$), and there was a trend for CFT Copy ($p = .005$); however, Letter Fluency did not correlate with age ($p \geq .05$). These correlations are tabulated below (Table 7).

Table 6

Correlations With Age for Attention and Perception, by Modality (Prediction 4a).

Test	*r*	*p*
Attention		
Auditory-Verbal		
Letter Cancellation, Discrimination Trials	.51	.0005
WMS-R Digit Span Backwards	-.26	.01
Phoneme Matching	.38	.0005
Visual-Spatial		
Symbol Cancellation, Discrimination Trials	.51	.0005
WMS-R Visual Memory Span Backwards	-.49	.0005
Shape Matching	.45	.0005
Perception		
Auditory-Verbal		
Speech-Sounds Perception Test	.46	.0005
Visual-Spatial		
Judgment of Line Orientation	-.39	.0005
CFT Matching	-.25	.01
WMS-R Visual Reproductions Matching	-.31	.001

Table 7

Correlations Between Age and Production, by Modality (Prediction 4b).

Test	r	p
Auditory-Verbal		
Letter Fluency	-.11	>.05
Category Fluency	-.43	.0005
Visual-Spatial		
CFT Copy	-.29	.005
WMS-R Visual Reproductions Copy	-.36	.0005

Note. All correlations in this table represent decline with age; variables with positive correlations were scored in terms of errors or time required to completion; variables with negative correlations were scored in terms of number correct.

Prediction 5a: The frequency of HTN, CHD, CVD, DM, and pulmonary disease will correlate positively with age.

Prediction 5b: Current alcohol and tobacco use will correlate negatively with age.

Prediction 5c: Nonsignificant correlations are expected between age and hydrocephalus, renal disease, hepatic disease, seizures, and LOC that follows traumatic head injury.

Prediction 6a: Depression scores and trait anxiety scores will not correlate with age in this community-dwelling sample.

Prediction 6b: State anxiety scores will correlate positively with age.

Correlations with age for health and emotion variables are presented in Table 8. In this sample, none of the health variables were related to age at the stringent significance level applied (p = .001), although DM approached significance (p = .005). Among the emotional variables, the prediction was supported: State Anxiety alone correlated with age, and positively ($p < .001$).

Prediction 1: When the variance associated with consolidation in secondary memory is isolated, age will not explain a significant portion of that variance.

For measures of association between a dependent variable and multiple independent variables, multiple regression was used. Although the careful stratification of the sample into discrete age groups lends the data to analysis of variance (ANOVA) for age and sex predictions,

Table 8

Correlations With Age for Health and Emotional Factors, by Direction of Expected Relationship (Predictions 5 and 6).

Variable	*r*	*p*
Factors Expected to Increase With Age		
Hypertension	.26	.01
Coronary Heart Disease	.24	.01
Cerebrovascular Disease	.26	.01
Diabetes Mellitus	.28	.005
Pulmonary Disease	.08	>.05
Reactive ("State") Anxiety	.31	.001
Factors Expected to Decrease With Age		
Current Alcohol Consumption	.10	>.05
Current Tobacco Smoking	-.16	>.05
Factors Expected to Be Unrelated to Age		
Hydrocephalus	--[a]	--[a]
Renal Disease	.15	>.05
Hepatic Disease	.00	>.05
Seizures	-.12	>.05
Loss of Consciousness Following Traumatic Head Injury	-.08	>.05
Chronic ("Trait") Anxiety	.15	>.05
Depression	-.01	>.05

[a] Negative history for all subjects, thus coefficient was undefined.

the classification of age into a discrete variable (age group) would sacrifice the natural variability on that variable. Furthermore, multiple regression yields a Multiple $\underline{R}$ and $\underline{R}^2$ that are more interpretable with regard to the effect size and with regard to the amount of variance explained by the multivariate association, respectively. Both $\underline{R}$ and $\underline{R}^2$ will be reported in each analysis, by the same rationale described above.

Power associated with the regression analyses conducted here was estimated beforehand in consideration of the sample size needed for this study. For the largest possible analysis, which could involve 15 independent variables (Prediction 3, entering both attention variables and health/anxiety variables), even very conservative power (.90) and significance levels (.01) could be maintained with a sample size exceeding 73 for an estimated effect size exceeding .35 (Cohen & Cohen, 1983, chapter 3).

For Prediction 1, performance on delay free recall trials imposes the same demands as immediate free recall trials (perception, attention, encoding/storage, and retrieval), with the added demand of consolidation of the memory trace. Consequently, variance in memory performance attributable to consolidation can be isolated by regressing delay recall scores on immediate recall scores for the same stimuli. If age fails to enter on the second step (i.e., if it fails to explain a significant portion of the remaining variance), it can be inferred that age does not affect consolidation.

In the auditory-verbal domain, Logical Memory II (delay free recall) scores were regressed on Logical Memory I (immediate free recall) scores in the first step. Then, age and age^2 were entered simultaneously and stepwise to assess whether a linear or curvilinear (quadratic) relationship exists between age and consolidation of memory traces (Cohen & Cohen, 1983, chapter 6). Immediate free recall entered in the first step, as predicted, and explained 24 percent (Adjusted R^2) of the total variance in delay free recall for an effect size of .50 (Multiple R). Age and age^2 failed to enter on the second step (pr > .05), as predicted, indicating that secondary memory consolidation does not change as function of age, either linearly or quadratically. The regression weight and significance value for each term in the equation are presented in Table 9 ($F[1, 88] = 366.89$, $p < .0005$).

In the visual-spatial domain, CFT Delay (delay free recall) scores were regressed on CFT Immediate (immediate free recall) scores in the first step. Then, age and age^2 were entered simultaneously and stepwise. CFT Immediate entered in the first step, as predicted, and explained 88 percent of the variance in delay free recall (Adjusted R^2) for an effect size of .94 (Multiple R). Age and age^2 failed to enter on the second step (pr > .05), as predicted. The regression weight and significance value for each term in the equation are presented in Table 9 ($F[1, 88] = 612.18$, $p < .0005$).

Prediction 2: Age will explain a significant portion of variance in retrieval operations of secondary memory.

Performance on delay free recall trials imposes the same demands as delay recognition trials (perception, attention, encoding/storage, consolidation), with the added demand of unassisted retrieval. Consequently, variance in memory performance attributable to retrieval

Table 9

Age Effects in Consolidation, by Dependent Variable (Prediction 1).

Step	Variable	B	SE_B	p^a	Mult R	Adj R^2
		Logical Memory II				
1	Logical Memory I	1.03	0.05	.0001	.495	.236
	Constant	- 4.17	1.48	.0061		
		CFT Delay				
1	CFT Immediate	0.89	0.04	.0001	.937	.877
	Constant	2.93	1.04	.0059		

Note. A stringent alpha criterion was used for variable entry ($p_r \leq .001$). F statistics for the total equations are reported in the text.

[a] Significance values reported in the table refer to the t-test for the regression weight, B.

can be isolated by regressing delay recall scores on delay recognition scores (first step) for the same stimuli. If age enters on the second step, it can be inferred that age does affect retrieval processes in secondary memory.

In the auditory-verbal domain, Logical Memory II (delay free recall) was regressed on Logical Memory Recognition (delay recognition) in the first step. Then, age and age^2 were entered stepwise. Logical Memory Recognition explained 30 percent of the variance in Logical Memory II, leaving 70 percent of the variance unexplained, presumably representing retrieval ability and other unmeasured variance. Age entered alone on the next step to explain an additional 10 percent of the total variance and 14 percent of the unexplained variance. A total of 40 percent of variance in Logical Memory II was explained by these variables for an effect size of .64. The regression weight and significance value for each term in the equation are presented in Table 10 ($F[2, 87] = 30.83$, $p < .0005$).

In a post hoc analysis, the potentially confounding health and emotion variables, history of cerebrovascular disease (CVD) and State Anxiety, were entered stepwise prior to age and age^2 to determine the extent to which the age effect reflects unhealthy aging rather than healthy aging. State Anxiety failed to enter ($p > .05$), but CVD did enter in the intermediate step between Logical Memory Recognition and age to explain an additional eight percent of the total variance and 11 percent of the unexplained variance. Age entered even after CVD to explain an additional seven percent of the total variance and 10 percent more of the unexplained variance. The final solution accounted for 44 percent of the total variance in Logical Memory II for an effect size of

Table 10

Age Effects in Retrieval Before Controlling for Attention, by Dependent Variable (Prediction 2).

Step	Variable	B	SE_B	p	Mult R	Adj R^2
	Logical Memory II (Without Health/Anxiety)					
1	Logical Memory Recognition	2.62	0.54	.0001	.556	.301
2	Age	- 0.21	0.05	.0001	.644	.401
	Constant	12.36	6.31	.0534		
	Logical Memory II (With Health/Anxiety)					
1	Logical Memory Recognition	2.70	0.53	.0001	.544	.288
2	Cerebrovascular Disease	-11.14	3.78	.0042	.620	.370
3	Age	- 0.18	0.05	.0010	.677	.439
	Constant	10.38	6.13	.0939		
	CFT Delay					
1	CFT Recognition	1.20	0.13	.0001	.711	.500
	Constant	7.60	2.20	.0009		

Note. A stringent alpha criterion was used for variable entry ($p_F \leq .001$). F statistics for the total equations are reported in the text.

[a] Significance values reported in the table refer to the t-test for the regression weight, B.

.68. The regression weight and significance value for each term in the equation are presented in Table 10 ($F[2, 87] = 23.98$, $p < .0005$).

In the visual-spatial domain, CFT Delay (free recall) was regressed on CFT (Delay) Recognition in the first step. Then, age and age^2 were entered stepwise. CFT Recognition entered on the second step to explain 50 percent of the total variance, leaving 50 percent of the variance unexplained, believed here to represent retrieval variance and other, unmeasured variance. Age and age^2 failed to enter on the next step ($pr = .03$). The total effect size was .71; the equation weights and significance values can be found in Table 10 ($F[1, 86] = 86.56$, $p < .0005$).

Prediction 3: After controlling for the effects of attention, age will explain significantly less variance in retrieval operations of secondary memory.

The rationale and method for isolating retrieval variance was described under Prediction 2. That method was repeated for Prediction 6, except that relevant attention measures were entered immediately before age variables.

In the auditory-verbal domain, Logical Memory II (delay free recall) was regressed on Logical Memory Recognition (delay recognition) in the first step. Then, auditory-verbal measures of attention and concentration were entered stepwise: Digit Span Backward, Discriminative Letter Cancellation, and Phoneme Matching. Finally, age and age^2 were entered stepwise. Although there was a trend for Digit Span Backward ($pr = .005$), none of the attention measures entered the equation at the specified alpha, .001. Consequently, the results for auditory-verbal retrieval were identical to those reported under Prediction 2. In the visual-spatial domain there was no age effect in the original analysis; consequently, there was no need to re-analyze the data with attention variables.

Because attention variables did not explain any variance in consolidation or retrieval, post hoc analyses were conducted to measure the contributions of attention to total memory performance. In post hoc analysis of auditory-verbal memory, Logical Memory I (LM-I) and II (LM-II) were regressed on measures of auditory-verbal perception (SSPT) and production (Letter Fluency) to isolate secondary memory ability. Then, age and age^2 were entered stepwise to determine the amount of variance accounted for by these variables prior to controlling for attention. Next, age and age^2 were removed and auditory-verbal attention variables were entered stepwise (Digit Span Backward, Discriminative Letter Cancellation, and Phoneme Matching). Finally, age and age^2 were entered again, stepwise.

For LM-I, neither SSPT nor Letter Fluency entered on the first step. Age^2 entered on the second step to explain 22 percent of the variance. After removing age^2, Phoneme Matching entered alone. Age entered on the last step to explain only 10 percent more variance after controlling for attention ($p < .0005$). Similar findings emerged for LM-II, except that attention played no role at all. Age^2 entered initially to explain 24 percent of the total variance. After removing age^2, Letter Fluency entered to explain 20 percent of the total variance. No attention measures entered. Age entered again, to explain only 14 percent more variance beyond that which was accounted for by production skills. The results of these analyses are available in Table 11.

In post hoc analysis of visual-spatial memory, CFT Immediate and Delay trials were regressed on measures of visual-spatial perception (CFT Matching, JOLO) and construction (CFT Copy, VR Copy) to isolate secondary memory ability. Then, age and age^2 were entered stepwise to determine the amount of variance accounted for by these variables prior to controlling for attention. For Immediate, JOLO and CFT Copy both entered to explain 41 percent of the variance. For Delay, only CFT Copy entered on the first step, explaining 32 percent of the variance ($p < .0005$). Surprisingly, age and age^2 failed to enter on the second step for either Immediate ($p = .01$) or Delay ($p = .05$). Visual-spatial attention variables were entered stepwise on the last step (VMS Backward, Discriminative Symbol Cancellation, and Shape Matching). Visual Memory Span Backward entered alone and for CFT Delay only, explaining an additional 12 percent of that total variance ($p < .0005$). Even when using liberal significance criteria ($p = .05$), the age effect (age and age^2 together explaining six percent of the total variance) disappeared after controlling for attention. The results of these analyses are available in Table 11.

Prediction 7: The only sex difference on the CFT will be on the delay recall trial, where men will outperform women.

To test this prediction, each of the CFT trials was correlated with sex. Sex was coded 0 for males and 1 for females, such that a negative value is indicative of males exceeding females on the task. Sex

Table 11

Age Effects in Encoding/Storage, by Dependent Variable (Post Hoc).

Step	Variable	B	SE_B	p[a]	Mult R	Adj R^2
			Logical Memory I			
1	Phoneme Matching	- 1.71	0.43	.0001	.493	.234
2	Age	- 0.18	0.05	.0004	.591	.334
	Constant	40.25	2.60	.0001		
			Logical Memory II			
1	Fluency	0.12	0.33	.0004	.453	.196
2	Age	- 0.24	0.05	.0001	.593	.336
	Constant	24.12	5.06	.0001		
			CFT Immediate			
1	JOLO	1.00	0.27	.0003	.589	.339
2	CFT Copy	0.59	0.17	.0009	.654	.414
	Constant	-26.13	6.88	.0003		
			CFT Delay			
1	CFT Copy	0.63	0.14	.0001	.570	.317
2	VMS Backward	1.83	0.42	.0001	.670	.435
	Constant	-17.40	6.15	.0058		

Note. A stringent alpha criterion was used for variable entry ($p_F \leq .001$). F statistics for the total equations are reported in the text.

[a] Significance values reported in the table refer to the t-test for the regression weight, B.

explained a small but significant portion of variance on the Immediate free recall trial (r = -.30, r^2 = .09, p = .001), but none of the other correlations was significant at the specified alpha: Copy, r = -.20 (p = .03); Delay (free recall), r = -.23 (p = .01); Recognition (delay recognition), r = -.23 (p = .01); and Matching, r = -.14 (p > .05). Therefore, in partial support of this prediction, no differences were found for Copy, Recognition, or Matching trials. However, contrary to the prediction, the sex difference that did appear was observed on the Immediate free recall trial, not on Delay free recall. The direction of the relationship (males outperforming females) was preserved.

Prediction 8a: The CFT Recognition Task will have homogeneous content, as indicated by a strong Total Scale alpha reliability and by moderate subscale alpha reliabilities.

On the CFT Recognition Trial, Cronbach's alpha was computed for the Total Scale, Global Element Scale, Detail Element Scale, as well as for the Left Detail and the Right Detail subscales. These are presented in Table 12. As expected, the Total Scale had a strong interitem reliability (alpha=.84). The subscales ranged from moderate (.59, .61, and .66) to high (.81), in rough relation to the number of items on each scale; this was also consistent with the prediction. Each of the items contributed substantially to the integrity of its host scale. None of the items detracted from any of the alpha reliabilities except for Item 27 on the Left Detail subscale, and that alpha was reduced by less than .02. Consequently, these data support the retention of all items on their host scales except for Item 27 on the Left Detail subscale.

Table 12

Cronbach's Alpha Reliabilities for CFT Scales and Subscales, by Trial.

Scale	Composite Items	No. of Items	Alpha
	Recognition Trial		
Total	1-30	30	.84
Global Elements	1-4, 6-8	7	.61
Detail Elements	10-28 30	20	.81
Left Detail	10 11 14 15 18 20 23 24 27	9	.59
Right Detail	12 13 16 17 19 21 22 25 26 28 30	11	.66
	Matching Trial		
Total	1-10	10	.58
Left Detail	2 3 7 8	4	.40
Right Detail	4 5 9 10	4	.08

Intercorrelations among scales and subscales can be found in Table 13; all were significant ($p < .0005$). Correlations between the Total Scale and each of other scales are, of course, very large because each scale is nested within the Total Scale; correlations between the Detail Scale and its nested subscales, the Left and Right Detail subscales, are high for the same reason. More important is the corrected correlation between the two unnested scales, Global and Detail (.75). Because this relationship is only moderate, we can conclude that the two scales measure unique variance and, thus, unique constructs. The corrected correlations of the two Detail subscales with the Global scale (.65 and .77) are virtually identical to the Global-Detail correlation; in addition, the corrected correlation between the two subscales is virtually perfect (.99). These latter data indicate that the two Detail subscales are parallel short-forms of the Detail Scale and that they measure the same construct.

Prediction 8b: The CFT Recognition Total Score will have good convergent validity, that is, will correlate positively with the WMS-R Visual Reproductions recognition score.

Recognition correlated modestly with VR recognition ($r = .40$, $p < .0005$). CFT Recognition also correlated moderately with VR-I and VR-II (.50 and .57, respectively, $p < .0005$).

In addition, correlations between CFT Recognition and the other CFT memory trials were computed. The Total Score on the Recognition Trial correlated strongly and positively with both Immediate free recall ($r = .74$, $p < .0005$) and with Delay free recall ($r = .71$, $p < .0005$).

Table 13

Intercorrelations Among CFT Scales and Subscales, by Trial.

	Recognition Trial				
	GLO	DET	L-DET	R-DET	TOT
Global (GLO)	.61	.75	.65	.77	1.02
Detail (DET)	.53	.81	1.24	1.24	1.18
Left Detail (L-DET)	.39	.86	.59	.99	1.15
Right Detail (R-DET)	.49	.91	.62	.66	1.18
Total (TOT)	.73	.97	.81	.88	.84

	Matching Trial		
	L-DET	R-DET	TOT
Left Detail (L-DET)	.40	3.07	.99
Right Detail (R-DET)	.55	.08	4.27
Total (TOT)	.82	.92	.58

Note. All values are significant ($p < .0005$). Values on the diagonals are reliabilities (Cronbach's alpha). The values above the diagonals are corrected for attenuation; the values below the diagonal are not corrected for attenuation.

Correlations with the nonmemory trials were much weaker (Copy, $r = .38$, $p < .0005$; Matching, $r = .18$, $p = .05$).

Prediction 8c: The CFT Recognition Total Score will have good construct validity in that it will load on a factor with other visual-spatial secondary memory test scores.

For the confirmatory factor analysis, LISREL (Joreskog & Sorbom, 1989) was preferred over the SPSS (SPSS, Inc., 1990) Factor routine because the former allows (and requires) the investigator to specify the loadings of variables onto theorized factors; that is, it is truly confirmatory of an a priori model. Also, the results of the LISREL analysis provide goodness-of-fit indices, which summarize how well the data fit the a priori model, and modification indices, which identify individual variables that would fit better on other factors.

For this prediction, correlations among all of the measures listed in Table 14 were entered as a matrix and analyzed in a multitrait-multimodality model using the LISREL program for confirmatory factor analysis. (The descriptives for each variable and the correlations among all of the variables are tabulated in Tables 15 and 16, respectively.) As shown in Table 14, each test is nested within one trait (attention, perception, production, or memory) and within one modality (auditory-verbal or visual-spatial). This organization dictated the parameters for the Lambda X and Phi matrices; the initial estimates for factor loadings were generated from a review of past research with these same tests or with very similar tests. However, the Phi matrix was not positive definite, resulting in premature termination

Table 14

A Priori Factor Structure of Selected Measures, by Trait and Modality.

Auditory-Verbal Measures	Visual-Spatial Measures
Perception	
Speech-Sounds Perception Test	Judgment of Line Orientation
	CFT Matching
	VR Matching
Attention	
Digit Span Backward	VMS Backward
Discriminative Letter Cancellation	Discriminative Symbol Cancellation
Phoneme Matching	Shape Matching
Production	
Letter Fluency	CFT Copy
Category Fluency	Visual Reproductions Copy
Memory	
Logical Memory I	Visual Reproductions Immediate
Logical Memory II	Visual Reproductions Delay
Logical Memory Recognition	Visual Reproductions Recognition
Cowboy, Immediate	CFT Immediate
Cowboy, Delay	CFT Delay
Cowboy, Recognition	CFT Recognition

Table 15

Descriptive Data for Test Scores Used in Factor Analyses.

	Total (N=90)		Younger (n=47)		Older (n=43)	
Variable	M	SD	M	SD	M	SD
SSPT	3.7	3.1	2.4	1.9	5.0	3.5
JOLO	25.5	3.9	26.2	3.4	24.7	4.4
CFT, Match	9.4	1.0	9.6	.8	9.3	1.2
VR, Match	4.8	.5	4.9	.4	4.7	.6
DS, Backward	7.1	2.2	7.5	2.1	6.7	2.3
Letter Canc.	6.1	2.3	5.3	1.2	7.0	2.8
Phoneme Matching	2.3	1.7	1.9	1.3	2.7	2.0
VMS, Backward	8.0	2.1	8.6	2.0	7.2	2.0
Symbol Canc.	4.3	1.6	3.7	.7	5.0	2.0
Shape Matching	1.9	1.2	1.5	.8	2.4	1.4
Letter Fluency	46.0	14.7	47.1	15.6	44.7	13.7
Category Fluency	53.8	11.7	57.8	12.0	49.3	9.7
CFT Copy	47.4	6.1	48.5	4.6	46.2	7.3
VR, Copy	38.0	3.5	38.7	2.7	37.2	4.0
LM I	26.5	7.5	29.0	6.7	23.7	7.4
LM II	23.1	8.5	26.1	7.7	19.9	8.1
LM Recog	8.5	1.4	8.7	1.0	8.3	1.7
Cowboy, Immed	14.3	3.8	15.1	3.9	13.5	3.5
Cowboy, Delay	13.9	3.9	14.5	4.1	13.3	3.5
Cowboy, Recog	9.3	.8	9.4	.7	9.1	0.9
VR, Immed	33.1	6.3	35.3	4.2	30.8	7.3
VR, Delay	27.5	9.0	30.9	7.4	23.7	9.2
VR, Recog	3.9	1.3	4.3	1.0	3.4	1.4
CFT, Immed	26.9	10.2	30.4	10.1	23.0	8.8
CFT, Delay	26.9	9.7	30.2	9.7	23.0	8.4
CFT, Recog	16.0	5.7	17.9	5.5	14.0	5.3

Note. The Older group was missing two subjects on some measures.

Table 16

Correlations Among the Test Scores Used in Factor Analyses.

	Test	1	2	3	4	5	6	7	8	9	10
1	SSPT										
2	JOLO	-49									
3	CFT, Match	-49	46								
4	VR, Match	-34	32	39							
5	DS, Backward	-36	43	37	23						
6	Letter Canc.	48	-47	-43	-51	-39					
7	Phoneme Matching	40	-58	-55	-54	-45	62				
8	VMS, Backward	-47	60	29	33	46	-46	-39			
9	Symbol Canc.	54	-48	-50	-41	-37	88	52	-48		
10	Shape Matching	63	-60	-54	-41	-49	58	68	-52	62	
11	Letter Fluency	-24	22	27	9	53	-36	-44	28	-33	-42
12	Category Fluency	-37	46	37	28	52	-47	-50	46	-47	-53
13	CFT Copy	-50	60	65	40	36	-46	-55	44	-55	-62
14	VR, Copy	-56	49	52	51	42	-53	-66	39	-55	-65
15	LM I	-34	39	37	27	44	-40	-52	55	-42	-51
16	LM II	-35	37	41	28	43	-39	-46	56	-42	-47
17	LM Recog	-42	41	48	32	35	-47	-63	41	-43	-55
18	Cowboy, Immed	-18	32	19	21	23	-11	-27	30	-17	-31
19	Cowboy, Delay	-27	36	24	27	25	-23	-28	36	-31	-37
20	Cowboy, Recog	- 8	11	19	29	5	- 2	-21	10	- 2	-16
21	VR, Immed	-51	60	56	43	47	-52	-59	53	-57	-61
22	VR, Delay	-48	50	47	38	54	-56	-62	49	-55	-56
23	VR, Recog	-40	48	37	28	44	-47	-46	47	-41	-61
24	CFT, Immed	-42	58	27	22	35	-38	-42	54	-40	-44
25	CFT, Delay	-45	55	29	16	34	-35	-38	57	-39	-44
26	CFT, Recog	-35	46	18	26	31	-29	-30	47	-30	-36

Note. Decimals were omitted.

Table 16 (cont'd)

Test		11	12	13	14	15	16	17	18	19	20
11	Letter Fluency										
12	Category Fluency	59									
13	CFT Copy	31	47								
14	VR, Copy	38	46	63							
15	LM I	40	41	34	49						
16	LM II	38	44	39	45	90					
17	LM Recog	33	38	39	46	60	56				
18	Cowboy, Immed	22	22	17	36	51	52	42			
19	Cowboy, Delay	30	27	19	43	55	55	43	92		
20	Cowboy, Recog	10	0	6	23	29	35	19	56	57	
21	VR, Immed	27	51	53	61	60	60	42	24	34	16
22	VR, Delay	42	60	49	58	58	62	41	24	27	17
23	VR, Recog	33	51	46	42	42	44	30	25	29	7
24	CFT, Immed	23	41	58	50	54	52	23	34	30	12
25	CFT, Delay	24	36	56	48	53	54	23	37	33	13
26	CFT, Recog	14	31	38	39	48	48	19	31	30	19

Note. Decimals were omitted.

Table 16 (cont'd)

Test		21	22	23	24	25	26
21	VR, Immed						
22	VR, Delay	79					
23	VR, Recog	65	63				
24	CFT, Immed	58	62	48			
25	CFT, Delay	59	61	46	93		
26	CFT, Recog	50	57	40	74	71	

Note. Decimals were omitted.

of the analysis. This appears to have been due to high intercorrelations among many of the tests and may reflect the influence of a strong general factor.

SPSS factor analysis, by contrast to LISREL, is confirmatory only inasmuch as it permits the investigator to specify the number of factors in the final solution; the investigator cannot specify the constitution of those factors in advance. This program classifies the variables into a solution for the number of factors specified, but the variables may or may not be organized around the principle intended. Because the data did not conform to the assumptions of LISREL, they were subjected to the SPSS Factor routine.

A principal factors analysis with varimax rotation of eight factors (four traits in the auditory-verbal modality and four traits in the visual-spatial modality) resulted in a solution (Table 17) that explained an unusually large proportion of the variance (80 percent). Factors were orthogonal, and the eigenvalues tapered off after the fourth factor was extracted. The solution was mostly test-specific, with trials of the same test coalescing onto a common factor. A "Visual Memory" factor did emerge and explained a large portion of the total variance; it consisted of the three CFT memory trials and Visual Reproductions II. A second factor was much more heterogeneous with the two alphabet tracking tasks (phoneme and shape matching), the two copying tasks (CFT and Visual Reproductions Copy trials), and two of the perceptual measures (SSPT and CFT Matching). The three trials of Cowboy story comprised the third factor. The two fluency tasks and Digit Span Backward loaded onto the fourth factor. The fifth and sixth factors were Cancellation (Discriminative Letter and Symbol Cancellation tasks)

Table 17

Test Loadings on an Eight-Factor Solution Using SPSS Factor Analysis.

		Factors							
Variable	h^2	1	2	3	4	5	6	7	8
VR, Delay	84	49	24	-02	41	18	34	19	43
CFT, Immed	92	89	22	11	14	13	12	15	2
CFT, Delay	91	88	24	13	12	10	14	16	- 5
CFT, Recog	75	80	4	15	5	10	13	16	18
SSPT	61	-24	-52	- 7	- 7	-36	- 8	-36	2
CFT, Match	78	3	80	4	13	7	25	9	20
Phoneme Matching	74	-13	-54	-11	-33	-30	-28	- 7	-36
Shape Matching	74	-16	-55	-16	-32	-32	-16	-38	-13
CFT Copy	81	40	75	0	19	20	1	11	4
VR, Copy	74	31	57	26	27	33	9	- 1	23
Cowboy, Immed	91	18	7	89	11	2	20	13	- 6
Cowboy, Delay	92	13	8	89	15	15	20	17	- 2
Cowboy, Recog	76	5	9	75	- 5	-12	9	-14	37
DS, Backward	65	13	19	5	64	5	20	37	11
Letter Fluency	87	5	15	15	87	15	14	- 8	- 8
Category Fluency	71	20	21	3	70	22	10	25	10
Letter Canc.	91	-15	-23	2	-25	-82	-17	-15	-23
Symbol Canc.	86	-20	-32	- 2	-20	-79	-17	-16	- 8
LM I	91	35	13	30	22	15	77	11	9
LM II	89	37	13	31	23	10	74	12	12
LM Recog	79	- 9	45	25	14	27	62	16	- 3
JOLO	75	36	48	17	12	18	2	56	3
VMS, Backward	74	37	11	14	14	30	30	61	- 2
VR, Recog	71	30	18	3	37	7	12	55	36
VR, Immed	81	42	36	2	21	15	34	36	44
VR, Match	77	3	30	23	- 3	44	0	8	66
% Variance Explained	--	45	9	7	5	4	3	3	3
Eigenvalue	--	11.7	2.4	1.9	1.4	0.9	0.9	0.8	0.7

Note. Decimals were omitted. h^2 = communalities. Please see text for explanations of variable abbreviations.

and Logical Memory (all three trials), respectively. Factor 7 consisted of JOLO, Visual Memory Span, and Visual Reproductions Immediate trial. Visual Reproductions II and the corresponding matching task made up the last factor. The final solution explained 80 percent of the total variance. However, only one factor (Visual Memory) accounted for the majority (56 percent) of the explained variance. Furthermore, 17 of the variables had considerably large loadings on multiple factors. The factor loadings, eigenvalues, and communalities are in Table 17.

Specifying two factors for the two modalities generated a solution that explained 54 percent of the variance; however, the test did not divide solely on the modality principle. One factor was characterized by tests of Verbal Learning (Logical Memory I and II and the three Cowboy Story trials); the other consisted of all of the other tests and could therefore be called a Broad Cognition or General Ability factor. Factor loadings and communalities for this outcome are in Table 18.

Finally, specifying four factors yielded the most interpretable solution, although it was not the four traits that were hypothesized. Factor 1 consisted of all of the measures of perception, production, and attention in both modalities, except Digit Span and Visual Memory Span. Factor 2 was the Visual Learning factor, consisting of the three CFT memory trials and the three Visual Reproductions memory trials. Factor 3 contained the two memory span tasks (Digit Span and Visual Memory Span) and the two fluency tasks. Factor 4 was the Verbal Learning factor, consisting of two of the three Logical Memory trials and the three Cowboy Story trials. Logical Memory Recognition was also grouped with Factor 4 variables because of the conceptual associations among those variables, even though empirically this test loaded slightly

Table 18

Test Loadings on a Two-Factor Solution Using SPSS Factor Analysis.

Variable	h^2	Factor 1	Factor 2
SSPT	47	-68	-10
JOLO	54	70	23
CFT, Match	43	65	10
VR, Match	26	49	14
DS Backward	46	60	31
Letter Canc.	61	-78	-00
Phoneme Matching	60	-75	-20
VMS Backward	50	62	35
Symbol Canc.	61	-78	-04
Shape Matching	67	-79	-21
Letter Fluency	26	46	23
Category Fluency	47	67	14
CFT, Copy	59	77	06
VR, Copy	57	70	28
VR, Immed	67	78	26
VR, Delay	67	77	27
VR, Recog	48	67	19
CFT, Immed	51	61	37
CFT, Delay	50	58	40
CFT, Recog	39	47	41
LM I	68	50	65
LM II	69	49	67
LM Recog	42	52	39
Cowboy, Immed	82	09	90
Cowboy, Delay	78	18	87
Cowboy, Recog	50	-06	70
% Variance Explained	--	45	9
Eigenvalue	--	12.2	2.4

Note. Decimals were omitted. h^2 = communalities. Please see text for explanations of the variable abbreviations.

better on Factors 1 and 3. Strong correlation with multiple factors was characteristic of this last solution, observed in no fewer than 14 variables. This model explained 66 percent of the total variance; communalities and factor loadings are tabulated below (Table 19).

Prediction 8d: As further evidence of construct validity, each item of the CFT Recognition Task will load on the a priori scale for which it was designed (Global, Left Detail, or Right Detail), except items 5, 9, and 29.

LISREL was again preferred over SPSS for confirmatory factor analysis, for the reasons given above. For this prediction, correlations among all the items of the CFT Recognition Trial, except Items 5, 9, and 29 (detail elements that are not purely lateralized), were entered as a matrix and analyzed in a multitrait model using the LISREL program for confirmatory factor analysis. (The descriptives and correlations among items are presented in Tables 20 and 21, respectively.) Table 12 provides a list of the items designed for the Global Scale and the Left and Right Detail subscales. This organization dictated the parameters for the Lambda X and Phi matrices; the initial estimates for factor loadings were generated from the pilot study. However, the Phi matrix not positive definite, resulting in premature termination of the analysis.

The same correlation matrix was subjected to a LISREL 2-factor confirmatory analysis in which each variable was specified to load onto the Global element factor or onto the Detail element factor. A chi-square analysis was conducted to compare the observed correlational

Table 19

Test Loadings on a Four-Factor Solution Using SPSS Factor Analysis.

		Factors			
Variable	h^2	1	2	3	4
SSPT	50	-60	-32	-19	- 5
JOLO	57	51	49	23	12
VR, Match	61	73	5	-12	25
CFT, Match	57	72	10	17	13
Phoneme Matching	68	-71	-16	-36	-18
Shape Matching	70	-66	-26	-41	-15
Letter Canc.	66	-71	-16	-37	4
Symbol Canc.	65	-69	-22	-36	1
CFT Copy	64	66	43	16	- 2
VR, Copy	67	70	29	16	27
VR, Immed	70	55	53	30	13
VR, Delay	70	45	55	43	9
VR, Recog	52	36	46	42	3
CFT, Immed	87	23	88	13	13
CFT, Delay	85	21	87	13	16
CFT, Recog	73	13	82	7	19
DS, Backward	64	27	22	70	17
VMS, Backward	55	32	39	50	20
Letter Fluency	65	14	1	79	10
Category Fluency	60	36	24	64	0
LM I	71	23	39	49	52
LM II	72	22	40	47	53
LM Recog	61	51	- 4	44	40
Cowboy, Immed	84	5	19	18	87
Cowboy, Delay	83	15	15	23	85
Cowboy, Recog	64	12	3	-13	78
% Variance Explained	--	45	9	7	5
Eigenvalue	--	12.2	2.4	1.9	1.5

Note. Decimals were omitted. h^2 = communalities. Please see text for explanations of variable abbreviations.

Table 20

Descriptive Data for the CFT Recognition Items.

Item No.	Mean	SD	Item No.	Mean	SD
1	.85	.36	16	.56	.50
2	.61	.49	17	.39	.49
3	.65	.48	18	.16	.37
4	.71	.46	19	.40	.49
5	.22	.41	20	.24	.43
6	.66	.48	21	.43	.50
7	.51	.50	22	.63	.49
8	.75	.44	23	.55	.50
9	.59	.49	24	.63	.49
10	.43	.50	25	.50	.50
11	.69	.46	26	.59	.49
12	.83	.38	27	.15	.36
13	.35	.48	28	.51	.50
14	.38	.49	29	.78	.41
15	.34	.48	30	.97	.18

Table 21

Correlations Among the CFT Recognition Items, by Item Number.

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1														
2	13													
3	30	29												
4	15	00	-01											
5	14	08	21	28										
6	11	07	17	38	20									
7	17	02	28	11	40	40								
8	06	19	23	43	24	30	12							
9	31	10	21	12	27	28	34	16						
10	17	13	26	11	21	05	12	13	17					
11	07	-07	13	33	35	15	14	18	35	13				
12	15	26	24	-03	24	-01	10	23	18	15	22			
13	17	15	-10	16	19	13	20	04	18	03	13	08		
14	19	23	13	04	16	11	10	07	26	27	16	29	12	
15	03	03	13	10	26	-04	22	08	06	00	22	13	02	19
16	34	-14	06	27	30	23	36	12	23	13	20	20	23	27
17	26	-14	15	10	15	13	12	03	23	02	22	-01	10	16
18	09	03	26	01	-08	05	-01	04	05	12	-05	11	00	18
19	14	22	40	02	19	29	14	15	11	-01	04	24	18	19
20	16	-10	19	07	03	12	12	08	03	05	14	04	03	06
21	30	13	35	06	16	05	21	03	21	12	18	21	08	13
22	21	06	17	06	18	19	28	04	31	11	30	09	28	16
23	-06	-12	-00	-10	20	16	34	-11	22	01	04	07	05	14
24	21	25	26	22	24	24	37	15	31	25	40	34	28	31
25	16	09	17	10	08	24	25	11	14	18	22	15	07	12
26	04	10	06	-13	-01	-01	11	05	20	07	10	36	08	21
27	-01	-13	11	-08	09	03	09	09	02	03	-00	02	-04	07
28	30	20	28	06	35	16	18	07	44	35	38	28	20	24
29	09	21	36	02	14	03	21	14	24	12	25	28	10	18
30	10	-15	-14	02	10	-14	07	04	10	16	15	-09	01	15

Note. Decimals were omitted.

Table 21 (cont'd)

No.	15	16	17	18	19	20	21	22	23	24	25	26	27	28
16	21													
17	12	24												
18	15	14	10											
19	35	21	17	22										
20	16	23	05	56	20									
21	10	13	02	12	04	10								
22	26	25	13	14	20	27	30							
23	13	20	02	09	04	08	10	14						
24	21	21	08	21	10	27	34	32	19					
25	05	21	19	12	02	19	18	12	18	26				
26	01	05	09	17	11	03	31	17	12	26	18			
27	-10	-08	06	17	-08	-01	22	-01	06	06	16	22		
28	03	13	17	11	10	12	30	32	25	37	07	16	09	
29	20	14	13	15	14	23	35	28	13	34	19	18	06	26
30	14	08	15	08	-23	11	16	24	-05	-02	06	10	08	19

Note. Decimals were omitted.

Table 21 (cont'd)

No.	29	30
30	05	

Note. Decimals were omitted.

matrix to the hypothetical matrix that was generated from the theoretical model that was specified. The Adjusted Goodness of Fit index was modest (.71), and the root mean square residual was large (.09). The chi-square was statistically significant (x^2[404, N=88] = 499.91, p = .001), indicating that the observed matrix differed from the correlation matrix that was reproduced from estimates of the theoretically relevant parameters. Reassignment of items with significant modification indices failed to change the summary statistics for the confirmatory factor analysis; that is, the indicated modifications of the model did not improve the overall fit of the model to the data. Factor loadings and communalities are listed in Table 22. The correlation between the two factors was .795.

As an alternative, SPSS was used. Specification of three factors resulted in an uninterpretable clustering of the test items; the solution explained only 32 percent of the total variance. A subsequent analysis designating two factors (Global and Detail) explained less variance (25 percent) and produced an uninterpretable solution. Post hoc exploratory factor analysis (leaving the number of factors unspecified, to be determined by an eigenvalue criterion of 1.0) resulted in an 11-factor solution that explained 66.8 percent of the variance, but the factor structure did not conform to any identifiable organizational scheme.

Prediction 8e: CFT Recognition Total Scores will distribute normally with no ceiling or floor effects.

Table 22

Recognition Item Loadings on Global and Detail Factors Using LISREL.

Item No.	h^2	Factor 1	Factor 2
1	18	42	00
2	7	26	00
3	27	52	00
4	12	34	00
6	24	49	00
7	31	56	00
8	15	39	00
5	23	00	48
9	31	00	55
10	12	00	34
11	26	00	51
12	19	00	43
13	10	00	31
14	19	00	43
15	10	00	32
16	20	00	45
17	8	00	28
18	7	00	26
19	10	00	32
20	10	00	32
21	21	00	46
22	27	00	52
23	8	00	28
24	43	00	66
25	12	00	35
26	10	00	32
27	1	00	11
28	34	00	59
29	23	00	48
30	2	00	16

Note. Decimals were omitted. h^2 = communalities.

Scores on the CFT Recognition Trial distributed normally, as predicted. For the 88 subjects who completed this task, the mean and median were 16.0, and the mode was 15. Scores ranged from 4 to 27 (out of 30 possible), with a standard deviation of 5.74. Performance on this task correlated significantly with age ($\underline{r} = -.41$, $\underline{p} < .0005$); consequently, descriptives are tabulated for younger and older subjects in Table 23. The relationship between sex and Recognition Total Score ($\underline{r} = -.23$) failed to reach significance at the level adopted in this study ($\underline{p} = .05$, two-tailed), as did the Age x Sex interaction.

Prediction 8f: Most items on the CFT Recognition Task will have significant, positive corrected item-total correlations.

Point-biserial correlations between each CFT Recognition item and the CFT Recognition Total Score were corrected by partialling out the variance in the Total Score that was due to the item itself (Table 24). All coefficients were positive. Only two values failed to reach statistical significance ($\underline{r}$s = .09 and .12; $\underline{p} > .05$); the others ranged from .18 to .60, with 17 of the 30 exceeding .31 to meet the stringent alpha criterion ($\underline{p} \leq .001$). Item difficulty indices (percent of the sample that responded incorrectly) ranged from 3% to 85% and distributed roughly normally, with 20 items in the 30%-to-70% range and 4 items and 6 items in the upper and lower tails, respectively; the mean item difficulty for the 30 items was .465.

Table 23

Descriptives for CFT Recognition (Raw Scores), by Scale

Group	n	Mean	Median	Mode	SD	SEM	Min.	Max.
				Total Scale				
Total	88	16.0	16.0	15.0	5.7	2.3	4	27
Younger	47	17.9	19.0	21.0	5.5	2.2	5	27
Older	41	14.0	15.0	15.0	5.3	2.1	4	25
Men	37	17.6	18.0	15.0	5.5	2.2	4	27
Women	51	14.9	15.0	11.0	5.7	2.3	5	27
Younger								
Men	21	20.0	21.0	24.0	4.5	1.8	11	27
Women	26	16.1	17.5	18.0	5.7	2.3	5	27
Older								
Men	16	14.4	15.0	10.0	5.0	2.0	4	23
Women	25	13.7	14.0	11.0	5.6	2.2	6	25

Note. Only the age effect was significant at the alpha designated for theoretical comparisons ($p \leq .001$). However, age and sex effects were significant at the more liberal alpha ($p \leq .05$). Consequently, data for all groups are presented.

Table 23 (cont'd)

Group	n	Mean	Median	Mode	SD	SEM	Min.	Max.
			Global Scale [a]					
Total	88	4.7	5.0	6.0	1.8	1.1	0	7
			Detail Scale [b]					
Total	88	11.3	11.5	12.0	4.6	2.0	3	20
Younger	47	13.1	14.0	15.0	4.3	1.9	4	20
Older	41	9.2	9.0	12.0	4.1	1.8	3	13
Men	37	12.6	12.0	12.0	4.4	1.9	3	20
Women	51	10.3	10.0	5.0	4.6	2.0	3	20
Younger								
Men	21	14.9	15.0	17.0	3.5	1.5	7	20
Women	26	11.6	12.0	15.0	4.4	1.9	4	20
Older								
Men	16	9.6	10.0	8.0	3.6	1.6	3	16
Women	25	9.0	9.0	5.0	4.5	2.0	3	18

[a] There were no age or sex differences on the Global Scale ($p > .05$).

[b] Only the age effect was significant at $p \leq .001$. Age and sex effects were significant at $p \leq .05$.

Table 23 (cont'd)

Group	n	Mean	Median	Mode	SD	SEM	Min.	Max.
			Left Detail Subscale [a]					
Total	88	3.6	4.0	4.0	2.0	1.3	0	8
Younger	47	4.3	4.0	5.0	1.9	1.2	1	8
Older	41	2.7	3.0	1.0	1.7	1.1	0	6
Men	37	4.3	4.0	5.0	1.9	1.2	0	8
Women	51	3.0	3.0	1.0	1.9	1.2	0	7
Younger								
Men	21	5.1	5.0	5.0	1.7	1.1	1	8
Women	26	3.7	3.5	3.0	1.8	1.2	1	7
Older								
Men	16	3.2	3.0	3.0	1.6	1.0	0	6
Women	25	2.4	2.0	1.0	1.8	1.2	0	6
			Right Detail Subscale [b]					
Total	88	6.1	6.0	9.0	2.4	1.4	1	11
Younger	47	7.0	7.0	9.0	2.3	1.3	2	11
Older	41	5.2	4.0	4.0	2.3	1.3	1	9

[a] Only the age effect was significant at $\underline{p} \leq .001$. Age and sex effects were significant at $\underline{p} \leq .05$.

[b] Only age differences were significant ($\underline{p} \leq .001$ and .05).

Table 24

Discrimination Ability of the CFT Recognition Items.

Item No.	Diffic. Index[a]	Item-Total[b]	Item No.	Diffic. Index[a]	Item-Total[b]
1	15	.38 ****	16	44	.43 ****
2	39	.18 *	17	61	.26 **
3	35	.43 ****	18	84	.27 ***
4	29	.24 **	19	60	.33 ****
5	78	.45 ****	20	76	.29 ***
6	34	.35 ****	21	57	.41 ****
7	49	.47 ****	22	37	.46 ****
8	25	.28 ***	23	45	.22 *
9	41	.49 ****	24	37	.60 ****
10	57	.29 ***	25	50	.35 ****
11	31	.42 ****	26	41	.27 ***
12	17	.39 ****	27	85	.09
13	65	.26 **	28	49	.51 ****
14	62	.40 ****	29	22	.44 ****
15	66	.28 **	30	3	.12

[a] Difficulty Index is the percent of the sample answering incorrectly.

[b] Item-Total is the partial correlation between the item score and the Total Score, controlling for the overlap between the two.

* $p < .05$. ** $p < .01$. *** $p < .005$. **** $p < .001$.

Prediction 9a: The CFT Matching Task will have homogeneous content, as indicated by a strong Total Scale alpha reliability and by moderate subscale alpha reliabilities.

On the CFT Matching Trial, Cronbach's alpha was computed for the Total Scale, as well as for the Left Detail and the Right Detail subscales. These are presented in Table 12. The Total Scale had a modest interitem reliability (alpha = .58), suppressed in part by three items with zero variance (all subjects answered three items correctly). None of the remaining items on the Total Scale detracted from the alpha reliability coefficient, indicating that all items contribute to the integrity of the scale.

The Right Detail subscale also had modest internal consistency despite the low number of items to its design and one item with zero variance (alpha = .40, 3 items). Item-total statistics on this scale indicate that Item 5 substantially reduced the subscale's reliability; deleting this item would raise the subscale alpha by .07.

Like the Right Detail subscale, the Left Detail subscale started with few items and was further limited by one item with zero variance; unlike the Right Detail subscale, however, this subscale failed to achieve predicted levels of homogeneity (alpha = .08, 3 items). In addition, one item detracted from the reliability coefficient by .08.

Intercorrelations among scales and subscales can be found in Table 13; all were significant ($p < .0005$). Correlations between the Total Scale and each of other scales are, of course, very large because each subscale is nested within the Total Scale. The correlation between the two unnested subscales, Left Detail and Right Detail, was $r = .55$ ($p < .0005$).

Prediction 9b: The CFT Matching Total Score will have good convergent validity, that is, will correlate positively with the WMS-R Visual Reproductions matching score and with the Judgment of Line Orientation test score.

Matching Total Score correlated modestly with the VR Matching Total Score ($r = .39$, $p < .0005$) and with JOLO ($r = .46$, $p < .0005$). The modesty of the relationship was expected given the limited number of items on the Visual Reproductions recognition task and given the specific nature of the JOLO stimuli (line orientations) compared to the complex spatial relationships involved on the CFT.

In addition, correlations between CFT Matching and the other CFT trials were computed. Correlations between the Matching Total Score and the CFT memory trials failed to reach significance at the designated probability ($p \leq .001$): Immediate free recall, $r = .27$, $p < .005$; Delay free recall, $r = .29$, $p < .005$; and Recognition, $r = .18$, $p = .05$. The correlations with the other nonmemory trial were much stronger (Copy, $r = .65$, $p < .0005$).

Prediction 9c: The CFT Matching Total Score will have good construct validity in that it will load on a factor with other visual-spatial perception tests, and not with auditory-verbal perception tests or with memory tests.

Correlations among all of the measures listed in Table 14 were entered as a matrix and analyzed in a multitrait-multimodality model using the LISREL program for confirmatory factor analysis, as described in Prediction 8c. However, as reported in that same section, the Phi matrix was not positive definite, thus resulting in premature termination of the analysis.

Because the data did not conform to the assumptions of LISREL, they were subjected to the SPSS Factor routine with varimax rotation, which organizes the variables into the solution that maximizes the variance explained. The results of those three analyses are reported under Prediction 8c.

Prediction 9d: As further evidence of construct validity, each item of the CFT Matching Task will load on the a priori scale for which it was designed (Left Detail or Right Detail), except items 1 and 6.

For this prediction, correlations were computed among all the detail items of the CFT Matching Trial (thus excluding the global, nonlateralized items, 1 and 6). However, two of the remaining eight items had zero variance so that correlations could not be computed between them and the other items. Consequently, neither LISREL nor SPSS could analyze the data.

Prediction 9e: CFT Matching Total Scores will be negatively skewed with a prominent ceiling effect.

Scores on the CFT Matching Trial were negatively skewed, as predicted. For the 88 subjects who completed this task, the mean was 9.4 and the median and mode were 10.0. Scores ranged from 6 to 10 (out of 10 possible), with a standard deviation of 1.0. Regression of the Matching Total Score on age and sex failed to identify an effect for age ($\underline{R}$ = -.25, $\underline{p}$ = .01), age^2 ($\underline{R}$ = -.27, $\underline{p}$ = .01), or sex ($\underline{R}$ = -.14, $\underline{p}$ > .05) at the significance level specified; the interactions also failed to enter the equation ($\underline{p}$ > .05). Descriptives can be found in Table 25.

Prediction 9f: Most items on the CFT Matching Task will have significant, positive corrected item-total correlations.

Point-biserial correlations between each CFT Matching item and the CFT Matching Total Score were corrected by partialling out the variance in the Total Score that was due to the item itself (Table 26). Three coefficients could not be computed due to zero variance. The other seven coefficients were positive and moderate, given the ceiling on point-biserial correlations at .80. One item correlated .24 ($\underline{p}$ <.01) with the Total Score; the others ranged from .28 to .41 ($\underline{p}$ < .005). Item difficulty indices (percent of the sample that responded incorrectly) ranged from 0% to 15%.

Table 25

Descriptives for CFT Matching Total Scale (Raw Scores).

Group	n	Mean	Median	Mode	SD	SEM	Min.	Max.
Total	88	9.4	10.0	10.0	1.0	.65	6	10
Younger	47	9.6	10.0	10.0	0.8	.52	7	10
Older	41	9.3	10.0	10.0	1.2	.78	6	10

Note. Only age differences were significant ($p \leq .05$).

Table 26

Discrimination Ability of the CFT Matching Items.

Item No.	Diffic. Index[a]	Item-Total[b]	Item No.	Diffic. Index[a]	Item-Total[b]
1	1	.28***	6	0	--[c]
2	2	.24**	7	1	.28***
3	0	--[c]	8	18	.37****
4	6	.30***	9	14	.41****
5	15	.38****	10	0	--[c]

[a] Difficulty Index is the percent of the sample answering incorrectly.

[b] Item-Total is the partial correlation between the item score and the Total Score, controlling for the overlap between them.

[c] Correlation could not be computed due to zero variance.

* $p < .05$. ** $p < .01$. *** $p < .005$. **** $p < .001$.

DISCUSSION

This project (1) introduced recognition and matching trials to supplement an existing (free-recall) measure of visual memory, the Complex Figure Test (CFT); (2) provided psychometric data and preliminary norms for the new instruments, using an age- and sex-stratified sample of healthy, community-dwelling adults; (3) evaluated the role of attention in secondary memory processes in healthy older adults; (4) and compared men and women on CFT performance. The findings are summarized and discussed relative to each prediction and then the findings are integrated within each of three sections: age differences, sex differences, and psychometric properties.

Age Differences

Prediction 4a: Eight of the 10 tests supported the prediction that attentional skill and perceptual accuracy would correlate negatively with age in both auditory-verbal and visual-spatial modalities. Two measures did not correlate with age: Digit Span Backwards and CFT Matching.

The absence of age differences on these two measures may reflect a sampling bias. Older adults in the community who were experiencing more decline than their peers perhaps were too self-conscious about their cognitive difficulties to participate in this study. If this is so, then these results could indicate that the eight measures that were significantly related to age are sensitive enough to detect these changes even in the healthiest of volunteers.

Prediction 4b: The prediction that production ability would correlate negatively with age in the auditory-verbal modality but not in the visual-spatial modality got mixed support. One measure in each modality (Category Fluency and Visual Reproductions [VR] Copy) correlated significantly, whereas another measure in each modality (Letter Fluency and CFT Copy) did not. These differences are difficult to reconcile. As in the case of the previous prediction, this inconsistency with prior research findings may reflect the different sensitivities of these measures to aging that are brought out in a healthy sample.

Prediction 5: The frequency of hypertension (HTN), coronary heart disease (CHD), cerebrovascular disease (CVD), diabetes mellitus (DM), and pulmonary disease will correlate positively with age; current alcohol and tobacco use will correlate negatively with age; and nonsignificant correlations are expected between age and hydrocephalus, renal disease, hepatic disease, seizures, and loss of consciousness (LOC) that follows traumatic head injury. In this sample, none of the health variables were related to age at the stringent significance level applied, although DM approached significance. The failure to find a relationship between age and those variables that were expected to increase with age may again be due to sample bias; that is, the older subjects in this study may represent an especially healthy subset of community dwelling older adults.

To investigate the possibility that this sample may not be very representative of the population at large, frequencies of these five medical conditions were compared to national statistics. Older adults in this sample less frequently reported HTN (40% versus 60%) and CHD (25% versus 50%); they reported DM at the same rate as the older American population at large (18%, within the reported range of 15-20%); and they reported a higher incidence of CVD (10% versus 1-5%). (The estimated rate of pulmonary disease in the general population could not be ascertained.) The expected age-related decline in alcohol use and smoking was also absent in this sample. This may be due to lower rates of alcohol and tobacco use in the younger subset of this actively religious sample.

Because the high incidence of CVD in this sample could potentially confound analyses of the effects of normal aging on cognition, analyses that produced evidence of age effects were run again, covarying for history of CVD. This procedure was required in only one situation (Prediction 2, Logical Memory analyses), and CVD failed to supplant age or dramatically reduce its explanatory potential.

The findings presented thus far warrant caution in generalizing from the rest of the results: Some impressions gained from this study may reflect very healthy aging only, especially given that the one blemish in the older adults in this sample (the high incidence of CVD) was statistically corrected in the aging analyses.

Prediction 6: The prediction that depression and trait anxiety would not correlate with age in this community-dwelling sample but that state anxiety would correlate positively was fully supported. Reactive anxiety during testing was more evident among older adults than among younger adults. Because the high levels of anxiety might have confounded analyses of the effects of normal aging on cognition, analyses that produced evidence of age effects were run again, covarying for State Anxiety. This procedure was required in only one situation (Prediction 2, Logical Memory analyses), and State Anxiety failed to explain any variance and did not diminish the age effect.

Prediction 1: The prediction was confirmed that age would not explain a significant portion of consolidation variance. Auditory-verbal and visual-spatial secondary memory consolidation did not change as a function of age, either linearly or quadratically. This suggests that healthy aging does not affect the automated consolidation processes of secondary memory. Therefore, the decline observed with aging is more likely due to effortful encoding/storage and/or retrieval processes. Encoding/storage could not be isolated by the paradigm used in this study; retrieval, however, was examined in the next prediction.

Prediction 2: The prediction that age would explain a significant portion of variance in retrieval operations of secondary memory was firmly supported in the auditory-verbal domain. Age explained 14 percent of the retrieval variance in a linear, not quadratic, relationship. Although a positive history of cerebrovascular disease (CVD) was also associated with decline in retrieval operations, this was not responsible for the observed age effect. Age continued to explain 10 percent of the retrieval variance even after controlling for CVD. Consequently, age was found to play a small but significant role in the decline of effortful, retrieval processes for auditory-verbal material. For visual-spatial material, however, age was not significantly related to retrieval efficiency. This is especially surprising given Craik's (1977) proposal that visual-spatial memory processing is even more effortful than is auditory-verbal and given Winograd and Simon's (1980) empirical support for that proposition. This finding in the present study is difficult to reconcile with the attention-deficit model of age-related memory decline that is under investigation here.

Prediction 3: The data failed to support the prediction that age would explain significantly less variance in retrieval operations of secondary memory after controlling for the effects of attention. Examination of the effects of attention on retrieval efficiency were relevant in the auditory-verbal modality only because age differences were not observed in the visual-spatial modality (Prediction 2). Although there was a trend for Digit Span Backward, none of the attention measures explained a significant portion of retrieval variance at the specified alpha. Consequently, the age effects observed in auditory-verbal retrieval were not attributable to attention.

Taken together, the results from the analyses in Prediction 2 and in Prediction 3 indicate that decline in attention capacity is not responsible for age-related declines in retrieval functions. This now puts the "anomalous" visual-spatial results from Prediction 2 in a clearer perspective, at least with regard to the attention-deficit model: It seems that effortful, attention-consuming processes are not required for retrieval from secondary memory; consequently, differences between auditory-verbal and visual-spatial effortful attention would not appear in analyses of these functions.

Earlier evidence with older adults had already implicated attention in encoding/storage processes (Craik & Byrd, 1982; Rabinowitz, Craik, & Ackerman, 1982). Some investigators had postulated effects of attention on retrieval processes, as well (Craik & Byrd, 1982). Others, however, presented substantial and convincing evidence that retrieval processes are spared by attentional decline and that only encoding/storage processes are affected (Perlmutter and Mitchell, 1982; Smith, 1977, 1980). The results of this study are consistent with the latter conclusion.

Although this study did not permit systematic isolation of encoding/storage processes, the results thus far allow us to make some inferences regarding these processes now. That is, because attention is not required in consolidation and retrieval, it seems, by default, to exert its influence in the first stage of secondary memory, encoding/storage. Evidence for this from other sources has already been presented (and cited in the previous paragraph). The current study, however, goes beyond previous studies in allowing us to determine the proportion of variance in encoding/storage that is attributable to age, apart from attention. Having concluded that any attention effects in secondary memory performance will reflect encoding/storage processing, and not retrieval or consolidation, regression of immediate or delay free recall on attention prior to age provided an index of the role of attention in encoding/storage processing.

In post hoc analysis of visual-spatial memory, Visual Memory Span Backward explained 17 percent of the total variance that was not explained by perception and production variables ($\underline{p} < .0005$). Even when using liberal significance criteria ($\underline{p} = .05$), the age effect (age and age^2 together explaining six percent of the total variance) disappeared after controlling for attention.

In post hoc analysis of auditory-verbal memory, age entered on the last step to explain only 10 percent more variance in LM-I after controlling for attention ($\underline{p} < .0005$). This is identical to the relationship observed when retrieval alone was regressed on age; consequently, this appears to be the same age-retrieval effect observed earlier and does not represent new age differences in encoding/storage. Therefore, in the auditory-verbal domain, age effects persisted even after controlling for attention, but the effects represented age differences in retrieval only; age explained none of the encoding/storage variance.

Similar findings emerged for LM-II, except that attention played no role at all. Age explained only 14 percent more variance beyond that accounted for by production skills. Again, this amount is no different from the retrieval variance already attributed to aging; age explained little, if any, of the encoding/storage variance.

Summary. The expanded tests of auditory-verbal and visual-spatial memory, together with many measures of perception, construction, and attention, helped determine whether reduced attention capacity explains age-related secondary memory decline. On auditory-verbal memory, no age effect was observed on consolidation; encoding/storage varied by age, but the effect was due entirely to attention deficits; only retrieval showed age differences that could not be explained by attention (10 percent of total variance). On visual-spatial memory, no age effects were observed in encoding/storage, consolidation, or retrieval after perception and construction were controlled.

These findings have implications for memory intervention with older adults. First, efforts to train older adults in mnemonics will likely have only short-term effects during the training workshop where attention is focused solely on memorization of the stimuli. However, mnemonic devices typically demand substantial attention capacity and, therefore, are not likely to generalize outside of memory training workshops. Consistent with this are reports that older adults do not spontaneously use the mnemonics they learn (Perlmutter & Mitchell, 1982; Smith, 1980).

Second, visual learning appears to be very resistant to aging processes and does not require excessive attentional resources. Therefore, visual encoding of verbal material, for example, by means of reading, should reduce the age effects on memory performance. This was supported in a recent study by Denburg, Fastenau, and Fertuck (1994), which showed significantly weaker age effects for paragraphs that were read compared to paragraphs that were aurally presented. Even more impressive is the fact that the reading material was incidentally learned (i.e., the subjects were told that it was a test of reading and were not told to remember the material) whereas the aural material was presented in an intentional paradigm (i.e., subjects were told to memorize the paragraphs before hearing them). Consequently, memory in older adults may be best sharpened by increasing attention capacity rather than by increasing attention demand through mnemonics, and by encouraging visual encoding (e.g., using maps to supplement verbal directions and writing/reading auditory material that needs to be remembered).

Two limitations to this research warrant mention. The first, as already noted, is that the sample appears to be healthier and more educated than their cohorts in the population at large; consequently, these results may not generalize readily to the all adults. Furthermore, this sample was almost exclusively Caucasian.

A second limitation is that this study is cross-sectional in design. Consequently, age effects represent cohort differences and not necessarily the aging process itself. Plans are underway to seek funding for a five-year follow-up study of this sample for cohort-sequential analysis, which will allow true aging effects to be distinguished from cohort and time-of-measurement effects.

Sex Differences

Prediction 7: The prediction that men would outperform women on the delay recall trial of the CFT was not supported. No sex differences were found for Copy, Delay Recall, Recognition, or Matching trials. An unexpected finding was a sex difference on the Immediate Recall trial, accounting for nine percent of the variance on this measure. Although the effect was observed on Immediate recall rather than on Delay, the direction of the relationship (men outperforming women) was preserved. This adds to a collection of findings that show modest sex effect in favor of males on at least one of the CFT trials. This lends support to the proposition that males, as a group, possess some capacity for processing complex visual stimuli more efficiently and/or more effectively. However, there was substantial overlap on all trials between men and women in this study, thereby further supporting Harris' (1985) argument for describing sex differences in visual-spatial functions as sex-related variability and not as sexual dimorphisms.

Psychometric Properties of CFT Recognition and Matching

Prediction 8a: It was predicted that the CFT Recognition trial would have homogeneous content. As expected, the Total Scale had a strong interitem reliability (alpha = .84). The subscales ranged from moderate (.59, .61, and .66) to high (.81), in rough relation to the number of items on each scale; this was also consistent with the prediction. Each item contributed substantially to the integrity of its host scale. The correlation between the Global and Detail scales was only moderate, suggesting that each scale measures some unique variance. Left and Right Detail subscales, on the other hand, appeared to be no more than "alternate forms" for measuring the exact same construct.

<u>Prediction 8b</u>: The prediction that CFT Recognition Total Score would have good convergent validity was supported. CFT Recognition correlated modestly but positively with VR recognition. The modesty of the relationship was expected given the limited number of items on the VR recognition task and given the simplicity of the VR stimuli. As further evidence of convergent validity, CFT Recognition correlated moderately with VR-I and VR-II and highly with the other CFT memory trials; as evidence of divergent validity, CFT Recognition correlated weakly with nonmemory (Copy and Matching) trials. It is evident from these data that the Recognition Trial measures secondary memory and that it is not confounded by construction or perceptual demands.

<u>Prediction 8c</u>: Several factor analyses lent support to the construct validity of the CFT Recognition trial. On eight-factor and four-factor solutions, the CFT Recognition Total Score loaded onto a "Visual Memory" factor; on a two-factor model, the Recognition score loaded onto a "Broad Cognition" factor in contrast to the "Verbal Memory" factor. Thus, all three models provided strong and consistent support that the CFT Recognition trial is a measure of visual-spatial

secondary memory and that it is different from auditory-verbal measures of secondary memory.

Prediction 8d: Contrary to the other prediction of construct validity for the Recognition Trial, the a priori three-factor structure (Global, Left Detail, and Right Detail) was not validated with this healthy sample. Even after combining the two Detail subscales, the correlation matrix failed to match the theoretical two-factor model (Global and Detail scales).

Prediction 8e: As expected, CFT Recognition Total Scores distributed normally with no ceiling or floor effects. For the 88 subjects who completed this task, the mean and median were 16.0, and the mode was 15. Scores ranged from 4 to 27 (out of 30 possible). Performance on this task correlated significantly with age, so descriptives were tabulated for younger and older subjects.

Prediction 8f: As predicted, most items on the CFT Recognition Task had significant, positive corrected item-total correlations. All coefficients were positive, and only two values failed to reach statistical significance. Item difficulty indices reflected that the test samples a broad range of ability levels so that there are items within virtually everyone's capability and items that challenge even people with very good memory skills; yet, the set of items converges on an item difficulty of .50 where discrimination is maximized. This test discriminates very effectively at all levels of competence and should be equally useful with healthy and impaired persons alike.

Prediction 9a: The prediction that the CFT Matching Task would have homogeneous content, as indicated by a strong Total Scale alpha reliability and by moderate subscale alpha reliabilities, was supported for the most part. The Total Scale had a modest interitem reliability (alpha = .58), suppressed in part by three items with zero variance (all subjects answered three items correctly). All of the remaining items contributed to the integrity of the scale.

The Right Detail subscale also had modest internal consistency despite its low number of items and one item with zero variance (alpha = .40, 3 items); one of the three items substantially reduced the subscale's reliability. Like the Right Detail subscale, the Left Detail subscale started with few items and was further limited by one item with zero variance; unlike the Right Detail subscale, however, this subscale failed to achieve predicted levels of homogeneity (alpha = .08, 3 items). In addition, one of the items detracted substantially from the reliability coefficient.

The correlation between the two unnested subscales, Left Detail and Right Detail was moderate ($\underline{r}$ = .55), which may indicate that the two subscales measure unique variance. These data offer some support for the retention of the subscales but the evidence is relatively weak; these subscales will need to be administered to a clinical sample, where more variability can be expected, in order to examine their reliabilities more fully. The Total Scale reliability has been demonstrated here and this scale can be considered adequate for further use and appropriate for clinical trials.

Prediction 9b: There was modest support for convergent validity in the CFT Matching trial. Matching Total Score correlated modestly with the VR Matching Total Score ($\underline{r}$ = .39) and with JOLO ($\underline{r}$ = 46). The modesty of the relationship was expected given the limited number of items on the VR recognition task and given the specific nature of the

JOLO stimuli (line orientations) compared to the complex spatial relationships involved on the CFT.

In addition, correlations between CFT Matching and the other CFT trials supported that the Matching Trial is distinct from the secondary memory trials. A high relationship between visual-spatial construction was observed, which is conceptually meaningful because of the substantial contribution of visual-spatial perception to copying performance.

Prediction 9c: The prediction that the CFT Matching Total Score would have good construct validity received some support. On eight-factor and four-factor solutions, the CFT Matching Total Score consistently loaded apart from memory tests. Thus, there was some support that the CFT Matching trial measures nonmemory cognitive functioning; however, the evidence failed to confirm this as a pure visual-spatial task or as a pure perceptual measure.

Prediction 9d: As further evidence of construct validity, it was predicted that each Matching item would load on the a priori scale for which it was designed (Left Detail or Right Detail). Two of the eight items had zero variance, such that correlations could not be computed between them and the other items. Consequently, neither LISREL nor SPSS factor analysis could analyze the data.

Prediction 9e: As predicted, scores on the CFT Matching Trial were negatively skewed. For the 88 subjects who completed this task, the mean was 9.4 and the median and mode were 10.0. Scores ranged from 6 to 10 (out of 10 possible). The Matching Total Score failed to correlate with age and with sex. Descriptives were provided on the total sample and for relevant subgroups.

Prediction 9f: As expected, most items on the CFT Matching Task had significant, positive corrected item-total correlations. Three point-biserial correlation coefficients could not be computed due to zero variance. The other seven coefficients were positive and moderate, given the ceiling on point-biserial correlations at .80. One item correlated .24 with the Total Score; the others ranged from .28 to .41. Item difficulty indices ranged from 0% to 15%. Unlike the Recognition Task but similar to other tests of its kind (e.g., JOLO), the Matching Trial was very easy for most healthy adults and did not discriminate among these individuals very well. Data comparing clinical samples with healthy samples and comparing patients with different types or degrees of impairment will be necessary to demonstrate the utility of this measure for discriminating perceptual performance in lower ranges of ability.

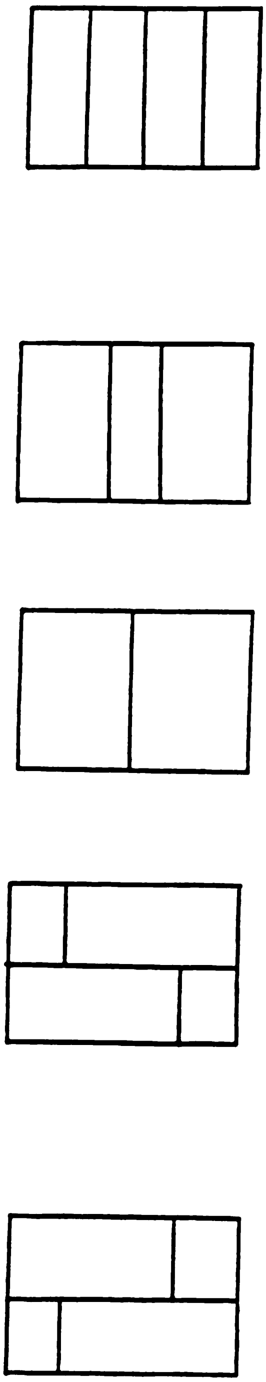
Summary. The new CFT Recognition Trial was found to be reliable and valid with this healthy sample. Psychometric evidence on the Matching Trial was much less impressive, mostly due to the small number of items on the measure. The ceiling effect on the Matching Trial also limited the psychometric characteristics, especially with 30 percent of the items producing zero-variance. Nonetheless, there are some indicators that the Matching Trial and its two subscales may perform better among clinical samples. Clinical trials for both the Recognition Task and for the Matching Task are indicated for their further development. Data are currently being collected at Henry Ford Hospital in Detroit, Michigan, with epilepsy patients undergoing unilateral temporal lobectomies; this is the first step toward clinical validation with the new instruments.

Appendix A

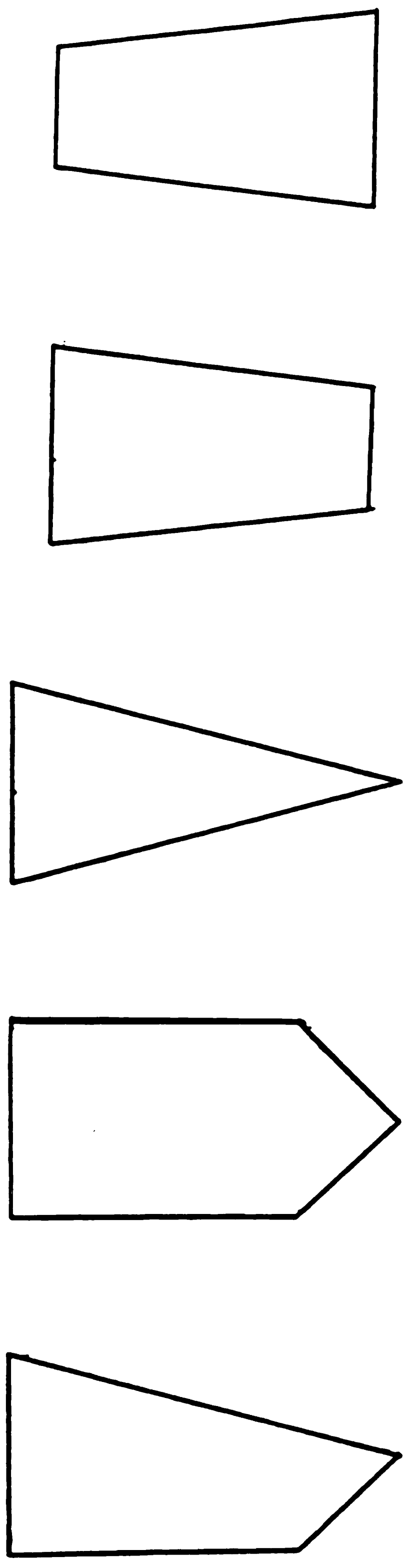
Appendix A

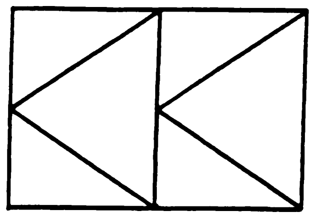
Recognition Items for the Complex Figure Test

2

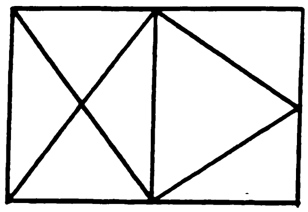


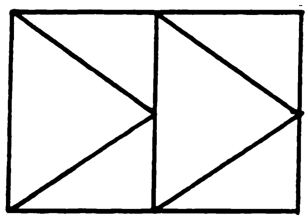
3

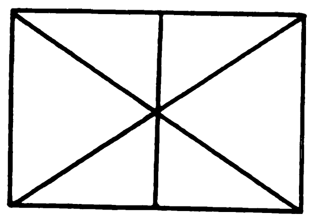


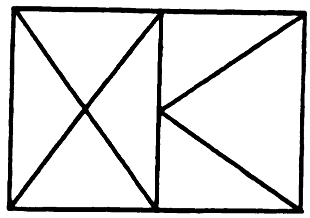


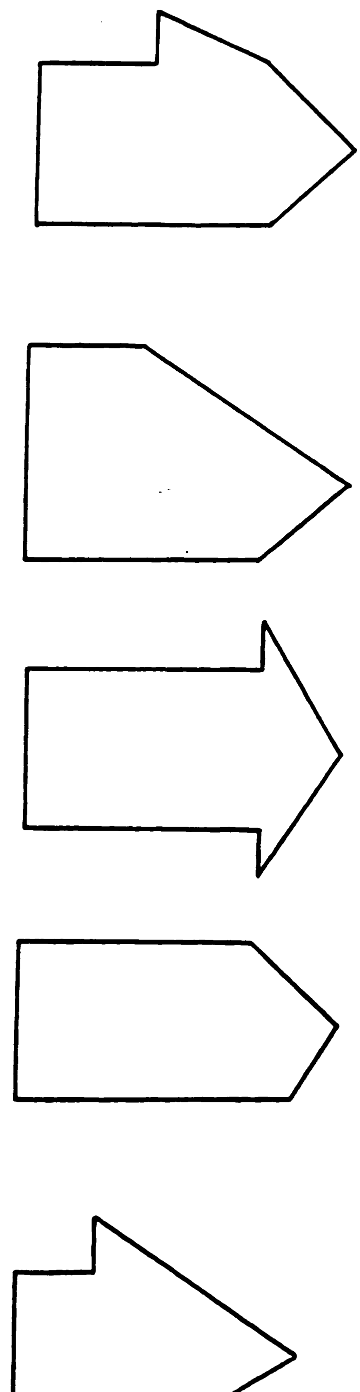
4



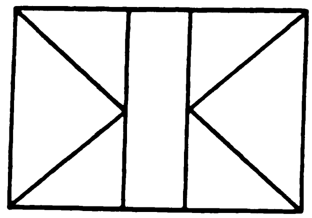




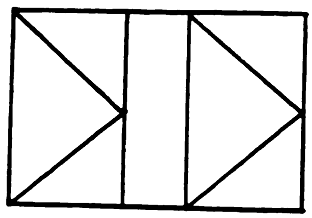


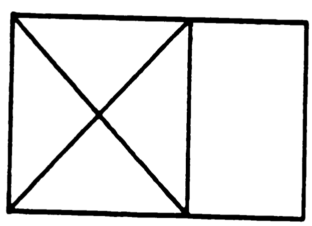


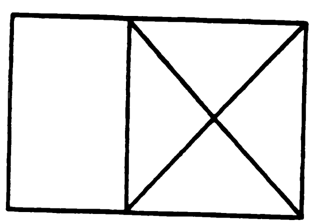
5

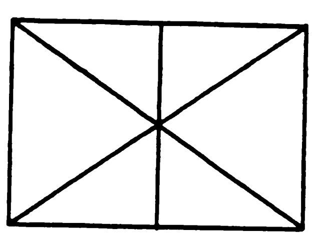


6

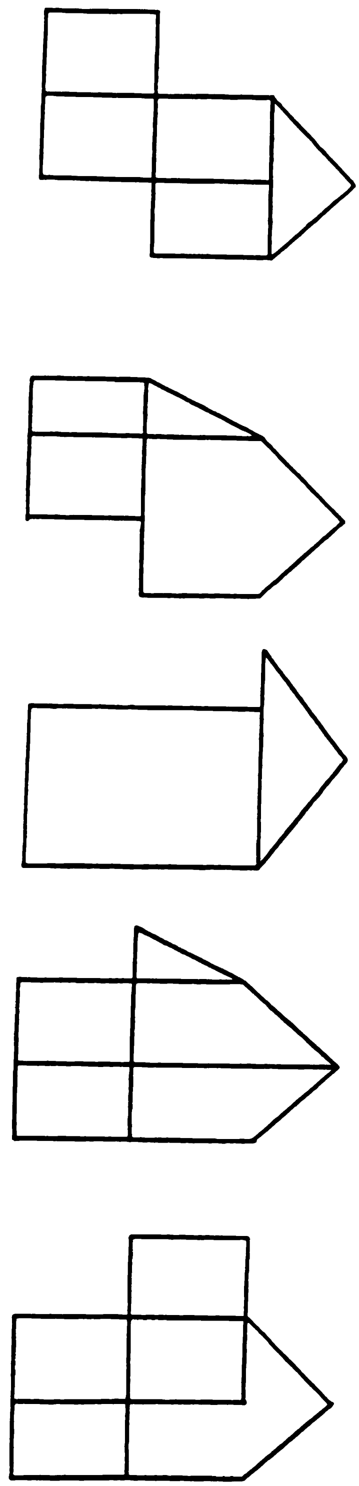


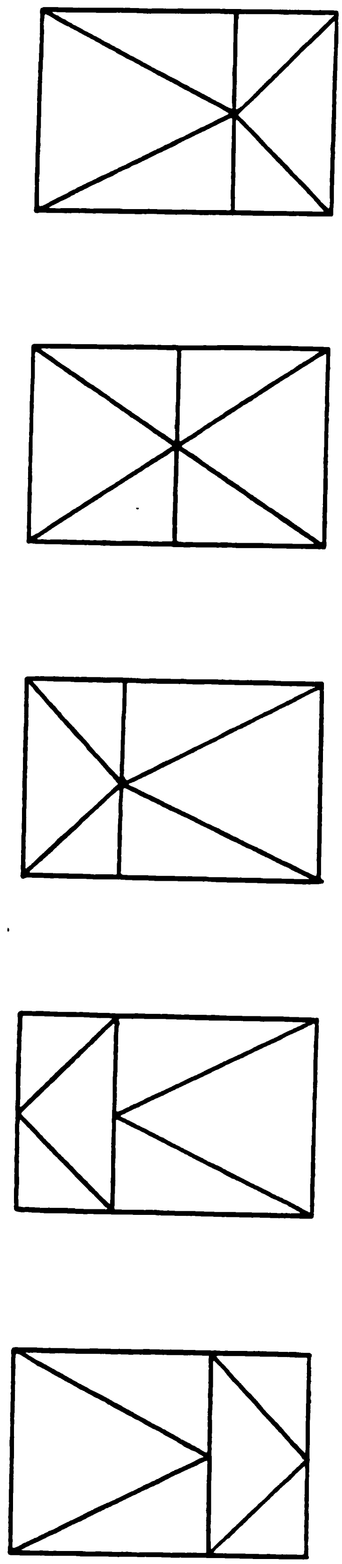




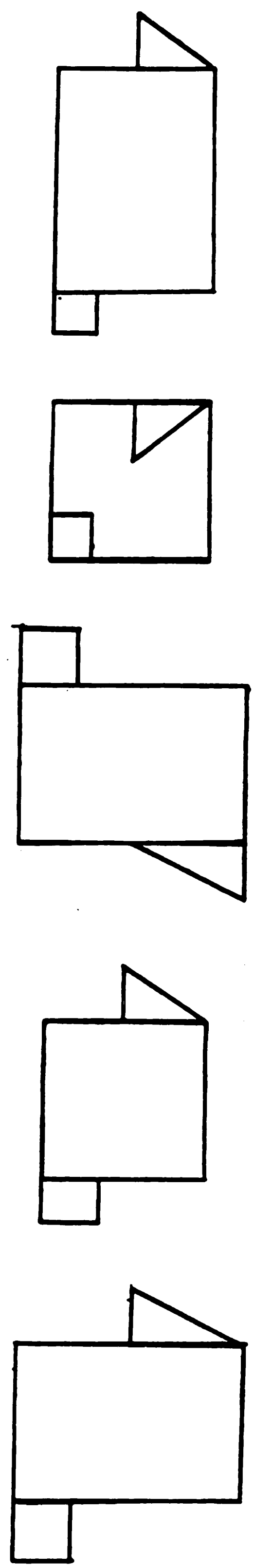


7



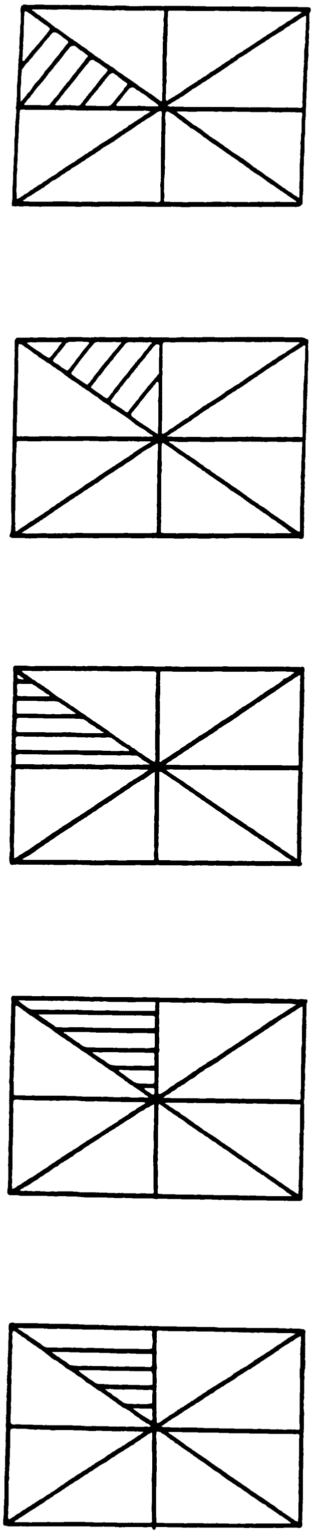


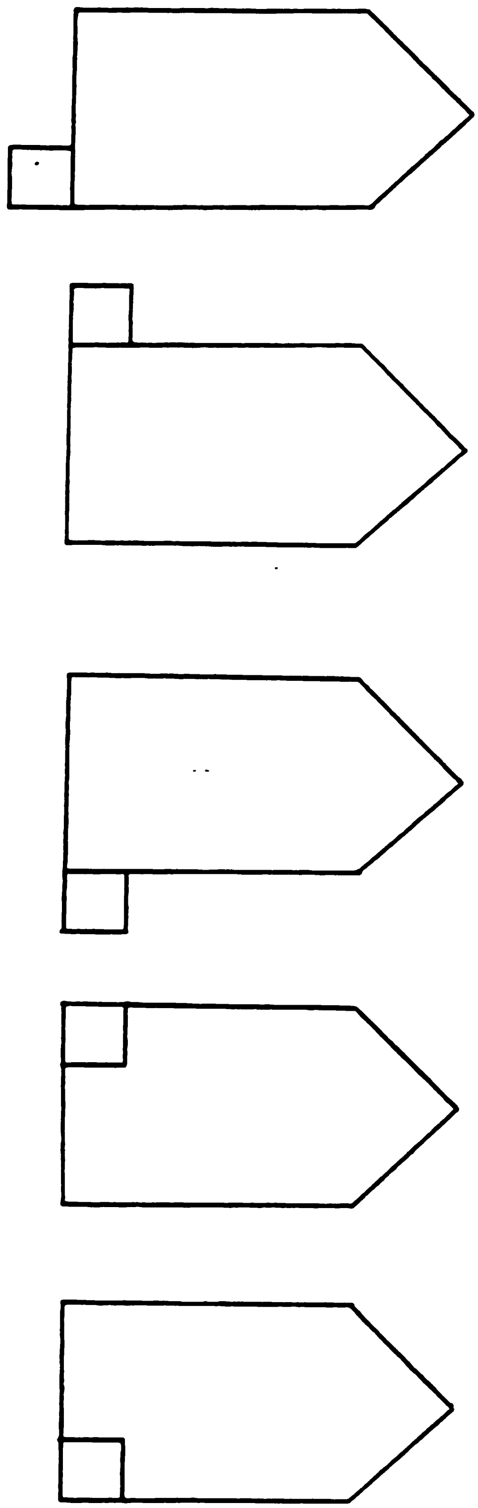
8



9

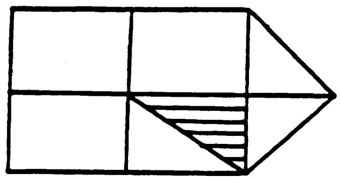
10

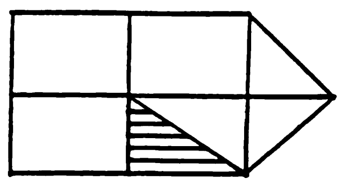


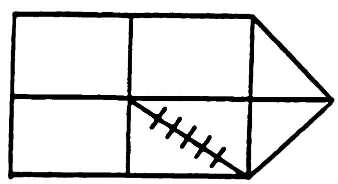


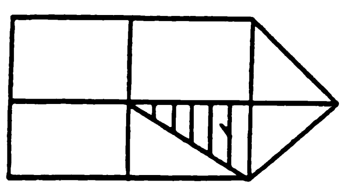
11

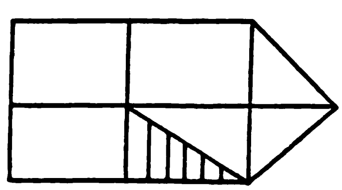
12

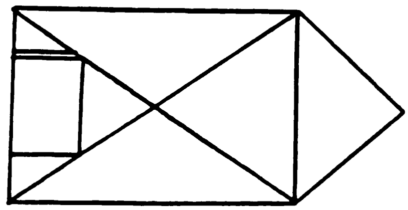




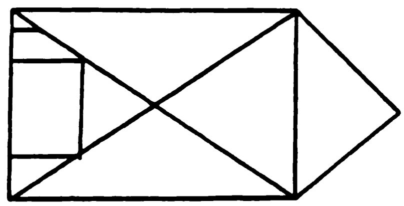


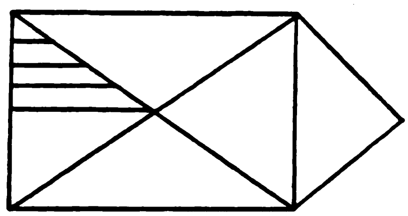


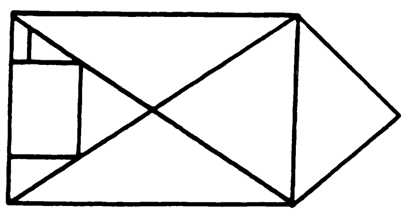


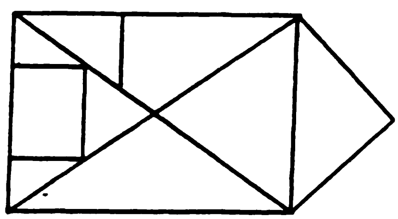


14

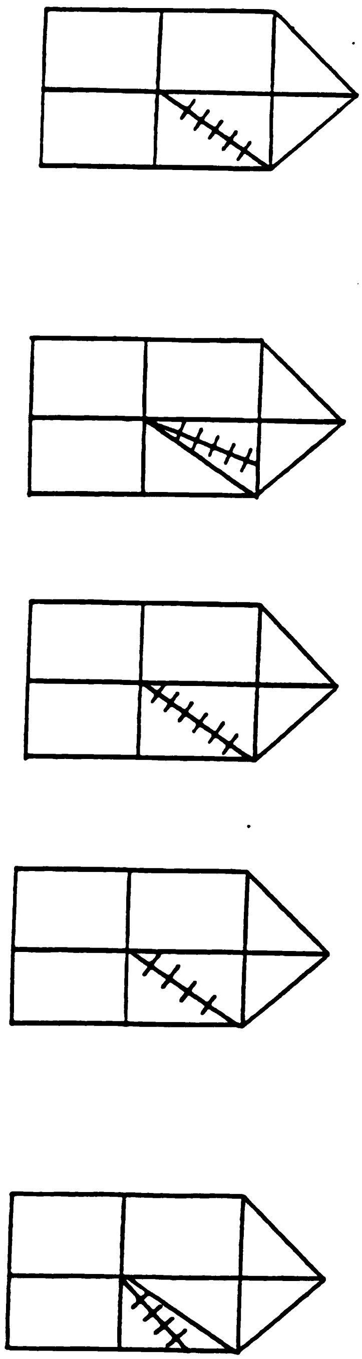




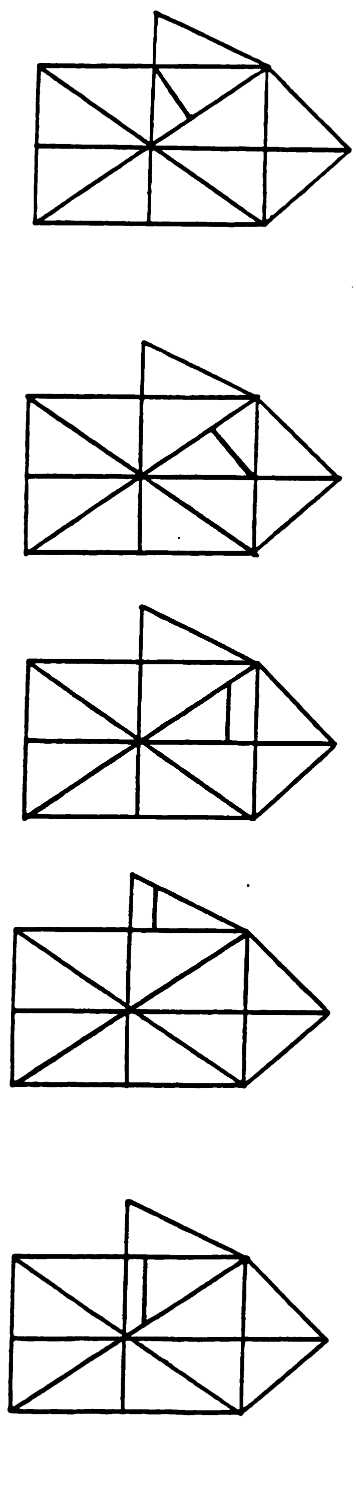




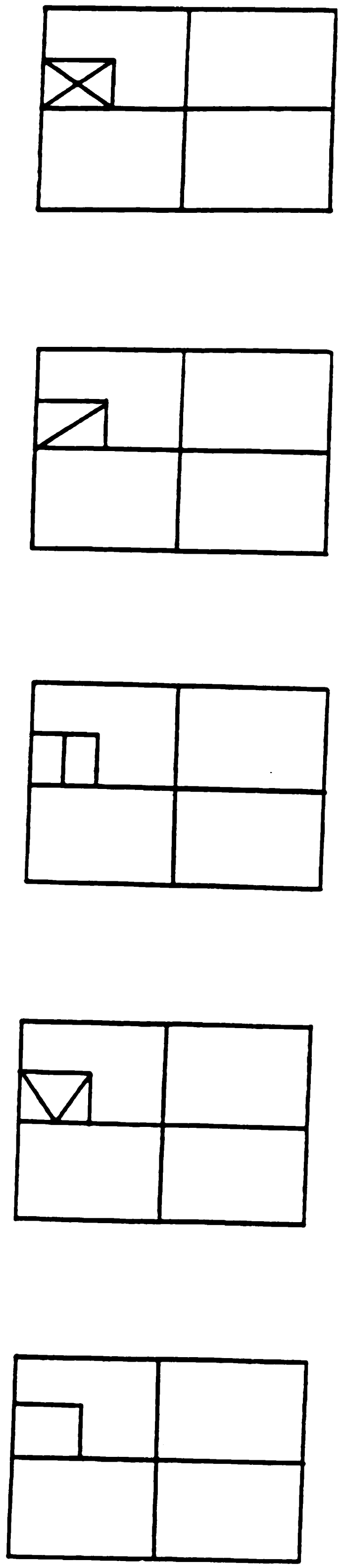
16



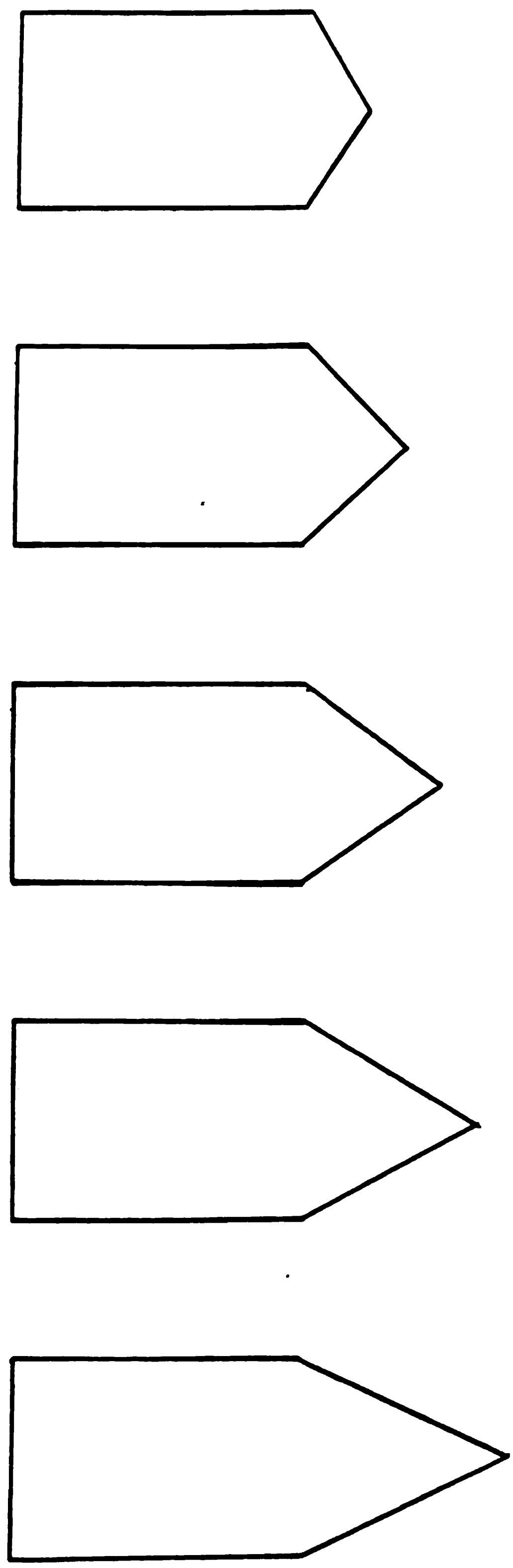
17

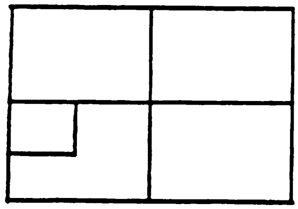


18

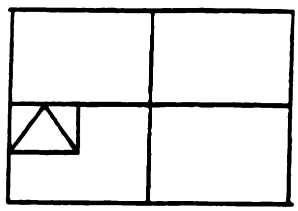


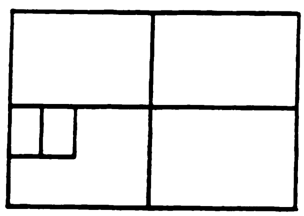
19

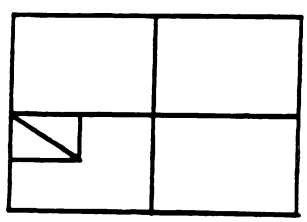


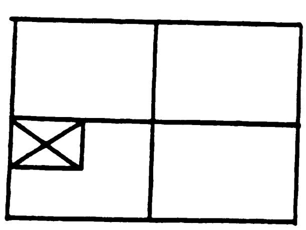


20

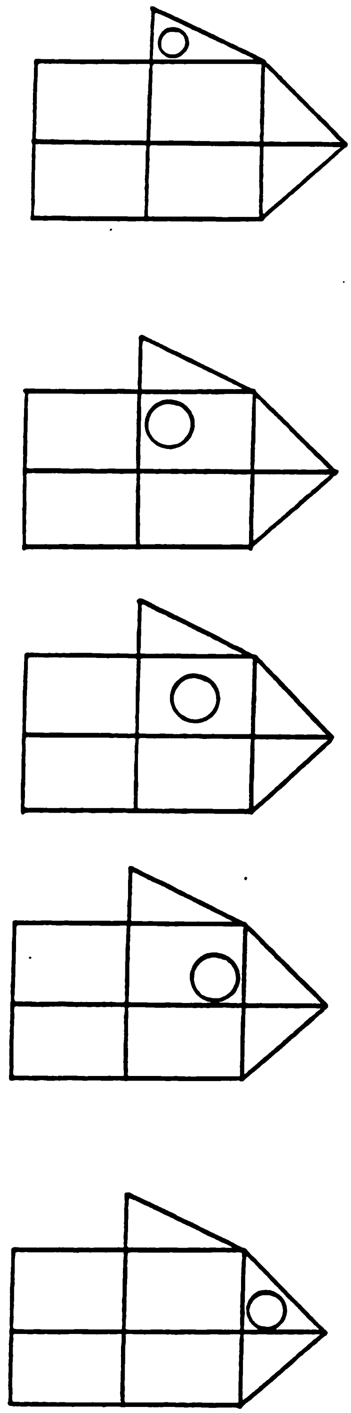




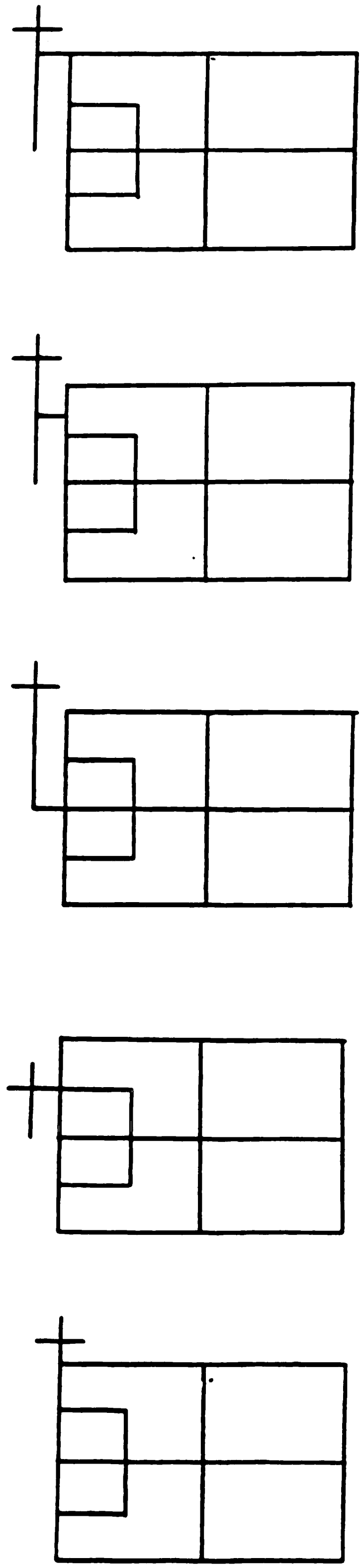




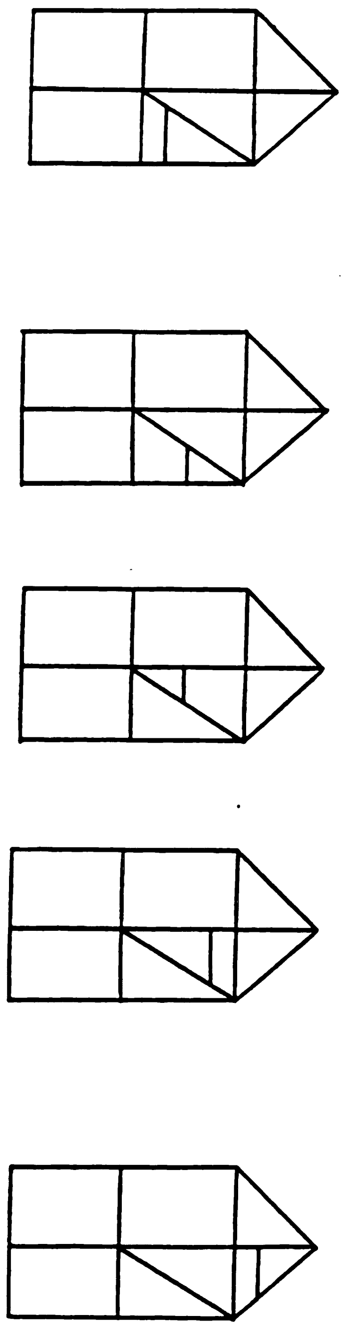
22

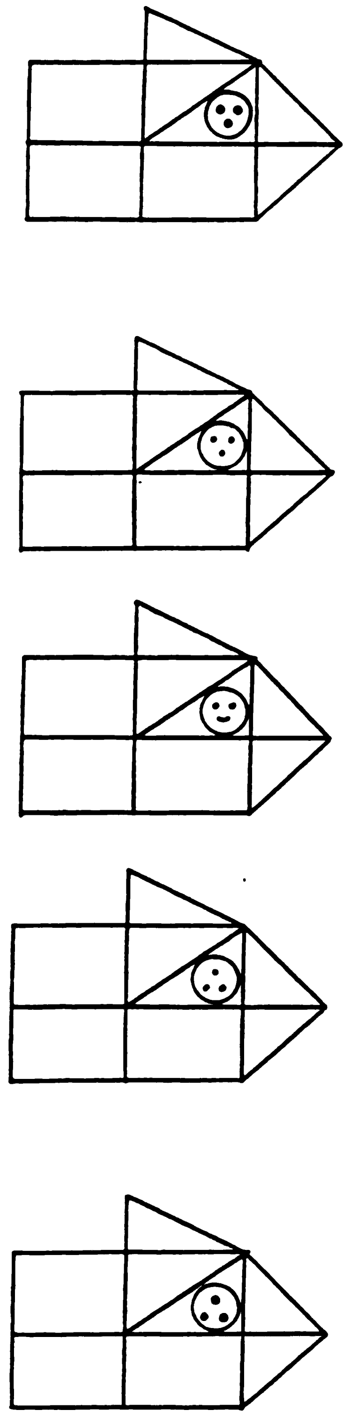


23



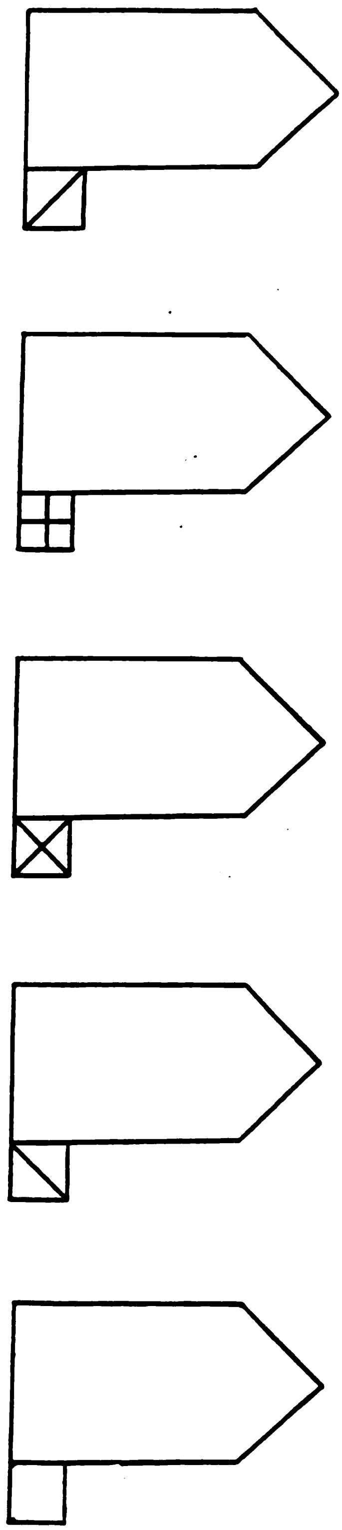
25

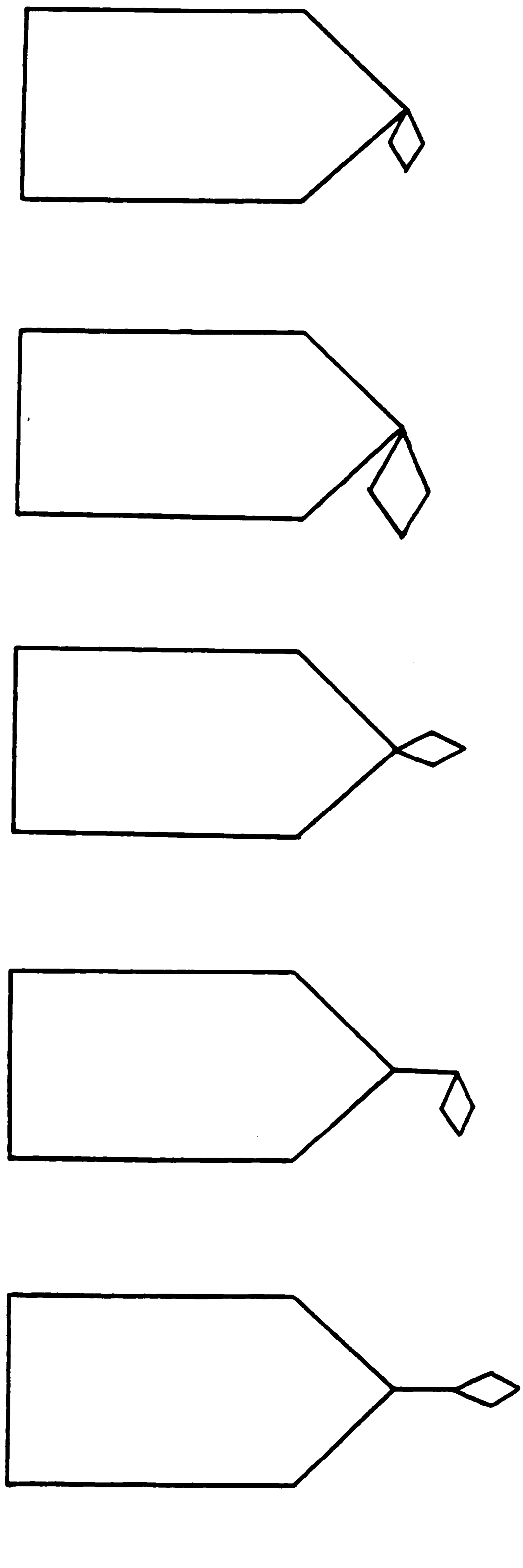




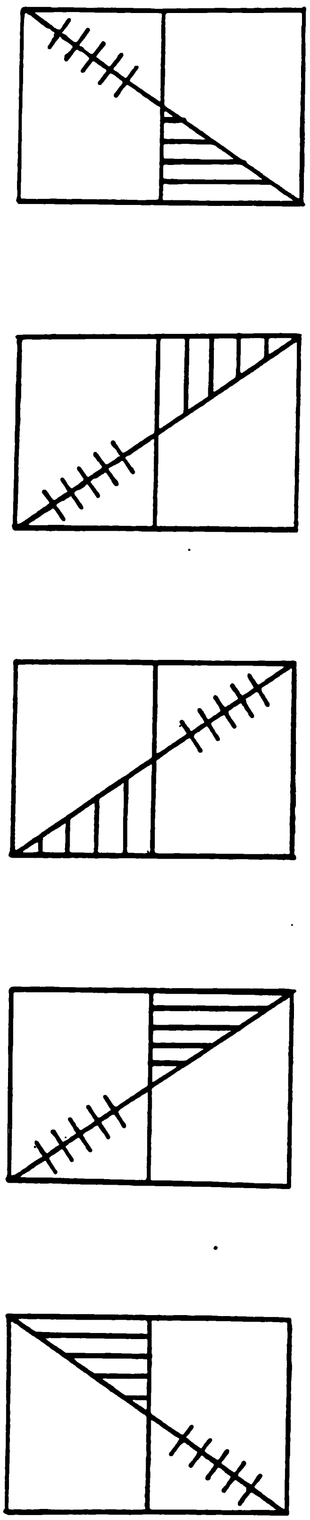
26

27



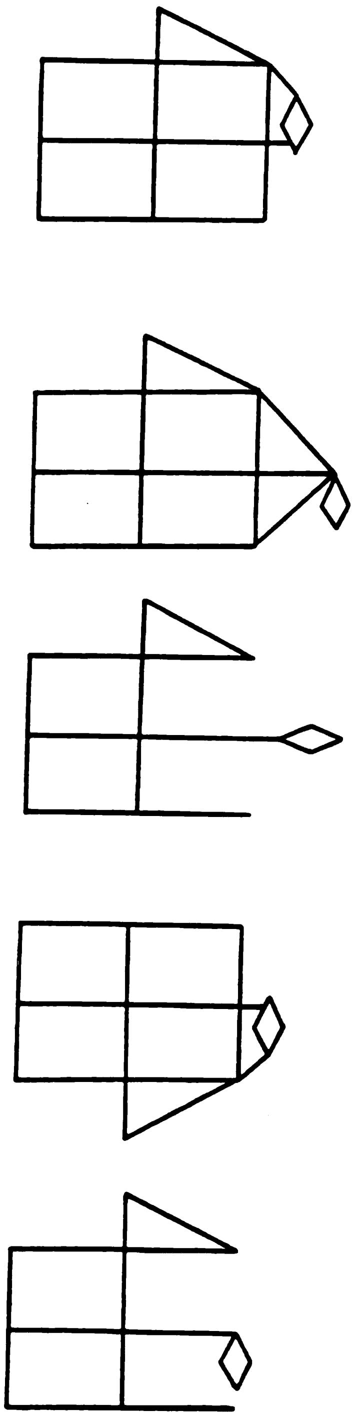


28



29

30

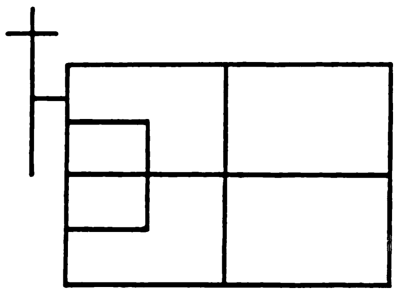


Appendix B

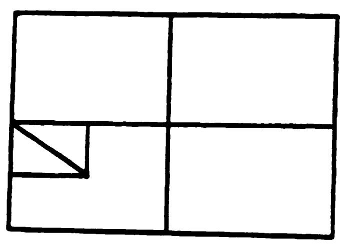
Appendix B

Matching Items for the Complex Figure Test

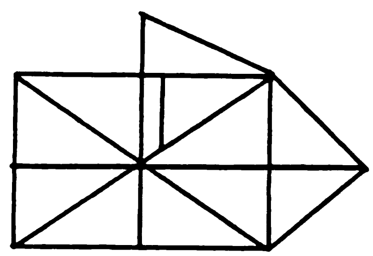
M- 2



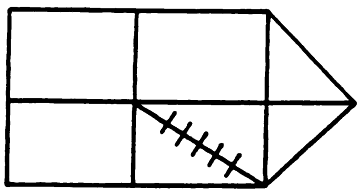
M-3



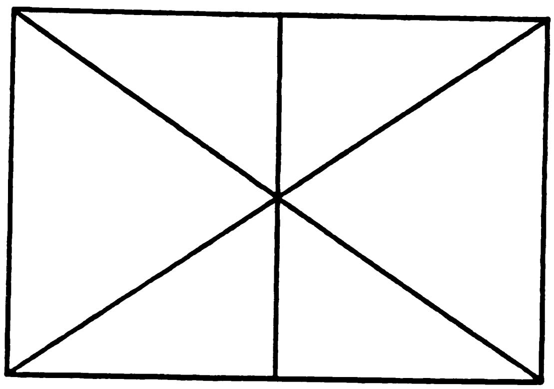
M- 4



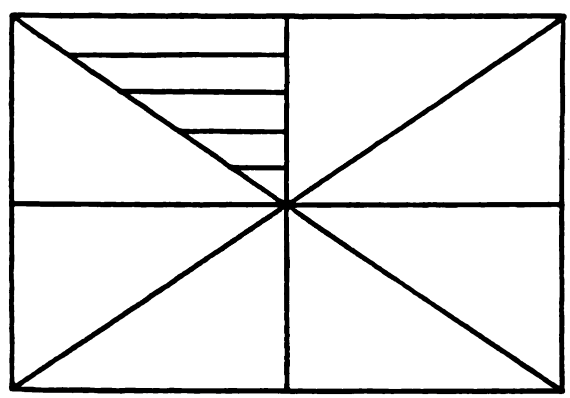
M-5



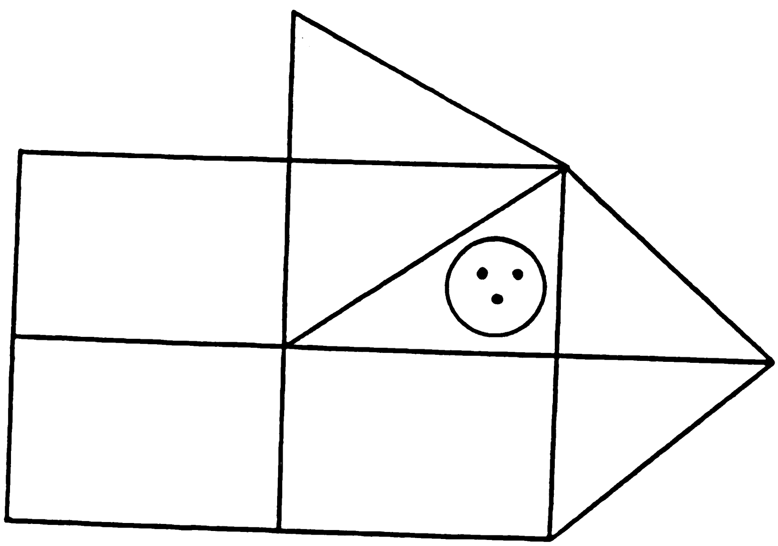
M-6



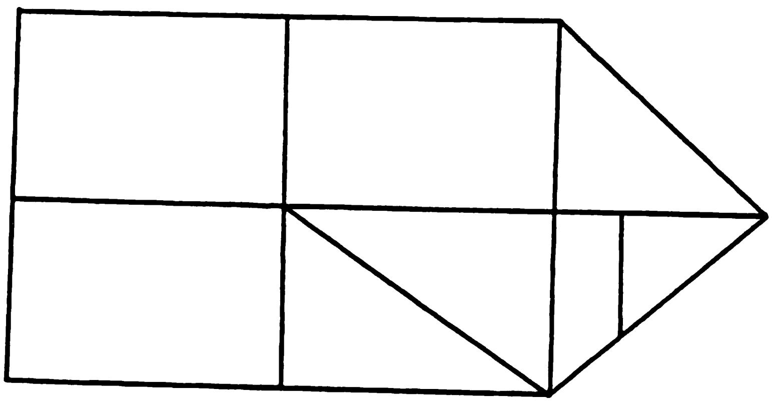
M-8



M-9



M-10



Appendix C

Appendix C

Neuropsychological Survey

Neuropsychological Questionnaire   Subject Number: _______ (Rec #3)

[Directions: Ask these questions before testing & record all responses. When recording "Year" values, values up through 5-months-31-days are truncated; values ≥ 6-mos-0-days are rounded up to next yr. Anything in parentheses should be communicated to the subject to clarify the question. Bracketed info is for the examiner only.]

[Universal Codes: "9/99/999" for no response, refusal to answer;
maximum value is "8/89/899"; "0/00/000" if "No";
"1/01/001" is the min. value for affirmative answer.]

"BEFORE WE BEGIN TESTING, I HAVE SOME QUESTIONS TO ASK YOU. SOME OF THESE MAY BE DIFFICULT TO ANSWER. ANSWER TO THE BEST OF YOUR ABILITY."

[CIRCLE SUBJECT'S GENDER] .... M [1]   F [2]

What is your date of birth? .... __ __ - __ __ - __ __ __ __

How many years of school have you completed? .... __ __

When did you last complete a class for a
numerical grade (not S/U, Pass/Fail, or Audit)? ... __ __-01-__ __ __ __

Can you remember the WORST time that you hit your head or
suffered a blow to your head? [If no, "000" for next 2 qus]

Were you dizzy afterwards? How long? [days; "000" if "No"] __ __ __

Were you unconscious? .... Yes [1]   No [0]

How long? [minutes; "00" if "No"]   __ __

How many times have you been knocked unconscious? .... __

Have you ever had a stroke or a transient ischemic attack
(sometimes they're called TIA's or "mini-strokes")? ... Yes [1]   No [0]

How many times has this happened? ....   __

Following the (worst) stroke, were you hospitalized?
[If yes] How long? [in days; "00" if "No"] .... __ __

Following the (worst) stroke, did you have rehabilitation?
[If yes] How long? [in weeks; "00" if "No"] .... __ __

Have you ever had hydrocephalus (too much fluid
in the brain)? .... Yes [1]   No [0]

How many times have you had this? [If "No," "0"] .... __

Neuropsychological Questionnaire 2 Subject Number: ________ (Rec #3)

===

Have you ever "blacked out" or lost consciousness without knowing why? .... Yes [1] No [0]

How long did it last? [In minutes; code "000" if "No"] __ __ __

Have you ever been treated for seizures or seizure prevention? .... Yes [1] No [0]

How many years were you in treatment? [If "No," "00"] .... __ __

Do you know what caused the seizures? [See if this revises others]

Have you ever taken anticonvulsant medications, like Dilantin, Tegratol, Phenobarbital, Depakene, or Depakote? 00 [No]

[If Yes] How many years did you take that? .... __ __

What was that for?

Have you ever had numbness or tingling in your arms, legs, or face? (Can you tell me more about that? Do you know why?) 00 [No]

How many times has this happened? [Exclude "falling asleep"] __ __

Have you ever had spells of sudden weakness or paralysis in your arms, legs, or face? (Can you tell me more about that?) 00 [No]

How many times has this happened? [Exclude "falling asleep"] __ __

Have you ever seen a neurologist for a health problem? Yes [1] No [0]

What was that for? [See if this revises other responses.]

Have you ever been tested with EEG, CT of the head, or MRI of the head? .... Yes [1] No [0]

What was that for? [See if this revises other responses.]

Have you ever had neurosurgery? .... Yes [1] No [0]

What was that for? [See if this revises other responses.]

Have you ever had high blood pressure? .... Yes [1] No [0]

How many years was it a problem? .... __ __

Are you currently on any medications for that? ... Yes [1] No [0]

Was it under control (back to normal) when you last had it checked? .... Yes [1] No [0]

Neuropsychological Questionnaire 3 Subject Number: _______ (Rec #4)

Have you ever had angina (chest pains)? .... Yes [1] No [0]

Have you ever had a heart attack, heart disease, or
any other heart problems? .... Yes [1] No [0]

Have you ever had a medical procedure on your heart or
arteries, such as angioplasty, endartarectomy, surgery,
or a pacemaker? .... Yes [1] No [0]

Have you ever had diabetes? .... Yes [1] No [0]

How many years was it a problem? .... __ __

Are you currently on any medications for that? ... Yes [1] No [0]

Was it under control (back to normal) when you last
had it checked? .... Yes [1] No [0]

Have you ever smoked cigarettes? [If No, "00" for next 4 questions.]

At present, how many packs do you smoke PER WEEK? .... __ __

How many years have you smoked at this level
(total no. of years, not necessarily in succession)? .... __ __

In your heaviest year, how many packs did you smoke PER WEEK? __ __

How many years did you smoke at *that* level
(total no. of years, not necessarily in succession)? .... __ __

On average, how many alcoholic drinks* do you have PER WEEK? __ __

*** Ask type/amt: 12 oz beer (verify size of "can" or "bottle")**
= 1.5 oz liquor (a "shot" or a "mixed drink")
= 5 oz wine
= 3 oz port

How many years have you been drinking at this level
(total no. of years, not necessarily in succession)? __ __

During your heaviest year of drinking, how many
alcoholic drinks* did you have PER WEEK? __ __

About how many years you drink at that level
(total no. of years, not necessarily in succession)? __ __

Neuropsychological Questionnaire 4 Subject Number: _______ (Rec #4)

Have you ever used "street drugs"? .... Yes [1] No [0]

What substances have you used?

How many years did you use (have you used) street drugs? .... __ __

Have you ever had any problems with dependency or addiction to *prescription* medication? .... Yes [1] No [0]

[If yes] What medications have been a problem for you?

How many years was this (has this been) a problem? .... __ __

Have you ever had problems with your kidneys? .... Yes [1] No [0]

Have you ever had problems with your liver? .... Yes [1] No [0]

Have you ever had problems with your lungs? .... Yes [1] No [0]

Can you list all the medications you have taken in the last week: [Record number of prescribed medications] ..... __ __

Name of Medication	Dosage	Frequency	[Rx Codes]				
________	______	________	MEM	COG	ANX	DEP	MTR
________	______	________	MEM	COG	ANX	DEP	MTR
________	______	________	MEM	COG	ANX	DEP	MTR
________	______	________	MEM	COG	ANX	DEP	MTR
________	______	________	MEM	COG	ANX	DEP	MTR
________	______	________	MEM	COG	ANX	DEP	MTR
________	______	________	MEM	COG	ANX	DEP	MTR
________	______	________	MEM	COG	ANX	DEP	MTR
________	______	________	MEM	COG	ANX	DEP	MTR

SUMS . . .

MEM: __
COG: __
ANX: __
DEP: __
MTR: __

Appendix D

Appendix D

Letter Cancellation Stimuli

LC-1

"Vacation"

In an antique store, we spotted a doll house that I bought for Jaime. The saleswoman said she'd ship my other purchases to Washington. I thanked her, and we got back into the car.

FINISHED

LC-2

It was also Ian who introduced me to my first oak-apples, pulling the tree branch low enough for me to touch them; and Ian who guided my fingers around the beautifully formed nest of a jenny wren.

FINISHED

LC-3

Whenever I have an appetite for fish, I go to a village on the lakeshore where it is served fresh off of the whaleboat. Lately, since my retirement, I have made the lakeward trip every weekend. I drive straight to Whitefish Bay and walk the wharf to an alehouse on the lakefront. My timetable has become so noticeable that the tradesmen pull out their timepieces and smile as I pass or even greet me with a mateworthy wave. Though nameless among them, I am not anonymous. When I arrive at the tavern, the native cooks prepare a tasteful solefish to mark my "homecoming." They affectionately call me the "homeless paleface," yet they keep a place for me there among them.

FINISHED

LC-4

What began as a harebrained idea became the Batemans' vacation cottage outside of Stoneford. Taking some time off to attend a free real estate venture, the hopeful couple spent nine days in the Whiterock mountains. While they were guests in Stoneford, the salesman took them on horseback through timeless forests and ancient graveyards. At the end of a ninety minute ride, two large redwoods formed a gateway to a slopeside terrace on the edge of the gorge. In the foreground was a lovely dome-topped rotunda, modeled from dwellings in early frontier settlements. As a timeshare, the saleprice was more-than-manageable, and the Batemans beamed with excitement when they signed the contract.

FINISHED

LC-5

There have never been any parents happier than Dwight and Harriet Hodges. Dwight and Harriet had never been able to have children, and the health specialists had told them it was impossible. However, this couple in their forties proved the experts wrong as they hurried to the hospital on that very wonderful birthday. How happy Harriet was to finally see this day come. And Dwight, overprotective of his mother-to-be, helped her with as much as he could. Obsessively, he attended to every detail of the hospital trip much as they had rehearsed it, even to the point of hailing three hacks!

FINISHED

LC-6

I hastily rolled up my rawhide this morning to get a headstart in the cool of the day. But already by nine, the fog burned off, unharnessing the heat of a searing sun. Hiking the mountain is hard enough in pleasant weather. But now, in the thick air of a hot and humid day like today, it seems I can't inhale deeply enough to ever catch a healthy breath. Nonetheless, I embrace these hardships because of a passion I hold for the wilderness. I find my home here with wild horses, in otherwise uninhabited hillsides. Here are the treasures that Nature withholds; she keeps them here in trust for the brotherhood of cowhands and in hope for humankind.

FINISHED

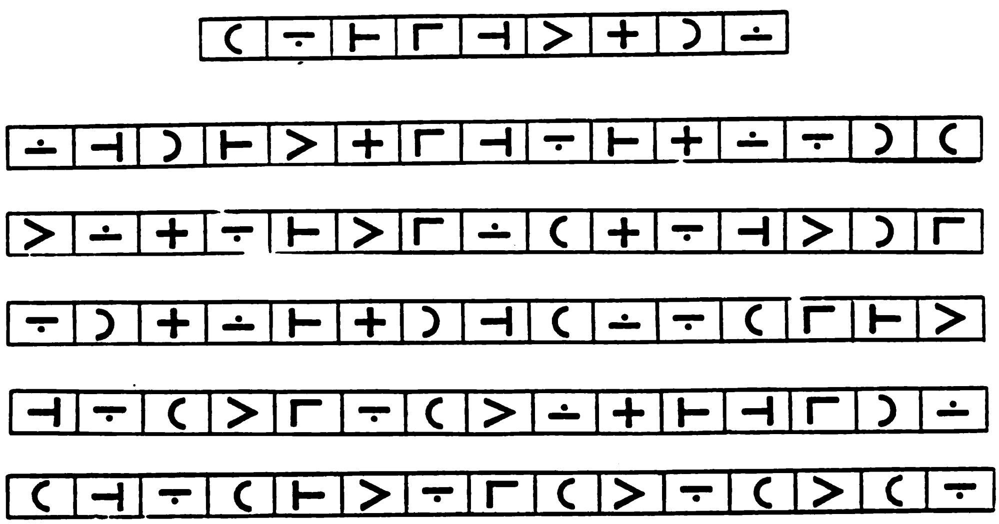
Appendix E

Appendix E

Symbol Cancellation Stimuli

SC-1

KEY



SC-2

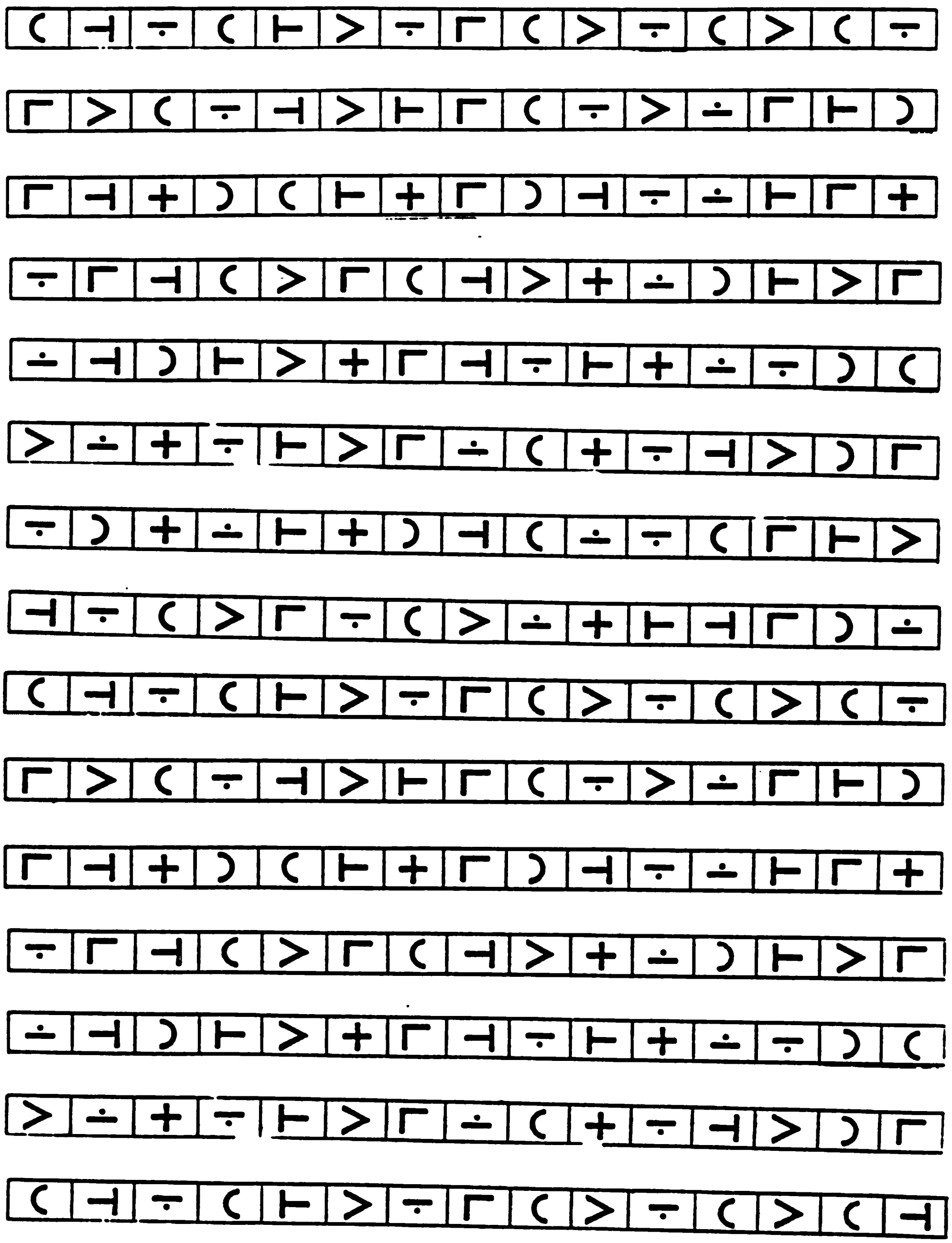
KEY

(	⨪	⊢	Γ	⊣	>	+	)	∸

(	⊣	⨪	(	⊢	>	⨪	Γ	(	>	⨪	(	>	(	⨪
Γ	>	(	⨪	⊣	>	⊢	Γ	(	⨪	>	∸	Γ	⊢	)
Γ	⊣	+	)	(	⊢	+	Γ	)	⊣	⨪	∸	⊢	Γ	+
⨪	Γ	⊣	(	>	Γ	(	⊣	>	+	∸	)	⊢	>	Γ
∸	⊣	)	⊢	>	+	Γ	⊣	⨪	⊢	+	∸	⨪	)	(
>	∸	+	⨪	⊢	>	Γ	∸	(	+	⨪	⊣	>	)	Γ
⨪	)	+	∸	⊢	+	)	⊣	(	∸	⨪	(	Γ	⊢	>
⊣	⨪	(	>	Γ	⨪	(	>	∸	+	⊢	⊣	Γ	)	∸
(	⊣	⨪	(	⊢	>	⨪	Γ	(	>	⨪	(	>	(	⨪
Γ	>	(	⨪	⊣	>	⊢	Γ	(	⨪	>	∸	Γ	⊢	)
Γ	⊣	+	)	(	⊢	+	Γ	)	⊣	⨪	∸	⊢	Γ	+
⨪	Γ	⊣	(	>	Γ	(	⊣	>	+	∸	)	⊢	>	Γ
∸	⊣	)	⊢	>	+	Γ	⊣	⨪	⊢	+	∸	⨪	)	(
>	∸	+	⨪	⊢	>	Γ	∸	(	+	⨪	⊣	>	)	Γ
(	⊣	⨪	(	⊢	>	⨪	Γ	(	>	⨪	(	>	(	⨪

SC-3

KEY



Appendix F

Appendix F

Scoring Criteria for the CFT Drawings

SCORING CRITERIA FOR THE COMPLEX FIGURE TEST
(Fastenau, 1991; rev. April, 1993)

General Principles

1. **ANY ELEMENT CAN ONLY BE SCORED ONCE.** That is, it can only serve as part of one unit. In times of doubt, it should be scored as the unit which brings the most points for the examinee.

2. For each scorable unit (numbered items below; 18 total) award 1 point for each criterion met (maximum of 3 points per unit).

3. For all measurements, because the lines are wide, measure from the approx. centers of the lines. Give the benefit of the doubt to the examinee--credit points when the measurement is borderline.

4. A metric ruler will be the easiest standard for scoring linear criteria because most criteria are expressed as "$\pm$10%."

5. A protractor is needed. Use endpoints of lines to measure angles.

6. For placement scoring, if the reference line (e.g., #1's right side in the phrase "+ #1's right side") is not present, then use the imaginary line as a reference point. For form scoring, all the lines within the scoring unit must be present for credit.

Criteria

RECOGNIZABLE: Some element can be identified as an attempt at the scoring unit in question. (Be lenient and credit as recognizable if there is *any* resemblance; however, each element can only be scored as *one* unit.)

GOOD FORM: Angles are accurate, lines intersect, shape/spacing is proportional, & the number of sides/lines/dots is exact. Form angles (v. placement angles) are those between parts of the *same* unit.

Number of Sides/Lines/Dots Is Exact.

Unit # 1: Four sides (including R side) must be present.
Unit # 4: Two diagonals are present, even if not corner-to-corner.
Unit # 5: There must be only 4 lines, not 5.
Unit # 6: Four sides (including L side) must be present.
Two diagonals are present, even if not corner-to-corner.
Unit # 8: Stem of the cross that attaches to #1 must be present.
Unit #11: There are 3 dots (*no* credit for circles or lines).
Unit #12: There must be exactly 5 hash marks.
Unit #17: One and only one diagonal must be present in box.
Unit #18: Stem of the cross that attaches to #1 must be present.

Angles Are Within 15° of the Angle in the Stimulus.

L Special Angles:

Unit # 9:	28-62-90
Unit #13:	48-48-84
Unit #16:	55-125-55-125

L Right angles: 90 degrees

^ Lines Intersect.

Using the *crossing* line as the standard, no gap/overhang > 10%.

__ Lines Are Straight.

Using the imaginary line between endpoints as the standard, no point on the actual line deviates by > 10%.

Shapes and Spacing Are Proportional.

Ratios are within the specified limits.

To compute the ratio, divide the 1st measurement by the 2nd one; if the resulting number falls within the boundaries of the criterion, give credit. For example, in #1, compute the ratio by dividing the length of the longest horizontal line by the length of the shortest vertical line; credit any dividend between 1.0 and 2.0.

R Critical Ratios:

Unit # 1:	Longest (L) side to shortest (S) side, L:S < 2.
Unit # 5:	Widest (W) space to narrowest (N) space, W:N < 2.
Unit # 6:	Longest (L) side to shortest (S) side, L:S < 2.
Unit # 8:	Long (L) bar to shorter (S) crossbar, 3 < L:S < 7.
Unit #11:	Longest (L) diameter to shortest (S) diam., L:S < 1.5.
Unit #12:	Widest (W) space to narrowest (N) space, W:N < 2.
	Longest (L) hash to shortest (S) hash, L:S < 2.
Unit #16:	R vertical of #1 (V) to length of diamond (d), V:d > 2.
Unit #17:	Longest (L) side to shortest (S) side, L:S < 1.5.
	Bottom of #1 (B) to shortest (S) side of square, 3 < B:S < 5.
Unit #18:	Long (L) bar to shorter (S) crossbar, 3 < L:S < 7.

GOOD PLACEMENT: Element is within proper boundaries, is properly oriented to at least one major referent, and intersects/bisects all other elements at proper locations. "Placement" angles (v. "form" angles) are those between one unit and *other* units.

= Parallel: Not skewed more than 15°.

Horizontal: Parallel to at least one of the following horizontal referents: top or bottom of base rectangle or horizontal midline.

Vertical: Parallel to any of the following vertical referents: L or R side of base rectangle or the vertical midline.

+ Bisecting: Using the <u>line bisected</u> as the standard, intersection is within 10% of the midpoint. Element must bisect at <u>all</u> relevant points (e.g., #2 must bisect <u>both</u> top and bottom of #1).

^ Intersecting: Using the *crossing* line as the standard, no gap/overhang > 10%.

Unit # 8: Connecting piece must meet #1 above horizontal midline and below the top of #1.

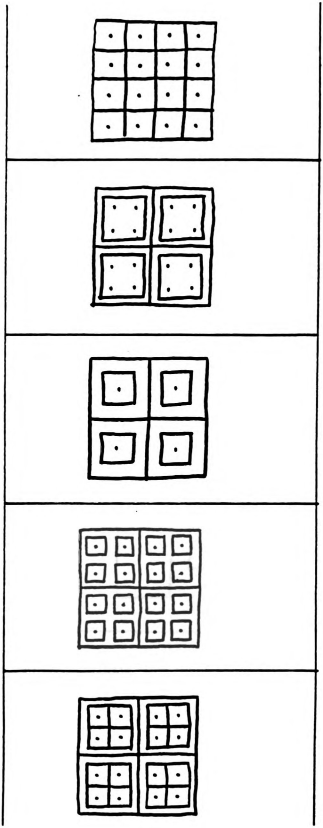
Unit #11: Circle must fall in correct octant, although some leniency is permitted if diagonal is missing.

The codes down the left margin are also recorded on the scoring sheet as prompts to the experienced examiner. Less-experienced examiners should take special care to consult the descriptions above, and inexperienced examiners should begin with the detailed, item-by-item description of scoring.

Appendix G

Appendix G

<u>WMS-R VR Recognition/Matching Stimuli</u>



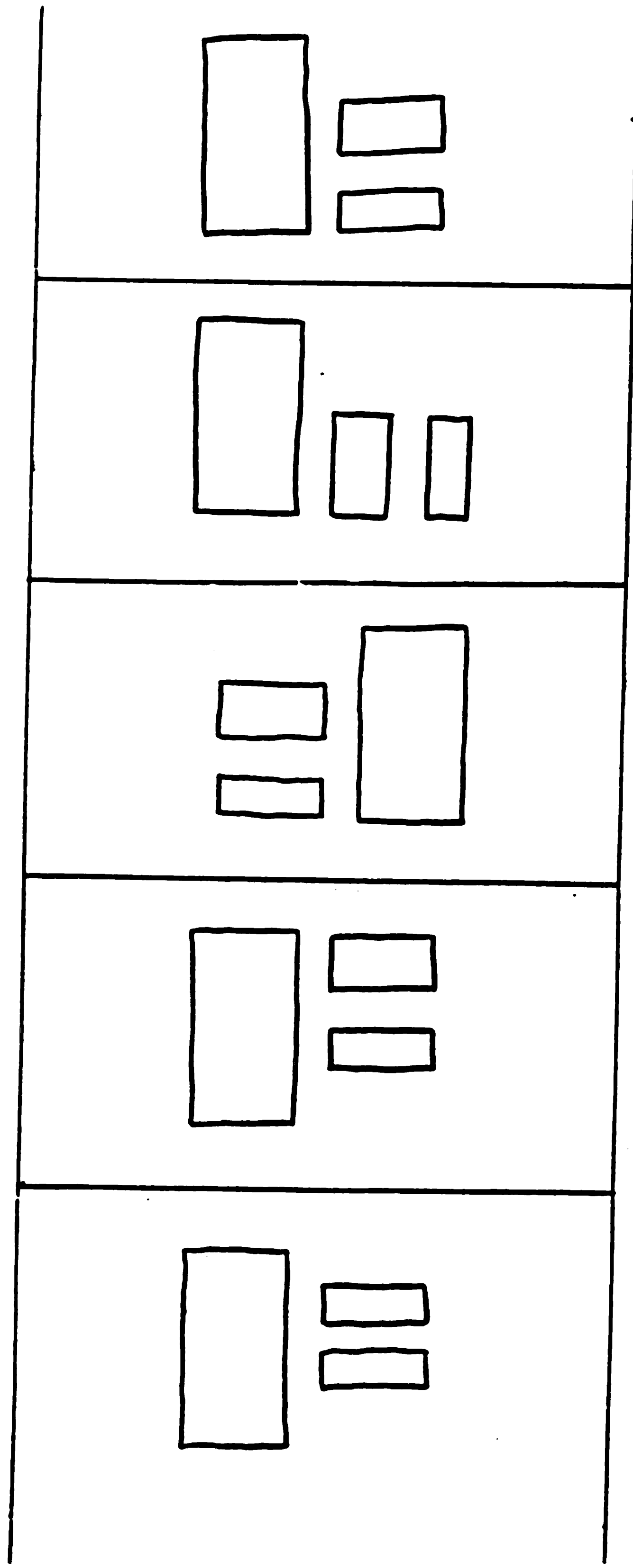
1.

2.

3.

4.

5.



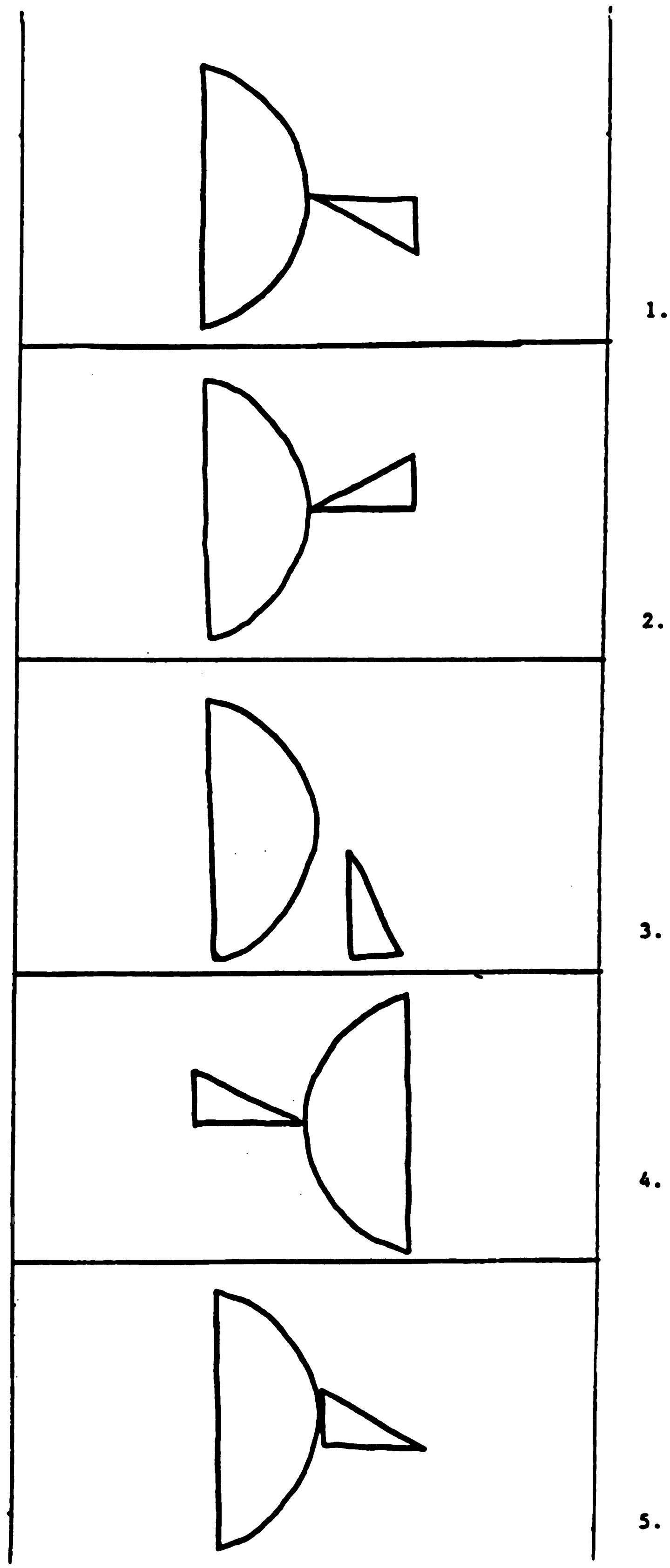
1.

2.

3.

4.

5.


1.
2.
3.
4.
5.

Appendix H

Appendix H

<u>Cowboy Story Stimuli and Scoring</u>

SCORING FOR THE "COWBOY" STORY

(Fastenau, 1991; modeled after Wechsler, 1987)

Words expressed verbatim but in mixed up order are credited, as long as each word is only credited to the phrase with which it belongs, and each word is credited to only one phrase. Examples:

"who went from AZ to S.F." = 2 verb pts;

"He had <u>his</u> pet <u>dog</u> <u>with</u> him" is credited 1 verb for "with his dog"; however, "left his dog with a friend" does not receive credit for "with his dog" because the word <u>with</u> is clearly belongs to the unit "at a friend's."

If there are extra words beyond the verbatim, the verbatim phrase still receives verbatim credit. For example, "<u>Dressed</u> very <u>finely</u> (1 verbatim pt), <u>he went back</u> there (1 V pt) <u>to</u> get <u>the dog</u> (1 V pt)."

Verbatim words must be exact: same tense, number, and person (e.g., no verbatim credit for "whistles" or "howled").

For CONTENT credit, any form of the critical words/phrases (see scoring criteria below) is credited. E.g., "howled" receives <u>content</u> credit even though it does not receive verbatim credit.

* Special CONTENT Rule: "To the dog"

"Dog" can be part of any of the three phrases that follow it: E.g., "whistled (1 content pt) to the dog (1 more content pt)," "called (1 C pt) the dog (1 more C pt)," or "patted (1 C pt) the dog (1 C pt)." Of course, "dog" receives credit only once even if it is used in two or three of those phrases.

However, "dog" can<u>not</u> be credited twice if used as part of "But the dog would have nothing to do with him." E.g., "He went back (V and C pt) but the dog (no credit) didn't recognize him (1 C pt)."

Text	General Rule	Examples of 1-pt Content Responses	Examples of 0-pt Content Responses
A cowboy	"Cowboy" is required	-----------------	man, guy, person, cowhand
from AZ	"AZ" and an indication that he lived there	who lived in AZ; was in AZ	visiting AZ; went to AZ; Phoenix; the desert/plains
went to S.F.	"San Francisco" and indication that he traveled	took a trip to S.F.; went to the Bay City; visited S.F.	CA, San Diego, the city; from S.F.; who was/lived in SF

with his dog	Indication that the dog accompanied him on a trip	with a puppy, taking his dog, carrying his mutt along	pet, cat, horse; to see his dog; to be with his dog
which he left	Indication that he voluntarily parted w/ the dog	dropped off, gave, tied up	which ran away, which was taken, which died
at a friend's	Indication of a friend's home	with a buddy, where his friends lived	neighbor's, ranch, parent's, a kennel
while he purchased	Indication that he was buying something	bought, went to the store for, picked up, shopped for; got (if coupled with "new" or with idea of buying)	retrieved, ordered, unpacked, looked at, priced
a new suit of clothes.	clothing & no suggestion that it's a type he already had	some clothes; a new outfit; a new suit	
Dressed finely,	Indication that he looked more formal in his new clothes	Dressed up; Looking fine; With a dapper look; In his sharp suit	In his new clothes, Dressed differently
he went back	Indication of a return trip	returned, came back, went to his friend's	he went home, he left the store
to the dog,*	dog (in any context)	doggie; puppy; St. Bernard, collie, etc.	pet, cat, horse
whistled to him,	"whistled" or form of the word	whistling, whistle	-------------------
called him by name,	Indication he vocalized in a beckoning gesture	yelled to him, hollered his name, called to him	yelled at him, screamed at him, grabbed his collar
and patted him.	Indication he touched dog in a friendly way	petted, stroked, rubbed	grabbed, hit, slapped
But the dog would have nothing to do with him	Indication dog did not recognize him; must include "dog" or a pronoun refering to dog	it ran away, he backed away, the dog ignored him, it did not notice the cowboy, he snubbed his master, the dog wouldn't come	snapped at him, bit him, jumped on him, chased him

in his new hat	"hat" (in any context)	--------------------	outfit, clothes
and coat,	"coat"	jacket	outfit, clothes
but gave a mournful	Indication that the dog was sad, missed his master	pining, bewailing, groaning, sorrowful	angry, resentful, threatening
howl.	"howl" (in any context)	cry, whined	bark, growl, whimper, moan, groan
Coaxing was of no effect;	Indication that the cowboy tried to persuade dog	He couldn't convince; Nothing worked to show the dog; urging	-----------------
so the cowboy went away	Indication that the cowboy left the dog's sight	left, went inside, took off	-------------------
and donned his old garments	Indication that he put on his former clothes	changed back, got into his old clothes	took off his coat, returned his clothes; put on new clothes; some other clothes
whereupon the dog	dog (in any context)	doggie; puppy; St. Bernard, collie, etc.	pet, cat, horse
immediately	Indication of dramatic change	suddenly, quickly, as soon as, now	began to, started to, eventually
showed his wild joy	Indication of pleasure (either by the dog or by the cowboy)	became ecstatic, was excited, was happy	came to him, was friendly, was back to normal, recognized him, welcomed his master warmly
on seeing his master	Indication that the cowboy was seen by the dog	when the cowboy showed up, when his master appeared, how his master looked	on knowing him, seeing the clothes in the house
as he thought he ought to be	Indication that the dog recognized the cowboy again	like he should be, back to his old self, in familiar garb, recognized him, knew him	in old clothes, looking better; came to him

Appendix I

Appendix I

Confirmation Letter to Participating Organizations

DEVELOPMENTAL MEMORY STUDY

The MSU Psychological Clinic is looking for volunteers for memory testing. Your contribution to this study would be invaluable to us. In this project, we are trying to better understand normal memory processes in adults of all ages. We are also trying to improve our current memory tests, and the results that you provide will help us do that.

In this study, you will do many different things. Many of the tests measure memory directly. There are also some non-memory tests that will help us examine functions that are sometimes related to memory test performance, such as the ability to read, write, hear, and draw. The exam will take approximately two and a half hours; in addition, you will be asked some questions over the phone, and we will have a brief questionnaire at the beginning of testing.

All information that you provide us will be strictly confidential. After your exam, your test results will be filed under a code, without using your name or any biographical information. These records will be maintained in a secured file. This exam is for research purposes, so no written report will be issued. However, if your test results suggest a possible problem, we may recommend that you see your primary physician.

Participation in this study is voluntary, and you will be free to withdraw from the project at any time. In addition, you may refuse to do a particular task, and we will continue with the next one. Certainly, the more that you are able to complete, the more your participation will assist us in our research.

In exchange for your participation, we will make a contribution of $10 to your church or to a fund your church designates. **IF ALL 20 SIGN-UP SPACES ARE FILLED AND THESE VOLUNTEERS COMPLETE TESTING, A BONUS OF $50 WILL BE PAID** in addition to the $10 per person, **FOR A TOTAL DONATION OF $250.**

Please indicate your interest by providing your name and phone number on the attached sign-up form. You will be contacted by one of the research coordinators who will answer any questions you might have and who will schedule you for testing. We will try to make the arrangements as convenient as possible.

WE REGRET THAT, FOR THIS PROJECT, WE ARE UNABLE TO ACCOMODATE INDIVIDUALS WHO HAVE (1) UNCORRECTABLE VISUAL IMPAIRMENT, (2) UNCORRECTABLE HEARING IMPAIRMENT, (3) OR SUBSTANTIAL SPEECH IMPAIRMENT. IN ADDITION, WE MUST LIMIT PARTICIPATION TO PERSONS WHO ARE ABLE TO WRITE/DRAW WITH THEIR PREFERRED HAND.

This research project has been reviewed and approved by the MSU University Committee on Research Involving Human Subjects. It is conducted under the supervision of Norman Abeles, PhD, ABPP. For more information, contact the Project Director, Phil Fastenau, M.A., at 355-9564.

Appendix J

Appendix J

Consent Form

DEVELOPMENTAL MEMORY STUDY

Thank you for volunteering for memory testing at the MSU Psychological Clinic! Your contribution to this study will be invaluable to us. In this project, we are trying to better understand normal memory processes in adults. We are also trying to improve our current memory tests, and the results that you provide will help us do that.

In this study, you will do many different things. Many of the tests measure memory directly. There are also some non-memory tests that will help us examine functions that are sometimes related to memory test performance, such as the ability to read, write, hear, and draw. The exam will take approximately two and a half hours.

All information that you provide us is strictly confidential. After your exam, your test results will be filed under a code, without using your name or any biographical information. These records will be maintained in a secured file. This exam is for research purposes, so no written report will be issued. However, if your test results suggest a possible problem, we may recommend that you see your primary care physician.

Participation in this study is voluntary, and you are free to withdraw from the project at any time. In addition, you may refuse to do a particular task, and we will continue with the next one. Certainly, the more that you are able to complete, the more your participation will assist us in our research.

At this time, please ask any questions you have. Then, indicate your understanding and willingness to participate by signing this form in the space provided below.

____
Signature

____
Date

Appendix K

Appendix K

Debriefing Form

DEVELOPMENTAL MEMORY STUDY:

A FINAL NOTE TO OUR VOLUNTEERS

Thank you so much for your help with our project. Your contribution will help us better understand normal changes that take place in memory throughout adulthood. Also, your responses--as a group--provide us with a baseline of normal functioning, a picture of how individuals in the community perform on these tests. As soon as the project is complete, we will use this information in our own work with neurological patients here in Lansing; in addition, there are many other health professionals worldwide who have expressed interest in our materials and in your results.

PLEASE: It is very important that other volunteers do not learn specifics about the testing materials or about the testing procedures, except information that was disseminated by the Clinic staff prior to testing. In other words, **PLEASE DO NOT DISCUSS WITH ANYONE THE SPECIFICS OF THE TESTING** until the project is complete. Even though it will be tempting to compare responses and to describe your experiences to family members and friends, it is vital, to our research and to our provision of effective clinical services, that you wait until the project is complete.

Thank you again for your support and thank you in advance for your cooperation with the above request. We apologize for any inconvenience this may cause. When the project is complete, Phil Fastenau will arrange to share the outcome of the study with you and to discuss it with interested groups.

LIST OF REFERENCES

LIST OF REFERENCES

Albert, M. [S.] (1984). Assessment of memory loss. Psychosomatics, 25 (Suppl. 12), 18-20.

Albert, M. S. (1988). Assessment of cognitive dysfunction. In M. S. Albert & M. B. Moss (Eds.), Geriatric neuropsychology (pp. 57-81). NY: Guilford Press.

Barbizet, J., & Cany, E. (1968). Clinical and psychometrical study of a patient with memory disturbances. International Journal of Neurology, 7, 44-54.

Barr, M. L., & Kiernan, J. A. (1988). The human nervous system: An anatomical viewpoint (5th ed.). Philadelphia: Lippincott.

Bauer, R. M. (1993). Agnosia. In K. M. Heilman & E. Valenstein (Eds.), Clinical neuropsychology (3rd ed., pp. 215-278). NY: Oxford University Press.

Beck, A. T. (1978). Beck Depression Inventory. San Antonio, TX: Psychological Corporation.

Beck, A. T., Steer, R. A., & Garbin, M. G. (1988). Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. Clinical Psychology Review, 8, 77-100.

Bennett, P. H. (1990). Epidemiology of diabetes mellitus. In H. Rifkin & D. Porte, Jr. (Eds.), Ellenberg and Rifkin's diabetes mellitus: Theory and practice (4th ed.) (pp. 357-377). NY: Elsevier.

Bennett-Levy, J. (1984). Determinants of performance on the Rey-Osterrieth Complex Figure Test: An analysis and a new technique for single-case assessment. British Journal of Clinical Psychology, 23, 109-119.

Benson, D. F. (1985). Language in the left hemisphere. In D. F. Benson, & E. Zaidel (Eds), The dual brain: Hemispheric specialization in humans (pp. 193-203). NY: Guilford Press.

Benton, A. L. (1974). The Revised Visual Retention Test (4th ed.). NY: Psychological Corporation.

Benton, A. L., & Tranel, D. (1993). Visuoperceptual, visuospatial and visuoconstructive disorders. In K. M. Heilman & E. Valenstein

(Eds.), Clinical neuropsychology (3rd ed., pp. 165-214). New York: Oxford University Press.

Benton, A. L., Hamsher, K. deS., Varney, N. R., & Spreen, O. (1983). Contributions to neuropsychological assessment: A clinical manual. NY: Oxford University Press..

Berry, D. T. R., Allen, R. S., & Schmitt, F. A. (1991). The Rey-Osterrieth Complex Figure: Psychometric characteristics in a geriatric sample. The Clinical Neuropsychologist, 5, 143-153.

Bienenfeld, D. (1990a). Physical changes with aging. In D. Bienenfeld (Ed.), Clinical geropsychiatry (pp. 3-16). Baltimore: Williams & Wilkins.

Bienenfeld, D. (1990b). Substance abuse. In D. Bienenfeld (Ed.), Clinical geropsychiatry (pp. 164-177). Baltimore: Williams & Wilkins.

Binder, L. M. (1982). Constructional strategies on Complex Figure drawings after unilateral brain damage. Journal of Clinical Neuropsychology, 4(1), 51-58.

Bornstein, R. A., & Kelly, M. P. (1991). Risk factors for stroke and neuropsychological performance. In R. A. Bornstein & G. Brown (Eds.), Neurobehavioral aspects of cerebrovascular disease (pp. 182-201). NY: Oxford.

Brouwers, P., Cox, C., Martin, A., Chase, T., & Fedio, P. (1984). Differential perceptual-spatial impairment in Huntington's and Alzheimer's dementias. Archives of Neurology, 41, 1073-6.

Chaplin, W. E. (1984). State-Trait Anxiety Inventory. In D. J. Keyser & R. C. Sweetland (Eds.), Test Critiques: Vol. I (pp. 626-632). Kansas City, MO: Test Corporation of America.

Chiarello, C. (1988). Lateralization of lexical processes in the normal brain: A review of visual half-field research. In H. A. Whitaker (Ed.), Contemporary reviews in neuropsychology (pp. 36-73). NY: Springer-Verlag.

Cohen, J., & Cohen, P. (1983). Applied multiple regression/correlation analysis for the behavioral sciences (2nd edition). Hillsdale, NJ: Lawrence Erlbaum and Associates.

Coltheart, M., Hull, E., Slater, D. (1975). Sex differences in imagery and reading. Nature, 253, 438-440.

Craik, F. I. M. (1977). Age differences in human memory. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging (pp. 384-420). NY: Van Nostrand Reinhold Co.

Craik, F. I. M. (1979). Human memory. Annual Review of Psychology, 30, 63-102.

Craik, F. I. M., & Byrd, M. (1982). Aging and cognitive deficits: The role of attentional resources. In F. I. M. Craik & S. Trehub (Eds.), Aging and cognitive processes (pp. 191-211). NY: Plenum Press.

Craik, F. I. M., & McDowd, J. M. (1987). Age differences in recall and recognition. Journal of Experimental Psychology: Learning, Memory, and Cognition, 13(3), 474-479.

Crossley, M., Hiscock, M., & Beckie, J. (1991, February). Aging and divided-attention: A four-year follow-up study. Paper presented at the annual meeting of the International Neuropsychological Society, San Antonio, Texas, USA.

Cummings, J. L. (1985). Hemispheric asymmetries in visual-perceptual and visual-spatial function. In D. F. Benson, & E. Zaidel (Eds), The dual brain: Hemispheric specialization in humans (pp. 233-246). NY: Guilford Press.

Cummings, J. L., & Mahler, M. E. (1991). Cerebrovascular dementia. In R. A. Bornstein & G. G. Brown (Eds.), Neurobehavioral aspects of cerebrovascular disease (pp. 131-149). NY: Oxford.

Damasio, A. R., & Anderson, S. W. (1993). The frontal lobes. In K. M. Heilman & E. Valenstein (Eds.), Clinical neuropsychology (3rd ed., pp. 409-460). New York: Oxford University Press.

Davidson, M. B. (1991). An overview of diabetes mellitus. In R. B. Frykberg (Ed.), The high risk foot in diabetes mellitus (pp. 1-31). NY: Churchill Livingstone.

Delaney, R. C., Rosen, A. J., Mattson, R. H., & Novelly, R. A. (1980). Memory function in focal epilepsy: A comparison of non-surgical, unilateral temporal lobe and frontal lobe samples. Cortex, 16, 103-117.

DeLuca, J., & Cicerone, K. D. (1991). Construct validity of tests of verbal and visual mental imagery. Clinical Neuropsychologist, 5, 176-182.

Denburg, N. L., Fastenau, P. S., & Fertuck, E. A. (1994, February). Cowboy Story: Resistance to aging found in reading memory. Paper presented at the annual meeting of the International Neuropsychological Society, Cincinnati, Ohio, USA.

Epilepsy Foundation of America (1992). How to recognize and classify seizures and epilepsy. Landover, MD: Author.

Erickson, R. C., & Scott, M. L. (1977). Clinical memory testing: A review. Psychological Bulletin, 84, 1130-1149.

Fastenau, P. S., & Denburg, N. L. (1994, February). Reliability and validity of the Extended Complex Figure Test (ECFT). Paper presented at the annual meeting of the International Neuropsychological Society, Cincinnati, Ohio, USA.

Fastenau, P. S., & Manning, A. A. (1992, February). Development of a recognition task for the Complex Figure Test. Paper presented at the annual meeting of the International Neuropsychological Society, Sna Diego, California, USA.

Fastenau, P. S., & Sloan, L. E. (1993, February). Copy trial for the Wechsler Memory Scale-Revised Visual Reproductions subtest: Normative study. Paper presented at the annual meeting of the International Neuropsychological Society, Galveston, TX, USA.

Fisher, D. G., Sweet, J. J., & Pfaelzer-Smith, E. A. (1986). Influence of depression on repeated neuropsychological testing. The International Journal of Clinical Neuropsychology, 8, 14-18.

Franz, S. I. (1919). Handbook of mental examination methods. NY: Journal of Nervous and Mental Disease.

Fromm, D., & Schopflocher, D. (1984). Neuropsychological test performance in depressed patients before and after drug therapy. Biological Psychiatry, 19, 55-72.

Gazzaniga, M. S. (1983a). Right hemisphere language following brain bisection: A 20-year perspective. American Psychologist, 38, 525-537.

Gazzaniga, M. S. (1983b). Reply to Levy and to Zaidel. American Psychologist, 38, 547-549.

Gazzaniga, M. S. (1984). Right hemisphere language: Remaining problems. American Psychologist, 39, 1494-1496.

Gazzaniga, M. S., & LeDoux, J. E. (1978). The integrated mind. NY: Plenum Press.

Gorsuch, R. L. (1991). Things learned from another perspective (so far). American Psychologist, 46, 1089-1090.

Hanger, P. A., Montague, J. R., & Smith, M. (1991, February). A recognition memory test for the Visual Reproduction Subtest of the Wechsler Memory Scale-Revised. Poster presented at the Annual Meeting of the International Neuropsychological Society, San Antonio, Texas.

Harris, L. J. (1978). Sex differences in spatial ability: Possible environmental, genetic, and neurological factors. In M. Kinsbourne (Ed.), Asymmetrical function of the brain (pp. 405-522). Cambridge: Cambridge University Press.

Harris, L. J. (1981). Sex-related variations in spatial skill. In L. S. Liben, A. H. Patterson, & N. Newcombe (Eds.), Spatial representation and behavior across the life span: Theory and application (pp. 83-125). NY: Academic Press.

Harris, L. J. (1985). Delicacy of fibres in the brain: Early and recent neuropsychological explanations of sex differences in cognition and temperament. In J. Ghesquiere, R. D. Martin, & F. Newcombe (Eds.), Human sexual dimorphism (pp. 283-321). London: Taylor and Francis.

Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. Journal of Experimental Psychology: General, 108, 356-388.

Heilman, K. M., & Valenstein, E. (Eds. 1993). Clinical neuropsychology (3rd ed.). NY: Oxford University Press.

Heilman, K. M., & Van Den Abell, T. (1979). Right hemispheric dominance for mediating cerebral activation. Neuropsychologia, 17, 315-321.

Heilman, K. M., & Van Den Abell, T. (1980). Right hemispheric dominance for attention: The mechanism underlying hemispheric asymmetries of inattention (neglect). Neurology, 30, 327-330.

Heilman, K. M., Watson, R. T., & Valenstein, E. (1993). Neglect and related disorders. In K. M. Heilman & E. Valenstein (Eds.), Clinical neuropsychology (3rd ed., pp. 279-336). NY: Oxford University Press.

Hemsley, D. (1974). Relationship between two tests of visual retention. Perceptual and Motor Skills, 39, 1132-1134.

Howe, M. L., & Hunter, M. A. (1985). Adult age differences in storage-retrieval processes: A stages-of-learning analysis of developmental interactions in concreteness effects. Canadian Journal of Psychology, 39(1), 130-150.

Howe, M. L., O'Sullivan, J. T., Brainerd, C. J., & Kingma, J. (1989). Localizing the development of ability differences in organized memory. Contemporary Educational Psychology, 14, 336-356.

Hyde, J. S. (1990). Meta-analysis and the psychology of gender differences. Signs, 16, 55-73.

Jacoby, L. L. (1984). Incidental versus intentional retrieval: Remembering and awareness as separate issues. In L. R. Squire and N. Butters (Eds.), Neuropsychology of memory (pp. 145-156). NY: Guilford Press.

Joreskog, K. G., & Sorbom, D. (1989). LISREL 7.16: Estimation of linear structural equation systems [Computer program]. Mooresville, IN: Scientific Software, Inc.

Kaplan, E. (1988). A process approach to neuropsychological assessment. In T. Boll & B. K. Bryant (Eds.), Clinical neuropsychology and brain function: Research, measurement, and practice (pp. 125-167). Washington, DC: American Psychological Association.

Kimura, D. (1963). Right temporal-lobe damage. Archives of Neurology, 8, 264-271.

King, G. D., Hannay, H. J., Masek, B. J., & Burns, J. W. (1978). Effects of anxiety and sex on neuropsychological tests. Journal of Consulting and Clinical Psychology, 46, 375-376.

King, M. C. (1981). Effects of non-focal brain dysfunction on visual memory. Journal of Clinical Psychology, 37, 638-643.

Klicpera, C. (1983). Poor planning as a characteristic of problem-solving behavior in dyslexic children: A study with the Rey-Osterrieth Complex Figure Test. Acta Paedopsychiatrica, 49, 73-82.

Koppitz, E. M. (1964). The Bender Gestalt Test for young children. NY: Grune & Stratton.

La Rue, A. (1992). Aging and neuropsychological assessment. NY: Plenum.

Levy, J. (1983). Language, cognition, and the right hemisphere: A response to Gazzaniga. American Psychologist, 38, 538-541.

Lezak, M. D. (1983). Neuropsychological assessment (2nd ed.). NY: Oxford University Press.

McGlone, J. (1978). Sex differences in functional brain asymmetry. Cortex, 14, 122-128.

Mesulam, M-M. (1985a). Attention, confusional states, and neglect. In M-M. Mesulam (Ed.), Principles of behavioral neurology (pp. 125-168). Philadelphia: F. A. Davis Co.

Mesulam, M-M. (1985b). Patterns in behavioral neuroanatomy: Association areas, the limbic system, and hemispheric specialization. In M-M. Mesulam (Ed.), Principles of behavioral neurology (pp. 1-70). Philadelphia: F. A. Davis Co.

Milberg, W. P., Hebben, N., & Kaplan, E. (1986). The Boston Process Approach to neuropsychological assessment. In I. Grant & K. M. Adams (Eds.), Neuropsycological assessment of neuropsychiatric disorders (pp. 65-86). NY: Oxford University Press.

Milner, B. (1971). Interhemispheric differences in the localization of psychological processes in man. British Medical Bulletin, 27(3), 272-277.

Milner, B. (1975). Psychological aspects of focal epilepsy and its neurological management. In D. P. Purpura, J. K. Penry, & R. D. Walter (Eds.), Advances in neurology (Vol. 8, pp. 299-321). NY: Raven Press.

Milner, B. (1978). Clues to the cerebral organization of memory. In P. A. Buser and A. Rougeul-Buser (Eds.), Cerebral correlates of conscious experience: INSERM symposium no. 6 (pp. 139-153). Amsterdam: Elsevier/North-Holland Biomedical Press.

Moss, M. B., Albert, M. S., Butters, N., & Payne, M. (1986). Differential patterns of memory loss among patients with Alzheimer's disease, Huntington's disease, and alcoholic Korsakoff's syndrome. Archives of Neurology, 43, 239-246.

Myers, J. J. (1984). Right hemisphere language: Science or fiction? American Psychologist, 39, 315-320.

Nakra, B. R. S., & Grossberg, G. T. (1990). Mood disorders. In D. Bienenfeld (Ed.), Clinical geropsychiatry (pp. 107-124). Baltimore: Williams & Wilkins.

National High Blood Pressure Education Program (1992). The fifth report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. Bethesda, MD: Author; National Heart, Lung, and Blood Institute; National Institutes of Health.

National Institute on Alcohol Abuse and Alcoholism (1990). Seventh special report to the U. S. Congress on alcohol and health (Contract No. ADM-281-88-0002). Rockville, MD: Author; Alcohol, Drug Abuse, and Mental Health Administration; Public Health Service; U. S. Department of Health and Human Services.

National Institutes of Health Consensus Development Conference (1990). Surgery for Epilepsy: Consensus Statement. Bethesda, MD: Office of Medical Applications of Research, National Institutes of Health.

Nelson, N., Rosenthal, R., & Rosnow, R. (1986). Interpretation of significance levels and effect sizes by psychological research. American Psychologist, 41, 1299-1301.

Ogden, J. A. (1987). The "neglected" left hemisphere and its contribution to visuospatial neglect. In M. Jeannerod (Ed.), Neurophysiological and neuropsychological aspects of spatial neglect (pp. 215-233). Amsterdam: Elsevier Science Publishers B.V.

Olton, D. S., Gamzu, E., & Corkin, S. (Eds.; 1985). Memory dysfunctions: An integration of animal and human research from preclinical and clinical perspectives. (Annals of the New York Academy of Sciences, vol. 444)

Osterrieth, P. A. (1944). Le test du copie d'une figure complexe. Archives of Psychology (Chicago), 30, 206-356.

Ozer, D. J. (1985). Correlation and the coefficient of determination. Psychological Bulletin, 97, 307-315.

Palmer, S. E. (1977). Hierarchical structure in perceptual representation. Cognitive Psychology, 9, 441-474.

Perlmutter, M., & Mitchell, D. B. (1982). The appearance and disappearance of age differences in adult memory. In F. I. M. Craik & S. Trehub (Eds.), Aging and cognitive processes (pp. 127-144). NY: Plenum Press.

Pillon, B. (1981). Troubles visuo-constructifs et méthodes de compensation: Resultats de 85 patients atteints de lésions cérébrales. Neuropsychologia, 19, 375-383.

Poon, L. W. (1985). Differences in human memory with aging: Nature, causes, and clinical implications. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging (2nd ed.; pp. 427-462). NY: Van Nostrand Reinhold Co.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. Annual Review of Neuroscience, 13, 25-42.

Posner, M. I., & Presti, D. E. (1987). Selective attention and cognitive control. Trends in Neuroscience, 10, 13-16).

Rabinowitz, J. C., Craik, F. I. M., & Ackerman, B. P. (1982). A processing resource account of age differences in recall. Canadian Journal of Psychology, 36(2), 325-344.

Rao, S. M., Hammeke, T. A., Huang, J. Y. S., et al. (1982, February). Memory disturbance in chronic, progressive multiple sclerosis. Paper presented at the tenth annual meeting of the International Neuropsychological Society, Pittsburgh.

Rausch, R. (1985). Differences in cognitive functions with left and right temporal lobe dysfunction. In D. F. Benson & E. Zaidel (Eds.), The dual brain: Hemispheric specialization in humans (pp. 247-261). NY: Guilford Press.

Read, D. E. (1987). Neuropsychological assessment of memory in the elderly. Canadian Journal of Psychology, 41(2), 158-174.

Reed, S. K. (1974). Structural descriptions and the limitations of visual images. Memory and Cognition, 2(2), 329-336.

Rehm, L. P. (1988). Assessment of depression. In A. S. Bellack & M. Hersen (Eds.), Behavioral assessment: A practical handbook (3rd ed.; pp. 313-364). NY: Pergamon Press.

Reitan, R. M., & Wolfson, D. (1993). The Halstead-Reitan Neuropsychological Test Battery: Theory and clinical interpretation (2nd ed.). Tuscon, AZ: Neuropsychology Press.

Rey, A. (1941). L'examen psychologique dans les cas d'encephalopathie traumatique. Archives of Psychology (Chicago), 28, 286-340.

Rey, A. (1964). L'examen clinique psychologie. Paris: Presses Universitaires de France.

Richards, P. M., & Ruff, R. M. (1989). Motivational effects on neuropsychological functioning: Comparison of depressed versus nondepressed individuals. Journal of Consulting and Clinical Psychology, 57, 396-402.

Rosnow, R. L., & Rosenthal, R. (1988). Focused tests of significance and effect size estimation in counseling psychology. Journal of Counseling Psychology, 35, 203-208.

Ruskin, P. E. (1990). Anxiety and somatoform disorders. In D. Bienenfeld (Ed.), Clinical geropsychiatry (pp. 137-150). Baltimore: Williams & Wilkins.

Smith, A. D. (1977). Adult age differences in cued recall. Developmental Psychology, 13 (4), 326-331.

Smith, A. D. (1980). Age differences in encoding, storage, and retrieval. In L. W. Poon, J. L. Fozard, L. S. Cermak, D. Arenberg, & L. W. Thompson (Eds.), New directions in memory and aging (pp. 23-45). Hillsdale, NJ: Lawrence Erlbaum Associates.

Snyder, P. J. (1993). Handedness and sex effects on visuoconstructive and visuoperceptual abilities in college students (Doctoral dissertation, Michigan State University, 1992). Dissertation Abstracts International, 53(7), 3830B.

Solomon, P. R., Goethals, G. R., Kelley, C. M., & Stephens, B. R. (Eds., 1989). Memory: Interdisciplinary approaches. NY: Springer-Verlag.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). Manual for the State-Trait Anxiety Inventory. Palo Alto, CA: Consulting Psychologists Press, Inc.

Springer, S. P., & Deutsch, G. (1985). Left brain, right brain (rev. ed.). NY: Freeman & Co.

SPSS, Inc. (1990). Statistical Package for the Social Sciences: Release 4 [Computer program]. Chicago, IL: Author.

Squire, L. R. (1982). The neuropsychology of human memory. Annual Review of Neuroscience, 5, 241-273.

Squire, L. R. (1986). The neuropsychology of memory dysfunction and its assessment. In I. Grant & K. M. Adams (Eds.), Neuropsychological assessment of neuropsychiatric disorders (pp. 268-299). NY: Oxford University Press.

Squire, L. R., & Butters, N. (Eds., 1985). Neuropsychology of memory. NY: Guilford Press.

Stankov, L. (1988). Aging, attention, and intelligence. Psychology and Aging, 3, 59-74.

Talland, G. A. (1965). Deranged memory: A psychonomic study of the amnesic syndrome. NY: Academic Press.

Taylor, L. B. (1959). The appraisal of children with cerebral deficits. Cambridge, MA: Harvard University Press.

Taylor, L. B. (1969). Localisation of cerebral lesions by psychological testing. Clinical Neurosurgery, 16, 269-287.

Tombaugh, T. N., Hubley, A. M., Faulkner, P., & Schmidt, J. P. (1990, February). The Rey-Osterrieth and Taylor complex figures: Comparative studies, modified figures and normative data for the Taylor Figure. Paper presented at the 18th Annual Meeting of the International Neuropsychological Society, Kissimmee, FL.

U. S. Department of Health and Human Services (1993). Health United States 1992 and Healthy People 2000 Review (DHHS Pub. No. PHS 93-1232). Hyattsville, MD: Author.

Waber, D. P., Bernstein, J. H., & Merola, J. (1989). Remembering the Rey-Osterrieth Complex Figure: A dual-code, cognitive neuro-psychological model. Developmental Neuropsychology, 5(1), 1-15.

Waber, D. P., & Holmes, J. M. (1985). Assessing children's copy productions of the Rey-Osterrieth Complex Figure. Journal of Clinical and Experimental Neuropsychology, 7(3), 264-280.

Waber, D. P., & Holmes, J. M. (1986). Assessing children's memory productions of the Rey-Osterrieth Complex Figure. Journal of Clinical and Experimental Neuropsychology, 8(5), 563-580.

Waldstein, S. R., Manuck, S. B., Ryan, C. M., & Muldoon, M. F. (1991). Neuropsychological correlates of hypertension: Review and methodologic considerations. Psychological Bulletin, 110, 451-468.

Waugh, N. C., & Barr, R. A. (1982). Encoding deficits in aging. In F. I. M. Craik & S. Trehub (Eds.), Aging and cognitive processes (pp. 183-190). NY: Plenum Press.

Wechsler, D. (1945). A standardized memory scale for clinical use. Journal of Psychology, 19, 87-95.

Wechsler, D. (1981). Wechsler Adult Intelligence Scale-Revised manual. NY: Psychological Corporation.

Wechsler, D. (1987). Wechsler Memory Scale-Revised manual. San Antonio, TX: Psychological Corporation.

Weintraub, S., & Mesulam, M-M. (1985). Mental state assessment of young and elderly adults in behavioral neurology. In M-M. Mesulam (Ed.), Principles of behavioral neurology (pp.71-123). Philadelphia: F. A. Davis Co.

Wilson, R. S., Rosenbaum, G., & Brown, G. (1979). The problem of premorbid intelligence in neuropsychological assessment. Journal of Clinical Neuropsychology, 1(1), 49-53.

Winograd, E., & Simon, E. W. (1980). Visual memory and imagery in the aged. In L. W. Poon, J. L. Fozard, L. S. Cermak, D. Arenberg, & L. W. Thompson (Eds.), New directions in memory and aging (pp. 485-506). Hillsdale, NJ: Lawrence Erlbaum Associates.

Witelson, S. F. (1976). Sex and the single hemisphere: Specialization of the right hemisphere for spatial processing. Science, 193, 425-427.

Woodcock, R. W., & Johnson, M. B. (1989). Woodcock-Johnson Psycho-educational Test Battery, Revised. Chicago: Riverside Publishing.

Wrightsman, L. S. (1962). The effects of anxiety, achievement motivation, and task importance to intelligence test performance. Journal of Educational Psychology, 53, 150-156.

Zaidel, E. (1977). Unilateral auditory language comprehension on the Token Test following cerebral commissurotomy and hemispherectomy. Neuropsychologia, 15, 1-18.

Zaidel, E. (1983). A response to Gazzaniga: Language in the right hemisphere, convergent perspectives. American Psychologist, 38, 542-546.

Zaidel, E. (1985). Language in the right hemisphere. In D. F. Benson, & E. Zaidel (Eds), The dual brain: Hemispheric specialization in humans (pp. 193-203). NY: Guilford Press.