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Rightward attentional bias in perception and memory in normal males and females and dyslexic males

Conder, Elizabeth Sarah, Ph.D.

The University of North Carolina at Greensboro, 1992

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RIGHTWARD ATTENTIONAL BIAS IN PERCEPTION AND MEMORY IN NORMAL MALES AND FEMALES AND DYSLEXIC MALES

by

Elizabeth Sarah Conder

A Dissertation Submitted to
the Faculty of the Graduate School at
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of the Requirements for the Degree
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Approved by

R. Reed Hunt

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APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

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This dissertation is the result of what some may consider too many years of data gathering, analyzing, thinking, hand-wringing, procrastinating, more data gathering and analyzing, thinking and writing, writing, and writing. However, contrary to appearances, it is not the product of solitary effort. My persistence was often fueled by the encouraging words of my friends and family. Their support will never be forgotten.

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Finally, I dedicate this work to my husband, John Allensworth, who encouraged me from the beginning and whose patience and understanding enabled me to reach my goals.

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These experiments were conducted to clarify left neglect or rightward attentional bias in normal adults. Rightward bias is found in parietal patients, but explanations of it suggest that a functional rightward bias also occurs in normals without lesions. Following a series by Reuter-Lorenze, Kinsbourne, and Muscovitch, the present studies (1) explore other independent variables for rightward bias, and (2) test its persistence after short term memory distraction.

In Experiment 1, 10 males and 10 females saw target marks or upper case letters on the central segment of a horizontal line. Orthogonal to gender, half of the subjects had 1.0 vs. 0.1 second target exposure times. Left or right bias was tested by immediate recognition probes (lower case in the letter condition) displaced to left or right. With vocabulary and block counting ability statistically controlled, there were no main effects or interactions of gender, exposure time, or stimulus type.

In Experiment 2, 10 females, 10 normal males, and 10 dyslexic males did the same task with three modifications: (1) only nonverbal marks were used as targets; (2) targets were presented in the left and right thirds of the line segment; and (3) recognition was tested after 0, 3, or 9 seconds of either verbal or spatial distraction. A significant rightward bias was induced by rightward targets, but only under the no distractor condition; it's strength was associated with verbal ability. The bias was found to be unrelated to performance accuracy and dissipated with the addition of distractor activity in the delayed memory tasks.

The results were interpreted as showing (1) that the strength of the rightward bias is predictable from certain measures of verbal skill, (2) it is likely preserved independently of positional information in memory and (3) may reflect the impact of other factors, such as adaptation level effects, in addition to those associated with activation theory.

CHAPTER I

INTRODUCTION

Among the most theoretically challenging clinical neuropsychological syndromes is that of unilateral neglect. A patient with this syndrome (often referred to as hemi-inattention) fails to report, respond to, or orient to novel or meaningful stimuli presented contralaterally to the side of a brain lesion (Heilman, 1979), and the failure can not be attributed to a sensory or motor deficit. The disorder has been shown to reflect a dysfunction of the cortical system which controls the distribution of attention in extrapersonal space, and is instructive because it demonstrates lateralities in attention, a process which is commonly thought of as a unitary phenomenon. Of special theoretical interest is the ubiquitous finding that left hemineglect is not only much more common than right hemineglect, but also much more intense or severe. That raises fundamental questions about lateral asymmetries, since it has been difficult to justify the argument that attention to contralateral space should be of different "strength" or vulnerability, in the two hemispheres. Instead, the issue has usually been framed in terms of interactions with the cognitive (verbal vs visuo-spatial) processing asymmetries of the two hemispheres. Thus, unilateral neglect, especially in its clinical tendency to be worse to the left than the right, raises fundamental questions about the general phenomonon of hemispheric asymmetries in cognitive function. In turn, these questions speak to fundamental properties of attentional and memory systems in human information processing.

It is thus the relationship between laterality and attention, and the way in which cerebral lateral asymmetries affect attentional and mnestic performance, that will be the focus of these studies. To understand the full impact of this interaction, it is necessary briefly to review the development of and evidence for the concept of hemispheric specialization.

It has only been within the last hundred years that the scientific community has begun to think of the two hemispheres of the brain as having specialized abilities. Prior to that time it was commonly believed that while each hemisphere was responsible for sensation and movement of the contralateral side of the body, both sides of the brain were equally involved in more complex activities such as perception and speech. This belief persisted until the mid-nineteenth century when Dax and Broca observed that among right-handed people, damage to the left hemisphere produced an inability to talk while damage to the right hemisphere generally did not. These observations led to the notion that the left hemisphere is the dominant hemisphere for speech, and that this relationship is associated with the preponderance of right-handedness in human populations.

By a process of extrapolation and generalization unsupported by explicit data, the left hemisphere eventually came to be regarded as dominant for all complex cognitive processes, with the right hemisphere relegated to a position of minor importance. It was not until after the second world war that investigators found that lesions of the right hemisphere produced distinctive syndromes. From clinical studies, it was noted that patients with well-lateralized lesions showed more severe visual-spatial and other perceptual disorders after right-sided lesions than after left (Paterson and Zangwill, 1944; Kimura, 1963; Milner, 1967). These findings indicated that it was not appropriate to speak of a dominant and a subordinant hemisphere; each had its own strong specializations for processes in which it was dominant.

While much of the earlier work on the nature of hemispheric specialization was done by studying the effects of lesions on abilities, the advent of various noninvasive techniques allowed the study of hemispheric functions in normals. Among the first of these techniques used were dichotic listening, the tachistoscopic presentation of stimuli, and event-related potentials (ERPs).

Dichotic Listening

Dichotic listening, in which both ears receive signals in a roughly simultaneous fashion, has been used with both normal and brain injured populations to assess the asymmetry in function of the two hemispheres for various types of acoustic signals. The controlled presentation of auditory stimuli is thought to suppress the ipsilateral route of access to the brain for each ear, thus allowing the contralateral cortical pathway to be represented first. Therefore, the ear advantage observed for a particular class of signals is assumed to represent the advantage of the opposite cortical hemisphere for perception of those materials.

Using this technique, a right ear (left hemisphere) advantage was found for verbal stimuli such as words (Kimura, 1967) and consonant-vowel nonsense syllables (Kimura, 1967; Shankweiler and Studdert-Kennedy, 1967; Morais and Landercy, 1977). Conversely, a left ear (right hemisphere) processing advantage was observed for melodies (Kimura, 1964), musical chords (Gordon, 1970), and environmental sounds (Curry, 1967).

A large body of literature has further defined the parameters of this relationship between ear advantage and hemispheric functional asymmetry. However, it has been observed that the size of the ear advantage typically elicited from normal listeners for dichotically presented signals is neither consistent across listeners nor overly robust (Lauter, 1982, 1983). For example, the results for a single subject of a dichotic syllable task presented over a long series of test sessions reveals a right ear advantage which is typically distributed evenly over those sessions so that 25-30% of the sessions will result in no ear advantage or a left ear advantage. Similar findings have been reported when a single test session is administered to a large number of subjects. Under such conditions approximately 27% of listeners will show no ear advantages for that one session, although the majority of those 27% will show a right ear advantage over repeated trials (Noffsinger, 1985). For some, these results argue against the proposed mechanism upon which dichotic listening tasks are based; factors in addition to the anatomy of the auditory system are obviously involved. At the same time, these findings have not been used to denigrate the evidence provided by dichotic listening tasks for a relationship between verbal and nonverbal materials and cerebral asymmetries in their processing.

Tachistoscopic Presentation of Stimuli

A similar pattern of lateralization has been observed when verbal and nonverbal material is presented tachistoscopically. This technique capitalizes on the anatomical arrangement of the optic neural pathways, which decussate partially at the optic chiasm such that sensory visual input occurring in one visual half-field reaches the hemisphere contralateral to the stimulated field. When

Kimura presented words and letters tachistoscopically to right-handed normal subjects, she reported a right visual field (RVF) recognition superiority for this material, which she suggested may be related to left-hemisphere specialization for linguistic material (Kimura, 1961, 1966).

Historically, however, early reports of a RVF superiority for verbal materials were attributed to the scanning habits involved in reading rather than to left hemisphere involvement in language functions. The chief evidence for this view was the reported tendency for Hebrew words, which are read right to left, to be better perceived in the left visual field (LVF) under conditions in which the right field is superior for English words (Mishkin and Forgays, 1952). However, subsequent hemifield studies, in which experimental parameters such as exposure duration and gaze fixation were carefully controlled, indicated that those earlier results could be interpreted differently. Thus when Carmon, Nachson, and Starinski (1976) employed more stringent controls on experimental conditions, they found a RVF advantage for Hebrew words with Hebrew speakers and concluded that it was the left hemisphere's specialization for verbal functions which was the underlying source of hemifield differences rather than directional reading habits.

Many of the investigators of the late 50s and early 60s chose to concentrate on the relationship between verbal materials and cerebral functional asymmetries as reflected by hemifield advantage. Fewer studies focused on the characteristics of the right hemisphere since its functions among normals were still not well documented. Kimura (1966) published one of the earliest reports of a LVF advantage for nonverbal material among normals when she described a left-field superiority for the enumeration and localization in space of tachistoscopically presented dots. Subsequent studies have reported a similar hemifield advantage for the recognition of complex forms (Hellige and Cox, 1976), overlapping figures (Kershner and Jeng, 1972), and line orientation (Fontenot and Benton, 1972). Nevertheless, the reported association between nonverbal stimuli and a LVF superiority for their recognition has generally been smaller and less consistent. For example, in the same series of experiments in which she found a LVF advantage for dot enumeration and localization, Kimura (1966) was unable to demonstrate a left-field superiority for the recognition of nonsense shapes such as inkblots. Similarly, Hines (1978) found no visual field advantage for nonsense shapes which varied in complexity. Results such as these suggest that it is generally more difficult to demonstrate a right hemisphere superiority over the left through the use of tachistoscopically presented stimuli. Though the reasons for these inconsistencies are no doubt complex, it has been suggested that one possible explanation is the interference in most tasks of the left-hemisphere due to the pervasive dominance of verbal reasoning or activation in attention tasks (Kinsbourne, 1970a, 1973, 1977, 1987; Zaidel, 1985).

Event-Related Potentials

While methods such as dichotic listening and the tachistoscopic presentation of stimuli have been used to contribute significantly to our knowledge of functional lateralization in normal subjects, they have done so largely by inference from behavior rather than from direct physiological measurement. It is in the area of direct measurement that event related potential (ERP) methodology has allowed notable advances in our understanding of hemispheric specialization by demonstrating processing asymmetries associated with language and non-language stimuli.

The validity of this methodology as a measurement of sensory and cognitive activity can be supported by the vast literature which has accumulated demonstrating a relationship between scalp-recorded electrical activity and cortical function. Its use in the study of cerebral functional asymmetries is one of its more recent and profitable applications.

Scalp-recorded ERPs can track fluctuations in brain electrical fields relative to sensory and cognitive processing occurring within a second or less. Components with latencies as brief as 100 msec have been found to reflect processing asymmetries in verbal and nonverbal tasks. For example, Molfese, Freeman, and Palermo (1975) found larger N1-P2 (the negative and positive waves which occur at 100 and 200 msec., respectively) amplitudes over the left hemisphere for speech stimuli but larger right hemisphere amplitudes to non-speech stimuli. An interesting aspect of this study is that these asymmetries were present in infants but actually decreased from infancy to adulthood.

Shucard, Shucard, and Thomas (1977) used a somewhat novel approach by studying changes in the amplitude of the N1 component to task-irrelevant stimuli during continuous left and right hemisphere processing tasks. Using this method, they found that responses to irrelevant clicks decreased over the left hemisphere during reading responses, and over the right hemisphere while listening to music.

Among the later components frequently studied is P3, which occurs at approximately 300 msec and is associated with cognitive decision-making. This component has been found to be larger over the left hemisphere when subjects were trying to detect a signal word from a list of words (Friedman, Simson, and Rapin, 1975). When non-speech sounds were used in a similar detection task, however, no lateralization was found. Desmedt (1977) was able to demonstrate lateralized response to nonverbal stimuli when he had subjects perform a tactile processing task (form and orientation discrimination). In this study, a large P3 was found over the right hemisphere, but not the left, regardless of which hand was used.

Measures of Cerebral Blood Flow and Metabolic Rate

Regional cerebral blood flow (rCBF) and positron emission tomography (PET) are two methods of in-vivo measurement which provide information about the metabolic and functional level of the cortex. Since they allow inferences to be made about local brain activation, these techniques are ideally suited to the study of hemispheric specialization.

Regional cerebral blood flow is the older of the two methodologies and has been used extensively to study hemispheric differences in cortical function. Risberg and Ingvar (1973) were among the first to demonstrate that blood flow to the brain is correlated with cognitive activity when they reported an increase in the average hemispheric blood flow in the left hemisphere of subjects who were performing mental tests. Two years later Risberg and his colleagues showed that blood flow increases differentially in the two hemispheres as a function of cognitive task (Risberg, Halsey, Wills, and Wilson, 1975). The 133Xe inhalation method was used with right-handed male subjects who were presented with a verbal reasoning test (analogies) and with a spatial test of perceptual closure (incomplete figures). When hemispheric activation was compared with that during a rest period, it was found that rCBF increased in both hemispheres during task performance but was greater in the left hemisphere during verbal problems and in the right hemisphere during the performance of spatial problems. It is interesting to note that the findings of lateralized activity were significant only when a monetary reward was offered. The laterality effects in the unrewarded conditions were insignificant, though the trends were in the expected directions.

Gur and Reivich (1980) replicated the Risberg study by showing selective hemispheric activation, as evidenced by increased rCBF, in the left and right hemispheres during the performance of verbal and spatial problems respectively. However, in this study, the findings of lateralized activity were significant without the monetary reward.

PET is a much newer technology and has been used to examine the effects of cognitive activity on brain function only since the beginning of the 1980s. Gur et al. (1983) and Reivich, Gur, and Alavi (1983) reported cerebral glucose metabolic asymmetries for tasks with assumed hemispheric specialization properties. Subjects who were asked to perform Miller Analogies had higher metabolic rates in select areas of the left hemisphere when compared to a group of subjects performing a spatial task (Benton's Line Orientation Task), in whom the right hemisphere was more active.

In sum, there is a substantial evidence from a variety of sources to support the notion of hemispheric specialization for verbal and visual-spatial abilities in normal humans. While this brief discussion has emphasized the dichotic nature of that specialization, it must be emphasized that the functional relationship between the hemispheres should actually be thought of as a continuum rather than a rigid dichotomy, "the differences being quantitative rather than qualitative, of degree rather than of kind" (Bradshaw and Nettleton, 1981). Nevertheless, it has become conventional to consider the left as the verbal hemisphere and the right as the hemisphere specialized for nonverbal abilities. This relationship, though firmly established, is subject to modification by individual differences, such as the gender of the subject.

Sex Differences in Hemispheric Specialization

Though men and women show the same types of functional asymmetries, there are some sex differences in the magnitude of their effects. Studies of normal individuals have shown enhanced lateralization of verbal stimuli for men, suggesting increased language specialization of the left hemisphere. They tend to show larger or more consistent left hemisphere advantage than women for verbal stimuli lateralized either through tachistoscopic visual presentation or dichotic auditory presentation (Lake and Byden, 1976; McGlone, 1980). Though less consistent, there is also evidence of a clearer asymmetry in men than women on tachistoscopically presented tasks composed of dots, which are presumed to be right hemisphere stimuli (McGlone, 1980).

In contrast to the greater lateralization of men than women for verbal and visual-spatial processing, many studies suggest that females show greater asymmetries than males in regard to handedness. Females are more likely to be right handed and tend to show greater preference for use of the right hand (Hicks and Kinsbourne, 1976; Searlman, Tweedy, and Springer, 1979). Piazza (1980) also reported that the asymmetry in performance on dichotic listening tasks composed of melodies or other nonspeech sounds tend to be enhanced in females when compared to males.

Not all studies have reported the sex differences discussed above. Those that do typically use large samples and the differences in asymmetries they report are usually small. In addition, it has been reported that the sex differences observed vary to some extent with certain aspects of the technique used to assess them. For example, Bryden (1979) reports that sex differences on certain tasks are influenced by the instructions given subjects or by attentional strategies.

It is clear that it can not be argued that one sex is simply more lateralized than the other. Rather, males seem to be more lateralized than females in some respects; females more lateralized than males in other respects; and the sexes appear to be equally lateralized in still other respects. When analyzing the influence of sex on results it is obvious that the nature and demands of the task must also be taken into consideration.

Attentional Asymmetries in Clinical Populations

In contrast to the majority of the literature, the focus of which has been the "input" portion of the sequence of events leading to a behavioral response, there is a large body of evidence which suggests that processing asymmetries have lateralized biasing effects on behavior, among the most subtle of which are the resulting asymmetries in attention.

Striking evidence of asymmetries in attentional control is found in the literature on unilateral neglect syndrome, a neurological disorder which is associated with parietal lobe damage. The symptomatology of this syndrome can be quite striking. For example, patients with severe hemi-inattention may fail to recognize their own extremities contralateral to their lesion as being part of their body and may complain that someone else's arm or leg is in bed with them. When confronted with evidence to the contrary, they may still deny that the extremities are their own (Heilman, 1985). In mild cases, a patient who initially fails to respond to a stimulus may be able to detect it if his attention is directed toward the area of neglect.

There is a great deal of evidence to suggest that neglect is due to a unilateral disturbance of arousal and attention mechanisms. The nature of the disturbance is the subject of a number of theories, most of which generally assume that separate cortical mechanisms control attention within left and right hemispace. In this context, hemispace is defined by the midline of the body trunk and refers to the area on one side or the other of the midline. Heilman and his colleagues (Heilman, 1979; Heilman, Valenstein, and Watson, 1985) have proposed that each hemisphere is responsible not only for receiving stimuli from contralateral hemispace and controlling the contralateral limbs, but also for attending in contralateral hemispace. Parietal lobe lesions result in the dearousal of the involved hemisphere and impairments in attention in the hemispace contralateral to the lesion. Since it is suggested that the hemispheric attentional control mechanisms are separate, attention to the hemispace ipsilateral to the lesion is assumed to be fully normal.

Posner, Walker, Friedrich, and Rafal (1984) hypothesized that neglect symptomology reflect deficits in directional actions rather than impairments in hemispatial attention. Thus leftward actions (which include lateral disengagement of attention) are impaired regardless of the hemispace in which these actions occur, while rightward actions are intact. Similar to the hemispace attentional theory, this model is based on the assumption that the anomalous behaviors are caused by lesion induced deficits in separate hemispheric attentional mechanisms.

In contrast to these theories, which tend to relate the symptomatology of neglect to deficits in the attentional control mechanisms of the involved hemisphere, Kinsbourne (1970a, 1977, 1987) has suggested that neglect is actually a unilateral disorder of brain activation which results in an attentional bias rather than an attentional deficit. This explanation is based on his model of attentional asymmetries in which he proposes that the two cerebral hemispheres, each of which subserves contralateral orientation, are in reciprocal balance. The direction of attention at any specific moment is the line of a vector which results from the opposing influences arising from the two hemispheres (Kinsbourne, 1970b, 1975). In the case of the neglect syndrome, this mutually inhibitory interaction is disrupted by a unilateral lesion, which results in an imbalance in the opponent system that controls the direction of attention. Kinsbourne suggests that the lesioned hemisphere becomes hypoactive, thus allowing the intact hemisphere to become disinhibited. The intact, hyperactive hemisphere causes the focus of attention to shift in a direction ipsilateral to the lesioned hemisphere. As a result, stimuli contralateral to the lesioned hemisphere appear to be ignored. However, a more detailed analysis of the neglected stimuli reveals that the neglect is neither of some part of space as is often assumed (Heilman, 1979; Heilman, et al., 1985), nor does it reflect deficits in the leftward disengagement of attention (Posner, et al., 1984). Instead, it is of stimuli or parts of stimuli, regardless of where in space the stimuli occur or the direction of shift in orientation required to locate the stimulus. (DeRenzi, Gentilini, Faglioni, and Barbieri, 1989; Kinsbourne, 1970a, 1977, 1987; Kinsbourne and Warrington, 1962; Ladavas, 1987). The attentional bias demonstrated in the neglect syndrome is display-centered rather than space-centered and, thus, is expressed across the entire spatial field.

As stated above, at the outset, unilateral neglect following right parietal damage is generally more common and more severe than that following left parietal damage (Bradshaw, Pierson-Savage, and Nettleton, 1988). The basis of this asymmetry is unclear. Heilman and Van Den Abell (1980) have suggested that this asymmetric expression of neglect symptomatology reflects the right hemispheric dominance for attention. They propose that the right hemisphere is capable of distributing attention throughout the spatial field while the left hemisphere can attend only to stimuli to the right. Thus, lesions of the left parietal lobe typically have no measurable affect on contralateral attention because the intact right parietal lobe can continue directing attention to the left. In contrast, lesions of the right parietal lobe are more likely to lead to a profound contralateral inattention because of the inability of the left hemisphere's attentional mechanisms to attend to ipsilateral (left) stimuli. However, again, this theory, which describes the affects of lesions in normal attentional control mechanisms, can not account for the neglect of stimuli across the entire spatial field.

Kinsbourne (1974, 1987) has suggested that the asymmetry of unilateral neglect is related to a hemispheric activation imbalance, which occurs normally and reflects the greater left hemisphere activation due to tonic verbal activity. This activation imbalance is the basis of the proposed stronger rightward orienting bias. Though left hemisphere lesions result in some degree of hypoarousal in that region of the brain, they do not eliminate all verbal activity, which continues to contribute to left hemisphere arousal and sustains the attentional control mechanisms of that hemisphere. As a result, symptoms of neglect, when observed, are very subtle. In contrast, lesions of the right hemisphere are often associated with severe unilateral neglect, since the resulting hemispheric hypoarousal severely impairs that hemisphere's orienting capabilities, a situation which is exacerbated by the disinhibition of the left hemisphere. Therefore, it is suggested that the left neglect frequently associated with right parietal lesions reflects the substantial diminution of the leftward orienting tendencies caused by the lesion and the concurrent release of the stronger rightward orienting bias.

Attentional Asymmetries in Normal Populations

The above considerations, regarding lesioned patients, would be the most informative and helpful if there were ways to demonstrate and manipulate the mechanisms--presumed to explain the lesion data--in normals without lesions. At least, whenever that has been possible in neuropsychology, it has reassured both cognitive and neuropsychological researchers that they could potentially be discussing the same phenomena.

Subtle lateral attentional biases can indeed occur under normal conditions as well. Reuter-Lorenz, Kinsbourne, and Moscovitch (1990) demonstrated systematic attentional biases among normal subjects in a series of studies using a modified line bisection task. Subjects were asked to judge the location of an intersect on a tachistoscopically presented horizontal line. The intersect either bisected the line, or was slightly to the left or right of the midpoint. The results of the first experiment in the series indicated that unilateral presentation of the visual stimulus when subjects fixated centrally produced a contralateral shift of attention such that an intersect displaced to the right was erroneously perceived as bisecting the line when stimuli were presented to the right visual field, while a left displaced intersect was more likely to be identified as a bisect with left visual field presentation.

In order to demonstrate that these response biases were not related to the spatiotopic or egocentric location of the stimulus (which were confounded with the retinotopic location in Experiment 1), a second study was designed in which subjects fixated either to the left or right of center so the centrally presented stimulus would fall into the subject's right visual field and left visual field, respectively. This manipulation allowed the spatiotopic and egocentric locations of the stimulus to be held constant, while varying only its retinotopic location. The results of this study were strikingly similar to those of the first, which indicated that the observed response biases did not depend on the spatiotopic or egocentric placement of the stimulus, but rather to the asymmetrical increase in hemispheric activation caused by selective visual field (and corresponding contralateral hemispheric) stimulation.

Experiments 1 and 2 demonstrated an activational imbalance which could be elicited by a task-relevant stimulus. However, the authors reasoned that if the attentional biases were due to this imbalance, then they should not depend on stimulus relevance, but should also occur in the presence of any sort of unilateral stimulation, whether essential to the task or not. The stimulus chosen to demonstrate such an effect was a peripheral square which either did or did not contain a dot. In the first part of the third experiment, subjects were instructed either to ignore the peripheral stimulus and report the location of the intersect of a centrally presented line, or to attend to either the left or right square and report the presence or absence of a dot prior to indicating the location of the intersect. As predicted, under both conditions (attend and ignore) the direction of the bias depended on which hemifield was stimulated by the square, although the bias was accentuated under the attend condition.

It is noteworthy that the contralateral biases revealed thus far have been of equal magnitude suggesting no difference in left and right attentional effects. However, the authors proposed that under certain conditions, hemispheric differences in the control of the distribution of attention may emerge. Their hypothesis was based on the documented disproportionate occurrence and severity of left neglect following right hemisphere damage when compared to the effects of left hemisphere lesions. As noted previously, this pattern reflects the tendency for the rightward attentional bias to be somewhat stronger than the leftward bias. To demonstrate the differences in magnitude of these attentional biases, Reuter-Lorenze and her colleagues introduced an orienting conflict or uncertainty, since these factors have been shown to increase the effectiveness of attentional cues (Posner, Snyder, and Davidson (1980). In the previous experiments, presentation of the stimuli had been blocked, which allowed subjects to anticipate their location. To remove this element of predictability, the authors modified their third experiment by randomizing the location of the lateral stimulus. The results of this manipulation did, indeed, reveal an asymmetry in attentional control in the predicted direction, although the magnitude was limited. In an effort to demonstrate a more robust asymmetrical effect, the authors increased the degree of uncertainty in the experimental task by randomizing presentation of the lateral stimuli so that the square would either appear in one or the other visual fields or it would not. Subjects were to report the presence or absence of the square in the specified visual field prior to indicating the location of the intersect. As in the previous experiment, the left hemisphere's rightward attentional bias was found to be more robust than the left bias of the right hemisphere.

These findings emphasized the power of the lateralized visual stimulus to elicit an orienting bias. In the absence of such a stimulus, asymmetrical biases were not expressed. This pattern suggested that when both hemispheres were stimulated simultaneously, the conflict between them would be maximized and differential orienting would be elicited. The final experiment in the series was designed to demonstrate this effect. Squares were presented on both sides of the centrally presented line, and subjects were instructed to report the presence of a dot in the square in the specified visual field prior to reporting the line intersect location. Based on the results of a previous experiment, the authors knew that even if ignored, a laterally placed stimulus would compete for attentional control. The results indicated that in the right visual field detection task, a consistent rightward attentional bias was observed. In contrast, when the relevant square was in the left visual field, no such bias was observed, once again suggesting a more robust left hemisphere-rightward attentional shift bias.

The series of studies reported by Reuter-Lorenz and her colleagues were reported in some detail because of their clear demonstration of contralateral biases in the distribution of attention produced by lateralized sensory input. There is some indication that similar biases can be elicited as the result of material-specific asymmetric cortical activation (e.g. consistent with the discussion above, through the use of verbal or nonverbal tasks). According to the activation-orienting model of attentional control, among right-handed subjects, verbalization, which activates the left hemisphere, results in a detectable, concurrent orientation to the right. Likewise materials which are nonverbal in nature activate the right hemisphere and thus bias attention to the left. These subtle attentional shifts have been demonstrated through the use of tasks sensitive to lateralities in perception. For example, Kinsbourne (1970b) reported that subjects involved in a verbal task showed a right-sided advantage in the detection of gaps in a briefly exposed square. When not involved in the verbal task, the likelihood of failing to detect gaps on the right side of the square did not differ significantly from the likelihood of failing to detect gaps on the left side. Thus the presumed activation of the left hemisphere seemed to facilitate perception of stimuli on the right side of the stimulus display. Similar results were obtained in subsequent gap-detection experiments (Kinsbourne, 1973, 1975). Concurrent musical activity has also been shown to bias perception (or attention) to the left (Bruce and Kinsbourne, cited in Kinsbourne, 1975). Nevertheless, there have been failures to find biases of this kind (Allred and Bryden, 1979; Boles, 1979), suggesting that the influence of a cognitive task on a visual perceptual task may be quite complex.

Cerebral Lateral Asymmetries as Reflected in Mnemonic Processes

Hemispheric specialization has also been shown to be reflected in mnemonic processes. Brenda Milner and her colleagues were among the first to document the existence of material-specific memory disorders which resulted from unilateral lesions. Their subjects were patients who were undergoing unilateral temporal lobectomy for relief of epilepsy. When the effects on memory of left and right temporal lobectomies were compared, they found that the most significant factor was the verbal or nonverbal nature of the material to be retained. Thus, left temporal lobectomy selectively impaired verbal memory (Milner, 1958) regardless of whether the material was presented visually or auditorally (Milner, 1967) and regardless of how the retention was tested (Milner, 1958; Milner and Teuber, 1968). In contrast, removal of the right temporal lobe left verbal memory intact but impaired the recognition and recall of complex visual and auditory patterns which were difficult to label verbally (Kimura, 1963; Milner, 1968).

The memory deficits observed in patients with neglect syndrome differ from those discussed above in that the critical feature of the to-be-remembered material is its location rather than its verbal or nonverbal character. Heilman, Watson, and Schulman (1974) demonstrated that patients with this syndrome have a unilateral memory defect for auditory material presented to their neglected side. In this study, consonants were randomly presented to patients who were then asked to report the stimulus either immediately or after a distractor-filled interval. It was found that distraction produced more of a defect in the neglected ear than in the normal ear.

A similar phenomenon in the visual modality was found by Samuels, Butters, and Goodglass (1974), who tested patients who had not been evaluated for unilateral neglect but who had documented right parietal lesions (which are associated with the neglect syndrome).

Bisiach and Luzzatti (1978) described retrograde unilateral memory deficits in their case reports of two patients with neglect syndrome who were unable to recall left-sided (neglected) details when imagining they face toward a cathedral in a square in Milan. However, when asked to imagine that they were facing away from the cathedral, they could recall the previously "forgotten" left-sided details, which were now on the right. Meador, Loring, Bowers, and Heilman (1986) took this recall-from-remote-memory paradigm one step further when on follow-up they asked one of their three patients to recall left-sided details of imagined scenes while his eyes and head were oriented to each side. When oriented to the right, there was still a significant difference in the number of right verses left details remembered. However, recall for items to the left of the imagined scene improved 26% when the patient's eyes and head were physically oriented to the left. The authors interpreted these results as suggesting that the engrams for left-sided visuospatial memories in neglect syndrome are not destroyed, but rather fail to be activated. This interpretation is based on physiological studies in animals and man which have demonstrated that opposing directional turning tendencies (of gaze, head and whole body) are in mutually inhibitory competition. These opponent processors are represented at brain stem level, but are under ipsilateral hemispheric control. The assumption is that just as hemispheric activation leads to physical orientation, so does physical orientation to the left or right result in the activation of the contralateral hemisphere, and, in this case, to images which could not otherwise be recalled.

Thus far evidence has been presented which suggests that hemispheric activity is related to both memory for spatial location and the verbal or nonverbal nature of information to be processed. Since it has also been shown that lesions of the left and right hemispheres lead to verbal and nonverbal memory deficits, respectively, it is reasonable to assume that these deficits are also to some extent related to deficient hemispheric activation. One question which logically arises is the nature of the relationship between cortical activation due to the processing of information and the activation associated with mnemonic processes.

Wood (reported in Wood, Ebert, and Kinsbourne, 1982) designed an experiment which examined the differential effects of verbal and nonverbal (in this case, visual) activity on memory for a simple visual attribute. The design was their modification of Corsi's adaptation (as cited in Milner, 1971) of the Peterson and Peterson (1959) paradigm. The subjects in this study were shown a horizontal line with a cross mark in 1 of 10 evenly-spaced locations. They were then engaged in 30 seconds of distractor activity, either arithmetic calculations or tasks which required the adjustment of some configural aspect of the visual display (e.g., angles). The stimulus layout and the hand movements required were identical for both of the distractor conditions. After completing the distractor task, the subjects were asked to place a cross-mark on another horizontal line of the same length in the same position as originally presented. Among normal subjects, there was a tendency to place the mark slightly to the right of its original position after the visual distractor task and slightly to the left when the distractor task was verbal. Subjects with a diffuse compromise of cerebral function (in the pilot study, due to the influence of alcohol and in a second group attributed to diffuse cerebral vascular disease) simply exaggerated the displacements seen among normal subjects so that the effects of the verbal and visual distractor tasks were significantly different. For these groups, it was also observed that the displacement following verbal activity was more pronounced than that following the visual distractor task.

Wood and his colleagues explained these findings within the context of Kinsbourne's attentional model of hemispheric asymmetries (Kinsbourne, 1970b) by assuming that the distractor tasks are differentially fatiguing to the two hemispheres; the less fatigued hemisphere biases attention in the contralateral direction. For example, engaging in the visual distractor task leads to right hemisphere fatigue and a rightward shift in attention caused by the disinhibited left hemisphere. According to the Kinsbourne model, this attentional bias would result in the overestimation through perceptual enhancement of the right side of the line, thus causing the subject to judge the correct placement of the cross mark to be to the right of its true position.

One of the most interesting aspects of this study is the nonsignificant trend for the performance of normal subjects to reflect the same memory biases seen within the impaired group. These results suggest that (a) the paradigm described above can be reliably used to study systematic biases in memory as reflected in the performance on a simple visual task, and (b) these biases might be observed among normal subjects. However, one of the disadvantages of the recall memory task used in the Wood (1982) study is the confounding of the subject's actual memory for the position of the mark and the subtle inaccuracies which may be associated with the motor response of drawing the mark in the remembered position. It is conceivable that the differential hemispheric fatigue, which was originally proposed as an explanation for the performance bias, selectively affected the motor response rather than perception. An obvious method of removing this confound is to redesign the task so that recognition rather than recall memory is required. To determine the viability of using a recognition memory task to investigate the differential effects of verbal and visuospatial activity on visual memory among normal adults, two pilot studies were undertaken.

Preliminary Data

In addition to the use of a recognition memory task, other modifications to the original design were made. These changes were based in part on the assumption that increasing the overall difficulty of the distractor items and the number of trials under each condition (verbal and visuospatial) would increase the likelihood of observing a significant difference in memory performance following verbal and visuospatial activity

The basic design of these pilot studies is discussed in detail in the methods sections for Experiments 1 and 2. Briefly, subjects were asked to remember the position of a small vertical mark placed along a horizontal line; the position of the mark varied from trial to trial. The mark and the line were computer generated and were exposed for 1 second, after which the subject was engaged in distractor activity that involved rapid presentation of 3 letters positioned diagonally within a box centered on the monitor screen. Under the verbal condition, they were asked to decide whether the 3 letters made a real word when read from left to right. The nonverbal or visuospatial condition required the subjects to judge whether the 3 letters were arranged in a straight line. A series of 9 distractor items were presented followed by another horizontal line with a small vertical mark, which was either where originally presented or the width of about 1 computer character to the left or right of its original position. The subjects were simply asked to determine whether the mark was in its original position or not with a yes/no response, which was made by pressing the designated keys on the computer keyboard.

In the first pilot study, in which 8 females and 2 males took part, there was an overall tendency for subjects to make more errors on the memory task following nonverbal distractor activity when the probe was to the left of the target. In other words, they were more likely to accept a probe displaced to the left as being on-target than they were with a similar rightward displacement. There was no systematic error following verbal activity. It was also noted that judgements were generally more accurate under both conditions when the mark was at or near the center of the line.

These results are superficially quite different from those reported by Wood and his colleagues (1982). Since the structure of the experiment is essentially the same as that used in the previous study, the discrepant results are most likely due to differences in the design of the memory and distractor tasks in the pilot project, especially in the use of a recognition rather than a recall memory task. Specifically, as suggested above, the implication is that differential hemispheric fatigue had a selective effect on the motor component of the recall response, rather than affecting the memory for the position of the mark itself.

In regard to the absence of systematic error following verbal activity, an examination of the pattern of correct and incorrect responses for the verbal and visuospatial distractor tasks revealed a higher number of correct responses to the verbal items, which suggests that the lack of a response bias to the memory task subsequent to verbal activity may reflect the lesser difficulty of the verbal task.

These findings indicate that the recognition memory task used in this first pilot study may indeed allow a more direct examination of the differential effects of verbal and visuospatial distractor activity on memory for the correct position of the mark. These results also indicated the need for certain modifications to the verbal distractor items in order to equalize the difficulty of the two distractor tasks. Therefore, a second pilot study, which included the presentation of a greater number of difficult distractor words, was conducted. Equal numbers of males and females (5 in each group) participated in this study in order to collect preliminary data on sex differences in performance on the memory and distractor tasks.

The results suggest that females perform more poorly on the memory task than males regardless of the nature of the distractor task or the direction of the displacement of the mark from its original position. As in the first study, females tended to be more accurate when the mark was in a central position. This effect was less evident among males. There was also a consistent finding of greater rightward accuracy, among males in the right portion of the line regardless of the displacement of the mark and among females in the right portion with right displacement. Only males demonstrated a modality-specific effect, again in the right portion of the line; their judgements were more accurate following the visuospatial than the verbal distractor activity.

The modest modality-specific effect in this study may simply reflect the small number of subjects in each group rather than a relative lack of influence on memory performance by the distractor task. These results certainly indicate that the sex and line-portion effects on memory performance may be more robust than those of the distractor type and mark displacement. Since in the original study by Wood and his colleagues (Wood, et al., 1982), an evaluation of sex differences was irrelevant (as only males were used) and an analysis of results by line position (or line-segment in their study) was not reported, a direct comparison of these with current results is not possible. However, the current data suggest that perceptual biases may be reflected more strongly by differences in performance in different portions of the line rather than with the displacement of the mark to the left or right of its original position within a line portion. The significance of the position of the original mark and the recognition mark on the left or right portion of the line can be attested to by the literature demonstrating lateralized performance on perceptual tasks such as the recognition of line bisects (Reuter-Lorenze, et al., 1990), gap detection (Kinsbourne, 1970b) and for the memory of visual scenes (Bisiach and Luzzatti, 1978; Meador, et al., 1986).

The results of the current experiment also suggest that performance on the recognition memory task is influenced by the sex of the subject since males consistently demonstrated superior accuracy in their judgment of the correctness of the placement of the mark in the memory task. The documented superiority of males in the performance of tasks involving visuospatial skills (Harris, 1978) suggests that their memory for items not readily subject to verbal encoding is also superior to that demonstrated by females. It was, therefore, not surprising that the performance of male subjects on the memory task was generally more accurate than the performance of females on the same task. Nevertheless, whether these results reflect a true difference between males and females in hemispheric specialization for this specific ability, a more general difference in perceptual capabilities, or, alternately, individual differences in encoding strategies is uncertain.

These pilot projects, while revealing few definitive results, do suggest that the recognition memory task described herein is sensitive to certain individual differences and, perhaps, to modality-specific influences on the performance of normal subjects. It is on that basis that the following experiments were undertaken, to isolate and deconfound the several attentional and mnestic mechanisms that are presumed to be at work.

CHAPTER II

EXPERIMENT 1

Statement of Purpose and Hypotheses

Reuter-Lorenze and her colleagues (Reuter-Lorenze, et al., 1990) demonstrated that lateral stimuli induce lateral performance biases, and under conditions of orientation uncertainty (when the position of the lateral stimulus is unpredictable) the rightward bias is predominant. The present experiment was conducted in order to clarify the degree to which these biases, particularly the rightward bias, might be subject to other influences, such as gender, the verbal or nonverbal nature of the target, or the exposure duration of the target. It uses a two stimulus (target and probe) recognition paradigm that allows a test of the effect of manipulations of the target on the recognition of the probe. The target stimulus is either an upper case letter or a nonverbal vertical mark, placed on a horizontal line. The probe stimulus is in the same category as the target (lower case letter or mark) and follows immediately. The probe is also presented on a horizontal line, and the subject is instructed to signal if the probe matches the target in position and (in the case of letter stimuli) in letter name.

Pilot data on this two stimulus paradigm had shown that there might be a sex difference in performance. The results reported within the literature on sex differences in cognitive abilities are variable and somewhat inconsistent. Among the explanations proposed for this variability is the impact of individual differences in the choice of information processing strategies (Bryden, 1978, 1979; Butler, 1984; McGuinness, 1980). It has been shown that subjects, both male and female, tend to use verbal reasoning skills during experimental tasks (Kinsbourne, 1970a, 1973, 1977, 1987; Zaidel, 1985). However, it has also been demonstrated that females have a disproportionate bias toward problem-solving in a verbal mode (McGuinness, 1980). Thus, tasks which are considered to be "nonverbal" may not actually prevent the use of such a strategy, particularly among females. Nonetheless, the use of a verbal approach to encoding the position of the mark in the task used in the studies described in this paper would be inefficient because of the small positional differences a subject needs to detect between the to-be-remembered target and the recognition probe; a verbally encoded "description" of the position of the target memory item could, in most cases, also apply to the position of the recognition mark.

The contribution of encoding strategies to the overall accuracy of the performance of males and females can be evaluated by manipulations which are designed to influence verbal or nonverbal approaches to problem solving. In order to do so for the task used in these studies, the content of the stimulus and the exposure duration were manipulated. Displacement of the recognition probe from its remembered target position in the memory item remained the critical manipulation. However, in order to stimulate a verbal approach in both groups during the encoding of position, the target mark was varied within subjects: in the letter condition the vertical target was replaced by a letter--upper case at encoding of the target item, and lower case for the recognition probe item. In addition to evaluating the stimuli for a position match, subjects were required to identify the presence of a semantic letter match in each stimulus pair. The use of upper and lower case letters for the memory and recognition items, respectively, precluded the use of physical (and, thus, more nonverbal) characteristics for identifying a content match.

This logic of cross-case (meaning) letter matches was used by Geffen, Bradshaw, and Nettleton (1972) in their study of hemispheric asymmetries in the verbal and spatial encoding of letter pairs. Pairs of letters, which were either physically identical (the letters were the same and either upper case or lower case) or which had the same name (upper and lower case of the same letter), were tachistoscopically presented to subjects, who were to judge whether the letters were the same or different. Their results indicated that the physical matches were responded to more quickly when presented to the left visual field (right hemisphere), while the fastest responses to letters similar in name only were made when the stimuli were presented to the right visual field (left hemisphere). It was proposed that these response asymmetries reflected hemispheric differences in the fluency of processing these stimulus pairs with either physical or name matches. That is, an analysis of visual patterns (physical matches such as AA) was performed more rapidly by the right hemisphere, while letter pairs with physical differences but similar names (Aa) were processed more quickly by the left, language hemisphere. These data, and others like them (Hellige and Webster, 1981) suggest a preferential left hemisphere role for processing letter stimuli with like names but different physical appearances, and provide a basis for the assumption that the "letter task" of this first experiment, which required that a name or semantic match be made before the relative positions of the two letters became relevant, is primarily a verbal--and thus left hemisphere--task.

As a further manipulation of target encoding, the length of its exposure to the subject was varied--either 1.0 second or 0.1 second. The short interval was assumed to favor a nonverbal encoding strategy when the nonverbal mark stimulus was employed. However, given the automaticity and saliency of letter and word recognition (Miller, 1991; Posner, 1989), it was expected that the briefer exposure time would still permit the verbal encoding of the letter stimulus. Since the exposure is brief, this verbal encoding might then compete with the positional encoding to force a more verbal encoding of the position as well.

If the differences in the performance of males and females on this task reflect strategy rather than basic ability differences, then the manipulations described above should affect the accuracy of their judgements, although in different ways for the two groups. The addition of the letter match to the original position match task should have no significant impact on the overall accuracy of the performance of the females, if they were already using a verbal encoding strategy. The effects of this manipulation would more likely be seen among males who will be forced to adopt a less efficient verbal set when encoding the position of the target mark. The impact of this enforced verbal set would be more evident at the brief (0.1 second) exposure time, since the longer time would be assumed to make it easier to regain a nonverbal set for encoding of the position of the target. If the less accurate performance of the females can be at least partially attributed to their verbal approach to the task, then promoting this strategy among males, who would otherwise use a nonverbal strategy, should result in a decrease in the accuracy of their judgments.

Separate from the issue of accuracy, the letter target, if activating to the left hemisphere, should also induce rightward bias, i.e. a greater tendency to correctly reject leftward displacement and false positively to accept rightward displacement. According to the Kinsbourne theory, this rightward bias would involve a subjective underestimation of the left end of the line during encoding. Thus, when the recognition item was exposed, right displaced probes would be perceived as on-target (reflecting a leftward shift in perceived position) and left-displaced probes would appear to be even further displaced to the left (Figure 1).

Since this experiment is designed to investigate the degree to which factors other than the lateral position of the stimulus can induce a rightward bias, only the central portion of the line was used, which essentially removed the influence of stimulus position. Since sex differences in cognitive abilities were also at issue, two brief measures of verbal and spatial abilities were administered, and the results used as controls for these factors.

Method

Subjects. Twenty adults, ranging in age from 24 to 53, were recruited. They were divided into two groups of 10 males and 10 females, all of whom were right handed with the exception of one ambidextrous male. None had a history of neurological impairment. All subjects participated in the study on a volunteer basis.

Apparatus and Stimuli. A Commodore 8096 was used to present stimuli and record responses. While the stimuli were fundamentally quite different in the two conditions described below, they shared certain common characteristics. Each consisted of a horizontal line 18 cm in length, on which the task-relevant characters were displayed within a central 2.5 cm segment. The stimuli had two parts, the first a memory item referred to as the "target" and the second, a recognition item called the "probe". The target was placed randomly within the central segment in such a way that the probe never fell outside the 2.5 cm central range. The length and position of the horizontal line for the recognition item was identical to that of the memory item. However, the position of the probe during the recognition task varied and was in one of three positions: same as during the original exposure (on target), 0.5 cm to the left of target, or 0.5 to the right of target. In contrast to the design of the task used in the pilot studies, no distractor items were presented between the memory and recognition items. The length of presentation for the memory item varied; half of each group of subjects viewed the item for 1 sec., the other half for 0.1 sec. Beneath the line was the statement, "REMEMBER THE MARK!". The recognition item, with the question, "SAME AS TARGET?", remained on the screen until the subject responded, although no longer than 5 sec. Failures to respond within 5 sec were recorded as "no response". Subjects were required to make a Yes/No response by pressing the designated keys on the computer keyboard. On the computer keyboard the "H" and "L" keys (labeled "Y" and "N" for half of the subjects and "N" and "Y" for the other half) were used because of their position on either side of the midline of both the subject and the computer screen. All other keys, with the exception of the number keys to the right of the keyboard, were covered with white tape in order to obscure their symbols. The number keys were used for specifying task parameters and for resuming data collection following a rest break.

The nature of the target and probe differed in the two experimental conditions. In the Mark condition, both the target and the probe consisted of a small vertical line which intersected the horizontal line. The stimuli in the Letter condition were drawn from a group of eight letters (N, D, T, B, E, H, A, R), which were chosen because of the distinct appearance of the upper and lower case of each pair. The target in this condition was a capitalized letter and the probe, a lower case letter, which was either the same as or different from the target. Both the target and the probe were displayed 0.5 cm above the line.

<u>Psychological Tests Administered.</u> All subjects were administered two brief instruments designed to provide estimates of intellectual functioning. The Verbal Comprehension section of the Employee Aptitude Survey was used to estimate overall verbal skills, while the Space

Visualization section of the same battery was administered to provide an estimate of nonverbal abilities. In order to be included in the study, subjects were required to perform at or above the 16th percentile on both tests. No subject had to be excluded because of failure to meet these criteria.

Procedure. Following informed consent, the subject was oriented both to the nature of the tasks to be presented and to the response requirements. In order to become acquainted with the pace of stimulus presentation and the speed with which responses must be made, each subject completed according to task instructions, one or more trial runs. Once comfortable with the procedure, he or she began stimulus presentation by pressing a number key to the right of the keyboard.

The experimental session lasted approximately 2 hours with ample rest periods, during which time both experimental conditions (Letter and Mark) were presented. The order of presentation was counterbalanced for each group of 10 subjects.

The presentation of all stimuli in each of the conditions was completed in one experimental cycle. Each cycle was composed of 6 blocks of 24 trials each, and a single trial consisted of the presentation of the memory item followed by the recognition item. Subjects were allowed a brief rest period between each block and a longer break between each cycle. The time for completion of each cycle was approximately 20 minutes.

Data analysis. Raw data were converted to percent-of-correct responses for each subject under both conditions. Accuracy, independent of response bias, could then be measured as the mean percent correct response under any conditions or across conditions. Since a principle variable of interest was the response bias (leftward or rightward), the data were also converted into bias scores, consistent with the approach used by Reuter-Lorenze, et.al (1990). A rightward bias occurred when subjects more often incorrectly accepted probes displaced to the right as being on target. To calculate this value, the percent of correctly rejected right displaced probes was subtracted from the percent of rejected left displaced probes (L-R). Since the targets and probes were presented only in the central line segment, there was one value each for left and right displaced probes in each of the conditions (exposure time and letter or mark task) for males and females. Thus, for each condition, when L-R was positive, a rightward bias was demonstrated and when the resulting value was negative, the bias was to the left.

Results

Demographic and Psychometric Characteristics of the Subjects. Table 1 contains the demographic and psychometric data for subjects at each exposure time; sex and exposure time were the variables used to separate subjects into the four groups used in this study. An analysis of the data by exposure duration indicated that there were no significant psychometric or demographic differences between the exposure time groups, so the data were collapsed and are presented by sex only.

Table 1. Means and Standard Deviations for Demographic and Psychometric Characteristics of Subjects

	Males (n=10)		Females (n=10)	
	Mean	SD	Mean	SD
Age	34.0	7.2	31.8	10.1
Education	16.8	2.1	16.0	1.8
EAS Verbal (Percentile)	79.3	21.3	72.9	21.1
EAS Visual Spatial (Percentile)	80.2	27.5	48.5	26.7*

*p<.01

There was no significant difference between the groups in terms of age or years of education. The females performed significantly more poorly than males on the test of visual spatial abilities which was administered (F=7.44, p<.01), a pattern which is consistent with that reported in the literature on sex differences in cognitive abilities on such tasks (Harris, 1978). The group differences in performance on the verbal task were not significant.

<u>Accuracy of Performance by Gender and Exposure</u>

Duration. Table 2 presents the data for percent of correctly rejected displaced probes (probes to the left or right of the target position) for each task condition. Although these accuracy data were not the primary focus of interest (lateral bias was), they are nevertheless relevant to the issues of encoding strategy presented in the introduction.

Table 2. Mean Percent Correct Scores at Left and Right Displacement by Task, Gender and Exposure Duration (ED)

		Males				Females			
		Left		Right		Left		Right	
ED	Task	M	SD	M	SD	M	SD	M	SD
0.1	Letter	84.4	15.7	87.0	14.6	62.6	15.6	61.6	9.5
	Mark	74.6	14.2	73.4	10.7	59.8	13.2	45.2	26.7
1.0	Letter	81.4	14.1	65.4	20.3	82.4	14.8	84.8	11.0
	Mark	80.6	16.5	55.4	25.2	73.0	22.2	78.6	22.9

Analysis of Accuracy. As the above table shows, the accuracy under the Letter condition is better than the accuracy for the Mark condition; the effect is seen in each of the eight cells. Overall this effect is assessed by a Univariate T-test against the null hypothesis that the difference between accuracy for the Letter and Mark conditions is 0; this hypothesis was rejected at a statistically significant level (t=4.58, p<.001). The mean difference across subjects is 8.6 (SD=8.4) and the range is from -5.5 to 24.5. Sixteen of the 20 subjects showed better accuracy under the Letter condition (chi square=7.2, p<.01).

When the true positive condition is considered alone (where the probe matches the target perfectly), there is no difference in accuracy between the Letter condition and the Mark condition in any of the cells. Thus, the overall accuracy advantage for Letter stimuli occurs only in situations where there is a mismatch between target and probe, and since the Letter condition offers two criteria for mismatch (letter name and position), correct rejections may be inherently easier in this condition.

Notwithstanding the overall effects, it is clear that the data in Table 2 would disconfirm the assumptions about the effect of verbal encoding on accuracy of performance. The Letter task did not impair performance in any condition, and males were actually better, not worse, on the Letter task than they were on the Mark task, when the exposure was brief.

Analysis of Response Time as a Manipulation Check on the Letter Task. The fact that the Letter condition did not impair performance relative to the Mark condition raises the question of whether the Letter task had any of its expected verbal encoding effects in the first place. This question leads to a consideration of response times in the Letter vs.

Mark conditions. The verbal encoding demanded by the Letter task is assumed to consume processing time. If so, then response time should be increased for Letter probes compared to Mark probes. This comparison would only be valid for the true positive condition, however, since only in that condition is a position match added to a letter name match. The effect should also be more prominent when the target stimulus is briefly exposed than when it receives longer exposure. A longer exposure duration could give the subject time not only to do the verbal encoding but set up a purely physical image or template of the relevant lower case letter, thus saving processing time at recognition.

Response times for true positive probes were indeed longer for Letter stimuli than for Mark stimuli. Since the response time data were highly skewed, a non parametric analysis was done, showing that 14 of the 20 subjects showed longer response times for the Letter condition than for the Mark condition (z for this proportion = 1.79, p=.036). Moreover, as expected, the response time effect was especially strong when the target stimuli had been exposed for 0.1 seconds. In that condition, 8 of 10 subjects showed longer response times in the Letter condition than in the Mark condition (z for this proportion = 1.88, p=.031). Six of 10 subjects in the 1.0 second condition showed greater time for the Letter than for the Mark condition; that effect was nonsignificant.

Analysis of Bias-Main Effects. The bias scores for each condition are shown in Table 3. A univariate T-test was performed on these data to assess whether a mean rightward bias was demonstrated in performance on the experimental tasks. The results of this analysis showed that no bias was present overall (t=1.7, p<.10).

Table 3. Means and Standard Deviations for Bias Scores by Gender and Exposure Duration for Each Condition

Task	Exposure Time	Male		Female	
		M	SD	M	SD
Letter	0.1	-2.6	2.9	+1.0	8.5
	1.0	+16.0	12.1	-2.4	6.2
Mark	0.1	+1.2	12.1	+14.6	21.5
	1.0	+25.2	17.3	-5.6	33.4

Furthermore, there were no overall main effects on bias of exposure time, gender, or stimulus type (Figure 3).

Analysis of Bias-Interaction with Gender and Exposure Duration. Two General Linear Model (GLM) Analyses of of Variance were performed to study the interaction of sex and exposure time. The results, which are shown in Tables 4 and 5, indicate that the bias scores in both the Mark and the Letter conditions were significantly affected by the interaction of gender and exposure duration (Figure 2). The bias score for the Letter task was also influenced by exposure time alone.

Table 4 . Summary of GLM Analysis of Variance for Bias in Mark Task

Source	Type III ss	df	ms	F	Pr>F
Exposure Time	18.05	1	18.05	0.04	0.9
Sex	378.45	1	378.45	0.75	0.4
Time x Sex	2442.05	1	2442.05	4.82	0.04

Table 5 . Summary of GLM Analysis of Variance for Bias in Letter Task

Source	Type III ss	df	ms	F	Pr>F
Exposure Time	288.8	1	288.8	4.37	0.05
Sex	273.8	1	273.8	4.15	0.06
Time x Sex	605.05	1	605.0	9.16	0.008

In general, females demonstrated a greater rightward bias (made more correct rejections of probes displaced to the left) than males at the briefer exposure time. However, when the stimulus was presented for 1.0 sec., males showed the greater rightward performance bias.

Analysis of Bias-Psychometric Explanation of the Gender Effect. Since it had already been determined that these groups differed significantly by gender on performance on the Employee Aptitude Survey (EAS) spatial test, it was deemed appropriate to assess the relationship between the cognitive tests administered and the bias scores for each condition (letter and mark). The results of a Pearson Correlation Analysis were suggestive of a positive correlation between performance on the spatial test and rightward bias on the mark task ($r=.41$, $p<.07$). To pursue this suggested relationship between certain cognitive abilities and performance bias, the mark and letter task data were combined to provide an overall bias score; the absence of a main effect of stimulus type on bias scores allowed such a combination.

The partial correlation analysis indicated that when spatial (block counting) ability was controlled, verbal skill (vocabulary) was significantly negatively correlated ($r = -.49$, $p<.03$) with rightward bias. Thus, in this case, relatively better vocabulary was associated with less rightward bias.

Given these relationships between certain cognitive skills and both performance bias and gender, it was assumed that by controlling for cognitive ability level, the effects of gender would be significantly diminished. Under these conditions, the influence on the bias scores of exposure duration or the interaction between time and gender no longer emerge. This fact is illustrated by the comparison of Tables 6 and 7, where cognitive ability was controlled, with Tables 4 and 5, respectively, where cognitive ability was not controlled.

Table 6 . Summary of GLM Analysis of Variance for Bias in Mark Task When Controlling for Cognitive Abilities

Source	Type III ss	df	ms	F	Pr>F
Exposure Time	62.6	1	62.6	0.15	0.71
Sex	48.8	1	48.8	0.12	0.74
Time x Sex	876.5	1	876.5	2.09	0.17

Table 7 . Summary of GLM Analysis of Variance for Bias in Letter Task When Controlling for Cognitive Abilities

Source	Type III ss	df	ms	F	Pr>F
Exposure Time	315.2	1	315.2	4.31	0.06
Sex	170.0	1	170.0	2.32	0.15
Time x Sex	273.3	1	273.3	3.74	0.07

Thus, none of the variables manipulated, neither gender, nor stimulus characteristics (letter or mark), nor the length of time the stimulus was exposed, were able to create a systematic performance bias in the absence of confounding factors.

Discussion

The findings of Experiment 1 are essentially negative; none of the manipulations produced the expected changes in accuracy or bias. In particular, the Letter vs. Mark and the exposure time manipulations did not provide the expected explanations for gender effects; and the absence of a rightward bias, induced by Letter targets, failed to confirm the Kinsbourne hypothesis that verbal activation should induce rightward bias.

The important positive finding about gender differences was the existence proof that psychometrically measured verbal or visual-spatial ability can underlie gender differences and can explain group effects involving gender. Although it is not clear why vocabulary (relative to block counting ability) should be negatively related to rightward bias in this experiment, it is at least possible that the block counting task has elements of manipulative verbal (counting) ability that are also task-relevant. The next experiment will employ psychometric tasks more directly selected for relevance to the experimental procedure.

Letter name matching (across upper to lower case) is by definition verbal, and it did add to the processing time as indicated by the response time manipulation check. Its failure to generate rightward bias is reminiscent of a similar failure by Geffen, Bradshaw, and Nettleton (1972) to show rightward biasing of attention with cross-case letter matching, even though they showed a selective right visual field (left hemisphere) advantage for the detection of cross-case letter matches. Thus, the Kinsbourne theory must at least be modified to exclude relatively automatized verbal activation processes such as letter name recognition from the class of events that are assumed to activate the left hemisphere enough to generate rightward bias.

The studies by Reuter-Lorenze and her colleagues demonstrated the importance of position in eliciting a contralateral performance bias; lateral stimuli precipitated performance that was suggestive of leftward neglect. Their results also showed a more robust rightward than leftward bias, which they attributed to the differential orienting strength of the cerebral hemispheres. Because of the disproportionate left hemisphere activation associated with verbal activity, there was a tendency to orient more fluently to the right. However, no controls were reported for cognitive ability levels, which introduces the possibility that these skills may have influenced the pattern and strength of the result

CHAPTER III

EXPERIMENT 2

Statement of Purpose and Hypotheses

This experiment was designed to replicate and extend the findings of Reuter-Lorenze, et al. (1990), in which she showed systematic errors in perceptual judgment, elicited by the rightward or leftward position of the stimuli. In contrast to her studies, the present experiment used a two stimulus (target and probe) paradigm. This permitted the introduction of variable durations of distractor activity between target and probe. Any persistence of bias in memory (after distraction) could then be separated from the immediate bias that occurs when there is no intervening distraction between target and probe.

Although Reuter-Lorenze interpreted her findings in terms of a stimulus-induced attentional bias, there are other explanations which must be considered. The first of these is psychophysical scaling (Carroll and Arabie, 1980; Gescheider, 1988; Lockhead and King, 1983; Young, 1984; Zwislocki, 1983). Off centered targets (rightward or leftward) would establish a ratio between the minor and the major segment, so an absolute distance displacement of the probe to either side would create ratios of minor to major segment that would not be equally different from the target ratio. For example, in the forthcoming experiment the horizontal line is 18 cm in length, and the target might be placed rightward from the center, at a position 3 cm from the right end of the line, thus creating a ratio of minor to major segment that is 3/15 or 0.20. Probe placements are a constant 0.5 cm to either side of target. A probe displaced 0.5 cm to the left would, therefore, generate a ratio of 3.5/14.5 or .241, a value that differs from from the target by .041. On the other hand, a probe displaced to the left by 0.5 cm would generate a ratio of 2.5/15.5 or .16.1, a value that differs from the target by .039. Thus, in ratio terms, the right displaced probe is more similar to the target than the left displaced probe is, and if this small difference in ratios is detectable then performance might be better for leftward displacements than for rightward displacements (when targets are initially rightward). Exactly the same effect, of course, should be found for leftward targets.

Adaptation level effects could also be operating in this two stimulus target-probe paradigm. According to this explanation, a rightward target would reset the adaptation level rightward, thereby causing the even more rightward probe to be perceived as less extreme. This explanation (Lockhead and King, 1983; Staddon, King and Lockhead, 1980) would also be equally applicable to leftward targets.

Adaptation level effects, however, could accumulate across more than one trial; so if the immediately preceding trial also contained a rightward target, the adaptation level effect might be even stronger. This leads to a differential test: If such sequential dependency could be observed, then psychophysical scaling effects alone would be insufficient as an explanation.

In addition, adaptation level and psychophysical scaling effects should differ in their relationship to memory after distraction. The psychophysical scaling explanation is inherently tied to memory, since it depends on a quantitative comparison of the target ratio (of minor to major segment) to the probe ratio, and for this comparison to take place, the target ratio must be remembered. Therefore, the rightward or leftward bias that is caused by psychophysical scaling effects should be directly correlated with memory accuracy. (Accuracy is defined as the sum of percent correct responses for leftward and rightward probes, for a given target. By contrast, bias is defined as the difference of correct responses between the leftward and rightward probe).

Adaptation level effects, on the other hand, dissipate with time (Jesteadt, Luce and Green, 1977), and this is not necessarily or inherently linked to the accuracy of memory of the target. Thus, if the adaptation level effect is simply dissipating with time or distraction, then any bias induced by adaptation level would not necessarily be correlated with accuracy. It is true that, for the adaptation level effect to occur at all, the rightward orientation of the target must in one sense be remembered until the time of recognition of the probe. However, the level of remembering that is required to know that the target was simply rightward or leftward is different from the level of remembering that is required to make accurate positional judgements. Consequently, the adaptation level could persist to some extent even if positional accuracy was degraded with time. At minimum, a tight correlation between accuracy and bias is less necessary for the adaptation level explanation than for the psychophysical scaling explanation.

Both the psychophysical scaling and the adaptation level explanations are not inherently asymmetric, and they do not require that rightward bias should be greater than leftward bias. Kinsbourne's attentional theory, that was used to explain the Reuter-Lorenze findings, does propose greater rightward than leftward bias, but only in the general sense of a tendency for the left hemisphere to be more active in most situations. If that theory is to be extended or improved, it should address individual differences in the strength of this tendency toward left hemisphere activation, as has been urged by Levy (1983).

She argues strongly that individual differences in cognitive function (and, even, personality style) may account for otherwise unexplained variance in patterns of lateral asymmetry in perception. In this context, it would be compatible with the Kinsbourne theory to hypothesize that verbal ability would predict the degree of rightward bias. That is based on the assumption that higher verbal ability is associated with greater left hemisphere activation.

Two specific measures will be employed in this experiment to operationalize the individual differences in verbal ability. First, the combination of the vocabulary and block design subtests of the Wechsler Adult Intelligence Scale-Revised (Wechsler, 1981) will permit a relative comparison of overall verbal and visuo-spatial ability on standard, widely used tests. Second, the rapid letter naming and rapid object naming tests of Denckla and Rudel (1976) will be employed to measure fluency of letter naming that is separable from fluency in object naming. Letter naming becomes relatively faster than object naming over the course of childhood development, as children learn to read (Felton and Brown, 1990), and it remains impaired well into adulthood in those who have trouble learning to read (Felton, Naylor, and Wood, 1990).

A second test or extension of the Kinsbourne theory would be to consider the activating effects of verbal distraction, during an interval between the target and probe. Unless otherwise modified, the Kinsbourne theory should predict that this distraction would activate the left hemisphere and thereby generate a rightward bias that is greater than it would have been without distraction. Unlike the stimulus manipulation in Experiment 1, where the letter processing might have sufficiently automatized to be brief and only minimally activating to the left hemisphere, the verbal distractor task used in the forthcoming experiment would be effortful and sustained over 3 or 9 seconds of time. It should therefore activate the left hemisphere more, and should induce a rightward bias that is greater with a longer verbal distractor task.

The design of the memory task used in this study was modified after that of Peterson and Peterson (1959); therefore, manipulations similar to those which they used in their investigation of short-term forgetting were appropriate. Peterson and Peterson (1959) found that by manipulating the length of a distractor-filled interval between the presentation of a three-letter trigram and its recall, they could reliably demonstrate a relationship between the interval length and the probability of recall. As the interval increased, the likelihood of correctly recalling the trigram decreased, with very little retained after 18 seconds. Based on these results, it was assumed that by varying the number of distractor tasks presented between presentation of the stimulus and the recognition item, the contribution of memory to the performance bias could be determined.

The performance of normal males on the memory task will be compared with the performance on the same task of a group of males with moderate to severe dyslexia which has persisted since childhood. This group of subjects was included to permit the evaluation of the impact of a chronic language deficit on the pattern of biases. By definition, they should have less tendency to activate the left hemisphere than normal males or normal females, and should therefore have reduced rightward bias.

Method

Subjects. Three groups of 10 right-handed adults were recruited; their ages ranged from 22 to 46. Groups 1 and 2 consisted of females and males, respectively, with no history of neurological impairment or reading difficulties.

Subjects in Group 3 were males who were referred to Mrs. June L. Orton as children for evaluation of reading difficulties and who have been classified as having persistent reading disabilities as adults. These subjects were drawn from a larger group of reading disabled adults who were classified as such as part of a study of the physiological bases and behavioral concomitants of reading disabilities. All subjects received $25 for participating in the study.

Apparatus and stimuli. As in the first experiment, a Commodore 8096 was used to present stimuli and record responses. The stimuli were of two types. The first, a memory item and a recognition item, was identical to that used in the second pilot study and in the Mark condition of the first experiment, and consisted of a horizontal line 18 cm in length which was intersected by a small vertical line. For the purposes of this study, the vertical line was randomly placed within one of 3 evenly spaced 2.5 cm segments. Again the terms "target" and "probe" refer to the vertical line in the memory and recognition items, respectively. The outer edges of the lateral segments were 3.0 cm from the ends of the horizontal line; and the central segment was centered on the line. The length and position of the horizontal line for the recognition item was identical to that of the memory item. The position of the probe during the recognition task varied among three positions as described in the Method section of Experiment 1; response criteria were also the same. The target and probe were always within the same segment.

The second type of stimulus was a distractor task item, a variable number of which were interpolated between the presentation of the memory item and the recognition item.

Each of these distractor stimuli consisted of a 7 cm X 7 cm box positioned in the center of the computer screen and containing 3 diagonally positioned letters which, when read left to right, made either a real word or a nonsense word. The nonsense words were formed by scrambling the letters of each real word, so there were equal numbers of real and nonsense words. Forty words were chosen from the 1927 edition of Thorndike's The Teacher's Word Book. Along with their nonword counterparts, they comprised a pool of 80 items for use during distractor task presentation (Appendix A). Each item was exposed for 1.5 sec; failure to respond within this period was recorded as a "no response" rather than an error. The subject was asked to respond to one of two questions according to the experimental condition (to be described in the Procedure subsection). Under the verbal condition, the message read, "WAS THAT A REAL WORD?" and during the nonverbal trials, "WAS THAT A STRAIGHT LINE?". Subjects were required to respond "Yes" or "No" using the appropriate keys on the computer keyboard.

Psychological Tests Administered. The non-reading disabled and the reading disabled males in Groups 2 and 3, respectively, received an extensive battery of intelligence, reading achievement, memory and perceptual tests as part of a previous study. Selected tests from this battery were administered to the female subjects in Group 1. Since the subjects in Group 1 were required to meet the same criteria for inclusion in the study as the males in Group 2, the same standards for intellectual and reading ability were used. Therefore, they were required to have an extrapolated WAIS-R IQ of 85 or above on the verbal and performance scales and to demonstrate normal adult reading skills on tests of reading achievement. No subject had to be excluded because of low intelligence or poor reading skills. Administration of all the tests described below was completed in approximately 1 hour.

The tests administered to the subjects in Group 1 were chosen as measures of the following catagories of function:

1. Intelligence. Four subtests from the WAIS-R were administered, and an IQ was extrapolated from the results. The tests chosen were Digit Span and Vocabulary from the verbal scale, and Block Design and Digit Symbol from the performance scale.

2. Tests of reading ability. Tests included the Lindamood Auditory Conceptualization Test (Lindamood and Lindamood, 1971), which assesses phonological awareness, Word Attack from the reading cluster of the Woodcock-Johnson Psycho-Educational Battery, as a measure of phonological decoding ability, the reading section of the Wide Range Achievement Test-Revised Version (WRAT-R), which involves single word recognition and pronunciation, and Rapid

Automatized Naming of colors, numbers, objects and letters (Denkla and Rudel, 1976), which assesses fluency of lexical access.

3. Test of mathematic ability. To evaluate the level of proficiency in math, the math portion of the WRAT-R was administered.

4. Visual-spatial skills. Visual-spatial perception and analysis were measured by the Judgment of Line Orientation Test (Benton, Hamsher, Varney, and Spreen, 1983).

Procedure. Following informed consent, each subject was oriented both to the nature of the tasks to be presented and to the response requirements. For each condition, he or she was then allowed to complete according to task instructions, one or more trial runs in order to become familiar with the task parameters.

The experimental session lasted approximately 1 1/2 hours, during which time all 5 of the experimental conditions were presented (DT=0, verbal DT=3 and 9, and nonverbal DT=3 and 9). The order of presentation was counterbalanced for each group of 10 subjects.

Two variables were manipulated for each condition: the nature of the distractor task (verbal or nonverbal) and the number of distractor items interpolated between the memory and recognition items (in this study, 0, 3, and 9). The verbal/nonverbal specification was essentially irrelevant in the condition with no distractor items (DT=0) since the subject was required to recognize the correctness of the probe position immediately after the presentation of the memory item. For the remaining 4 conditions, the designation of verbal or nonverbal indicated which set of instructions the subject was to follow in order to respond correctly to the distractor task items. Under the verbal condition, the subject indicated with a Yes/No response whether the 3 letters in the box formed a real word when read from left to right. During nonverbal trials, the task was to determine whether the three letters formed a straight line. There was no difference in the physical appearance of the stimuli; only the instructions were manipulated.

Each of the 5 conditions was referred to as 1 cycle. A cycle, in turn, was composed of 6 blocks of 7 trials each. A single trial consisted of the presentation of the memory item followed by the number of distractor items specified and, finally, the recognition item. Subjects were allowed a brief rest period between each block and a longer break between each cycle. The time required for completion of each cycle varied according to the task parameters; in general, DT=0 was completed in 7 min, DT=3 in 15 min, and DT=9 in 25 min.

The memory item target was placed randomly within 1 of

3 segments. Order of target placement and recognition probe position within the segments was counterbalanced such that for each block of 7 trials, each segment and each displacement (2 spaces to the left and right) were represented twice. The target in the remaining trial was alternately placed within 1 of 3 segments for each of the 7 trials; in each case the probe was in the 0 displacement position (e.g. on target).

It should be noted that the design described above manipulated laterality in 3 ways: (1) by specifying the placement of the target and probe, not only in the center line segment, but in segments to the left and right of center as well; (2) by differential displacement of the probe to the left and right of the target position; and (3) through the use of a distractor task which presumably causes the activation of the left or right hemisphere based upon the instructions given the subject. In addition, individual differences in verbal ability, relevant to left hemisphere verbal activation, were also assessed. Of particular relevance were the vocabulary and block designs subtests of the Wechsler Adult Intelligence Scale-Revised (Wechsler,1981) and the letter and object naming subtests of the Rapid Automatized Naming Test of Denckla and Rudel (1976).

Data analysis. Raw data were converted to percent-of-correct responses for each subject under every condition. As for the first experiment, accuracy scores were calculated separately from bias scores. Accuracy in a given line segment was the mean of percent correct response to right-displaced and left-displaced probes. As before, bias was calculated for targets in the lateral segments using the procedure described in the Methods section of Experiment 1. The middle segment was not included in these analysis, since the results of the first study indicated that no performance bias occurred in that portion of the line.

In the Results section which follows, rightward bias (left minus right is positive) refers to the tendency to more accurately reject a left-displaced than right-displaced probe when the initial target was on the right side of the line. A negative bias value reflects a greater tendency to correctly reject right displaced probes, thus indicating a leftward performance bias within the right segment.

A leftward bias occurs when a probe displaced to the right is more accurately rejected in the left segment (right minus left is positive). Negative leftward scores indicate a rightward performance bias within the left segment (right displaced probes were more accurately rejected).

Results

Demographic and Psychometric Characteristics of the Subjects. Table 8 presents the demographic and key psychometric data for the three groups involved in this study.

Table 8. Means and Standard Deviations for Demographic and Psychometric Characteristics of Subjects

	Females (n=10)		NRD Males (n=10)		RD Males (n=10)	
	Mean	SD	Mean	SD	Mean	SD
Age	29.1	5.9	34.5	5.1	33.1	5.0
Education	16.4	1.3	16.7	1.6	13.1	2.6
RAN Letters (Time)	16.5	3.9	21.2	7.1	29.0	6.8
RAN Objects (Time)	32.2	7.2	35.2	3.8	46.4	8.0
Word Attack (Raw Score)	20.6	4.0	19.2	4.0	12.1	4.1
WRAT Reading (Standard Score)	101.2	12.2	104.1	6.9	77.1	7.1
WAIS-R Vocabulary (Scaled Score)	11.1	3.3	11.1	1.4	8.7	1.6
WAIS-R Block Design (Scaled Score)	10.0	3.0	12.3	1.4	10.2	2.7

The only tests reported are those relevant to the a priori hypothesis involving rapid naming of objects and general verbal and spatial ability as assessed by the Vocabulary and Block Design subtests of the WAIS-R. (Vocabulary and Block Design are the single best predictors of the Verbal and Performance IQ scores, respectively. Wechsler, 1981), Each table contains the data for the groups for whom comparisons across all measures would be made. As can be seen, the groups do not significantly differ in terms of age and the non-reading disabled (NRD) males and the females were very similar in their levels of education. However, the educational level of the dyslexic or reading disabled (RD) males was somewhat lower than that of the NRD males.

Group differences in performance on the tests administered were largely consistent with those reported in the literature. Females and NRD males performed quite similarly on most of the tasks administered with the exceptions of RAN Letters, which the females completed more quickly, and WAIS-R Block Design, on which males scored higher.

The RD males in Group 3 were significantly worse than the NRD males on all tests related to reading skills; their times for completion of the RAN tests was longer and they performed more poorly on a phonological decoding test (Word Attack) and on a test requiring the reading of individual words (WRAT Reading). The RD males also performed somewhat more poorly on the two WAIS-R subtests reported.

<u>Raw Accuracy of Performance by Group and Line Segment.</u> For purposes of comparison, values for the percent of correctly rejected displaced probes for all subjects under each condition are reported in Table 9.

Data analysis indicated that there was no overall significant difference between the verbal and nonverbal distractor task conditions ; therefore, these data were combined for many of the subsequent analyses. However, several significant interactions, described in some detail below, emerged between distractor type and certain aspects of performance on the experimental task. It is particularly

Table 9. Percent Correct Scores for Each Displacement in Right and Left Segments by Number of Distractors (ND) for Females (F), Non-reading Disabled Males (NRD), and Reading Disabled Males (RD)

		Left Segment				Right Segment			
		Left		Right		Left		Right	
Group	ND	M	SD	M	SD	M	SD	M	SD
F	0	40.0	33.4	53.3	29.1	66.5	26.1	21.7	15.7
	3	14.3	8.8	37.6	26.1	40.8	28.3	24.3	14.9
	9	18.4	17.4	32.5	23.0	49.9	28.0	27.6	22.6
NRD	0	78.3	27.2	81.6	24.2	78.3	32.4	64.9	39.6
	3	45.0	27.6	41.8	22.1	39.1	31.6	46.7	28.0
	9	34.2	35.2	30.1	26.3	35.0	28.7	40.9	33.8
RD	0	78.4	20.8	76.7	24.9	74.9	30.6	71.5	24.9
	3	51.6	29.1	45.9	31.4	43.5	30.6	52.6	25.8
	9	50.8	24.6	32.6	28.5	42.6	33.4	48.4	32.1

noteworthy that among females only, several of the cells show distinctly below chance performance on the experimental task.

Analysis of Bias--Main Effects. As in the previous experiment, the dependent variable of interest is

Table 10. Means and Standard Deviations for Leftward Bias Scores by Group and Number of Distractors

Number of Distractors	Females		NRD Males		RD Males	
	M	SD	M	SD	M	SD
0	+13.3	45.6	+3.3	33.9	-1.7	24.1
3	+23.3	26.8	-3.3	14.8	-5.8	15.7
9	+14.1	28.7	-4.2	30.6	-18.3	20.0

Table 11. Means and Standard Deviations for Rightward Bias Scores by Group and Number of Distractors

Number of Distractors	Females		NRD Males		RD Males	
	M	SD	M	SD	M	SD
0	+44.8	32.4	+13.4	42.2	+3.4	21.8
3	+16.6	26.3	-7.7	32.1	-9.1	20.1
9	+22.4	34.9	-5.9	36.2	-5.9	15.8

performance bias scores for each group under each of the conditions. Tables 10 and 11, present the leftward and rightward bias scores respectively for the groups.

To determine the presence of a systematic leftward or rightward performance bias, a Univariate T-test was performed on the bias scores across groups for each of the three task conditions (0, 3, and 9 distractor items between the memory and recognition items). The results are presented in Table 12.

Table 12 . Univariate T-test Probabilities Across Groups for Left and Right Bias Scores for Each Distractor Condition

Number of Distractors	Leftward Bias	Rightward Bias
0	+4.9 (35.0)	+20.5 (36.7)*
3	+9.5 (46.7)	-0.1 (56.6)
9	-5.5 (58.4)	+7.1 (64.6)

*p<.005

Consistent with the findings reported by Reuter-Lorenze and her colleagues (Reuter-Lorenze, et al., 1990), these results show a significant rightward bias (e.g. subjects were more likely to incorrectly accept a probe displaced to the right as being on target) when no distractors were presented between the target and probe items. When a memory component was added with the addition of distractor activity, the rightward performance bias disappears.

Analysis of Bias--Effects of Sequential Dependency. Single trial data were evaluated to assess the impact of context effects on the accuracy with which displaced probes were correctly rejected and to identify lateral biases. Thus, bias on trials in which stimuli were presented consecutively in the same segment (left or right) was examined to determine if probes that were displaced further from the center than the target were more often incorrectly identified as being in the target position when the preceding trial's target was in the same lateral segment. A direct comparison of these sequential effects suggested that subjects showed a trend toward greater bias when the preceding trial's target was in the same lateral segment as the present trial. Thus, in blocks of trials with no distractor intervals, and on trials where the preceding target was in the same line segment as the present target, the probability of a false positive response to right-displaced probes from rightward targets and to left-displaced probes from leftward targets was 0.44. When the preceding trial's target was in the opposite segment, the false positive probability was 0.34. (These results do not average to the total false positive probability, since first trials and other irrelevant sequences were omitted from this analysis.) These differences, while suggestive, were not significant.

Analysis of Bias-Correlation with Accuracy. Separate accuracy and bias scores having been calculated for the percent of correct responses in the left and right segments (Tables 9, 10, and 11), it was then possible to calculate the correlation of accuracy with bias in each condition. Remarkably, none of these correlations even approached significance. These correlations ranged in absolute size from .01 (between rightward bias at nine seconds and accuracy at nine seconds to rightward targets) to -.21 (between rightward bias at zero seconds and accuracy to rightward targets at zero seconds). The latter, strongest correlation only reached a probability level of .27.

Analysis of Bias-Interaction with Group and Distractor Interval. For reference, the verbal and visual distractor accuracy data are present in Table 13, with the bias data in Table 14. As indicated above, there were no significant effects of the type of the distractor task on accuracy in any cell of the design.

In order to determine group differences in the rightward bias effect, a General Linear Model (GLM) procedure was performed on the data. The results showed that the bias is initially predicted by group (F=4.24, p<.03). A Univariate T-test was performed to assess individual group differences in performance bias, and this indicated that females demonstrated significant rightward bias in the absence of

Table 13. Means and Standard Deviations for Accuracy Scores (Percent Correct) for Left and Right Segments by Distractor Type (DT) and Number of Distractors (ND)

		Left Segment		Right Segment	
		M	SD	M	SD
ND	DT				
0	--	68.1	25.0	63.0	27.0
3	Verbal	38.9	25.6	37.8	26.9
	Nonverbal	39.7	28.6	44.5	25.2
9	Verbal	33.9	24.3	40.1	29.3
	Nonverbal	32.3	26.0	41.4	24.6

Table 14. Means and Standard Deviations for Bias Scores for Left and Right Segments by Distractor Type (DT) and Number of Distractors (ND)

		Left Segment		Right Segment	
ND	DT	M	SD	M	SD
0	--	+4.9	34.9	+20.5	36.7
3	Verbal	+4.5	31.4	-5.6	31.0
	Nonverbal	+5.0	25.5	+5.5	36.6
9	Verbal	-6.7	37.5	+4.4	38.6
	Nonverbal	+1.1	31.5	+2.7	33.3

distractor activity (t=4.37, p<.002) and a leftward performance bias after the presentation of three distractor items (t=2.76, p<.02). After the presentation of nine distractor items, the RD males showed significantly negative leftward bias (t=-2.88, p<.02), that is they showed a significant rightward bias to leftward targets.

Of significance with regard to the performance biases under the distractor item conditions is their relationship to distractor type (verbal and nonverbal). Regardless of group membership, it was general verbal ability (as indicated by performance on the WAIS-R Vocabulary test), that predicted the difference in rightward bias between verbal and nonverbal distractor conditions (even though there was no statistically significant overall difference between verbal and nonverbal distractor conditions). Thus, the correlation between between WAIS Vocabulary and mean rightward bias at nine seconds was 0.30 (p > .10). However, The correlation between WAIS Vocabulary and rightward bias after nine seconds of <u>verbal</u> distraction was 0.34 (p=.06); and the correlation between WAIS vocabulary and the difference in rightward bias between nine seconds of verbal and nine seconds of nonverbal distraction was .41 (p=.025). In subjects with higher verbal ability, the differential in rightward bias (more bias for verbal distraction than for nonverbal distraction) was greater; in less verbally able subjects, the differential rightward biasing effect of verbal distraction was less. These effects emerge only after nine seconds of distractor activity and are noteworthy because of their consistency with predictions that were made on the basis of Kinsbourne's activation theory.

Analysis of Bias--Psychometric Explanation of the Group Effect. As planned, a psychometric explanation was sought for the group differences in bias. A General Linear Model procedure was performed to test the hypothesis that by controlling for certain cognitive abilities, the group differences in performance bias on the experimental task in this study would disappear. The results indicate that group differences are significantly diminished when performance on the WAIS-R Vocabulary and Block Design subtests are controlled (F=1.78, p<.19, for the effect of group on bias). Likewise, controlling for performance on tests of rapid naming, RAN Letters and Objects, reduced the effect of groups on the bias (F=2.09, p<.15). Thus, the present experiment provides no compelling evidence for group differences in bias when confounding individual differences in verbal ability are accounted for.

Of particular interest given the relationships described above between cognitive abilities and group differences in performance bias is table of Pearson correlations, in which the bias scores for each of the distractor task conditions were correlated with those four psychometric tasks. The results, which are summarized in Table 15, indicate that only the RAN Letters task is

Table 15. Pearson Correlation Coefficients Between Bias Scores for Each Distractor Task Condition and Selected Tests of Cognitive Abilities

Bias Score	WAIS-R Vocabulary	WAIS-R Block Design	RAN Letters	RAN Objects
Left 0	0.19	0.31	-0.29	-0.05
Right 0	0.34	0.003	-0.45**	-0.17
Left 3	0.45**	0.26	-0.18	-0.15
Right 3	0.26	-0.02	-0.24	-0.28
Left 9	0.36*	0.02	-0.35	-0.34
Right 9	0.30	0.05	-0.14	-0.15

**$p<.01$
*$p<.05$

significantly correlated (negatively) with the right bias; greater fluency in letter naming is associated with diminished rightward bias. There is a significant positive correlation between performance on the WAIS-R vocabulary test and left bias at 3 and 9 seconds of distractor activity. The positive correlation only approaches significance for right bias in the no distractor condition (p<.07). This pattern suggests that performance on RAN Letters may be a more refined test of the cognitive ability which is the source of the rightward performance bias. The nonsignificant correlation between RAN Objects and right bias suggests that rather than indicating a relationship between this bias and general fluency, the significant correlation with RAN Letters reflects a more specific verbal fluency.

Discussion

Rightward Bias at Immediate Recognition (Zero Distraction). The findings reported in this second experiment show that there is a rightward bias under conditions of no distraction. There is no significant leftward bias, and this differential effect in favor of rightward bias replicates previous findings (Kinsbourne, 1974; Reuter-Lorenze, et al., 1990). The present study adds to that series of findings mainly by showing that greater verbal ability is associated with greater rightward bias.

These findings are consistent with the activation-orientation hypothesis, and the correlations involving verbal ability tend to modify the theory by introducing individual differences in cognitive ability as a potential explanation for some of the variance in rightward bias. It appears that verbal ability as a general concept, as measured by vocabulary, is somewhat relevant particularly when controlled by nonverbal problem solving ability as represented by block designs. However, the greater effect of letter naming fluency, distinct from object naming fluency, suggests that the most relevant verbal ability is not vocabulary but well practiced, rapid access to language symbols. A "hard" version of the Kinsbourne activation theory would assume that all right handers should show the rightward activation, and that was clearly not the case. For the Kinsbourne theory to encompass these results, it would have to isolate the role of letter fluency or vocabulary as a particular activating factor, separate from other verbal factors.

Psychophysical scaling and adaptation level effects cannot be ruled out on the basis of the data for the zero distractor condition, but neither explanation addresses the asymmetry in the results (rightward bias is found, but no leftward bias). Confidence in an adaptation level effect would certainly have been increased had the sequential dependencies been significant, but their absence does not rule out such effects. In order to maintain a role for psychophysical scaling and for adaptation level theory, however, some additional influence must be assumed, and it would have to be one that diminishes leftward bias while enhancing rightward bias.

Decreasing Rightward Bias after Distraction. The Kinsbourne activation theory explains the pattern of greater rightward bias in terms of disproportionate left hemisphere arousal associated with a sustained verbal set. A verbal distractor task occurring between target and probe would be expected to cause that type of arousal. The resulting imbalance between the opposing hemispheric control systems would cause a shift in the direction of the attentional vectors as verbal distraction accumulates.

The results did not confirm a general increase in rightward bias with verbal distraction, but they did show that vocabulary predicted the differential between verbal and nonverbal distraction, so far as the impact of that distraction on rightward bias was concerned. This result also indicates that an unelaborated Kinsbourne activation model is disconfirmed, since it should have predicted an effect of verbal distraction on rightward bias. However, as in the non-distraction condition, the psychometric correlates continue to suggest the verbal ability does play a role. In this case, better vocabulary predicts a greater biasing effect of verbal distraction. In terms of the theory, the fact that this correlation was not found for rapid naming suggests a slightly different subset of verbal skill. It would be a skill that is included under the general factor measured by vocabulary, but not the particular type of fluency measured by rapid naming of letters. It would be a skill that makes an individual activate the left hemisphere to verbal distraction particularly, and might have more to do with lexical access to whole words (since that was the distractor task). In any case, the factors inducing the development of rightward bias during the distractor period are much weaker than those inducing it at zero distraction, and they have a slightly different psychometric profile.

In more general terms, the experiment suggests the fading or dissipation of rightward bias during the memory distraction period. The fact that the bias is uncorrelated with memory accuracy suggests that it is not tightly linked or stored with the positional information about the target that is stored in memory. That does not mean that the bias operates independently of memory; but it does suggest that the forces operating to preserve it in memory are somewhat different from those operating to preserve the positional information.

CHAPTER IV

GENERAL DISCUSSION

The results of these experiments clearly demonstrate that, more than any other factor, it is the rightward position of the target stimulus, which causes rightward bias. This bias was not strongly induced by either the verbal quality of the stimulus or by the verbal distractor activity, a finding which tends to disconfirm at least a strong version of Kinsbourne's orientation-activation hypothesis. Although there was a modest increase in response time, verbal stimuli (as used in Experiment 1) were not associated with rightward bias. Similarly, in Experiment 2, verbal distractor activity did not sustain the bias, as might have been expected, but resulted in diminished bias, either because of its role as interference between the encoding and recognition tasks or simply because it allowed time to pass during which the initially strong rightward bias could fade.

The most important moderators of the strength of the relationship between the rightward position of the target and rightward bias are gender and certain cognitive abilites. Of particular interest is the relationship between rightward bias and verbal abilities, which were found to be potent predictors of the strength of the bias. This fact also, while interpretable within the overall framework of the orientation-activation hypothesis of Kinsbourne, represents an extension of that theory into the domain of individual differences.

Of the alternative or supplementary explanations, adaption level theory best fits the data. The adaptation level effect is set up by the target, but it is triggered only at the time of recognition, when the probe is displaced in the same direction as the target was. Consequently, adaptation level effects should fade with increasing time between target and probe, and in Experiment 2 it appears that 3 seconds was enough time to diminish the biasing effect of the target. This decrease in biasing effect need not be correlated with the accuracy with which the target is recognized, and it was not correlated in Experiment 2. Thus, the distractor interval could operate in different ways on the positional and biasing information contained in the target. That would be consistent with an old finding in the short term memory literature showing that a distractor interval can differentially interfere with some features of the target and not others (Reitman, 1971; Schiffrin, 1973; Salthouse, 1974).

By contrast, both the psychophysical scaling and the orientation-activation explanations imply that the effects of rightward targets should be active at the time of encoding, and would therefore be expected to affect the actual perception and encoding of the stimulus. This expectation is inherent in the psychophysical scaling explanation; and it is implied in the orientation-activation model, since the orientation to the rightward stimulus occurs right at the point of intial encoding.

Of course, the adaptation level theory can not account for the asymmetry of the bias, nor can the role of verbal skills or a verbal set be explained within its context. A modified hemispheric activation model, stressing the role of individual differences, would do so. In turn, since it has been suggested that the association between verbal skills and rightward bias is the basis for the preponderance of left neglect among individuals with parietal lobe lesions (Kinsbourne, 1987), then the present experiments offers a validation opportunity with lesioned patients. Lesions of the right parietal lobe presumably result in an activation imbalance in which corresponding areas of the verbal, left hemisphere become disinhibited. The results of this lesion-induced release from inhibition are intensified by normal verbal activity. Under these conditions, the vector along which attention is distributed is chronically biased to the right, resulting in the strong tendency of these individuals to neglect or fail to respond to the left side of visual input. The parallels between this population with a lesion-induced rightward bias and the normal population with a stimulus-induced bias suggests that it should be possible to demonstrate a positive correlation between the verbal skills of the neglect population and the strength of left neglect.

An experiment could also be designed to confirm the role of adaptation level on rightward bias. If the horizontal rightward bias described in Experiment 2 is produced by adaptation level effects, then a similar pattern of bias should be found when a vertical line with a target is used as the bias-inducing stimulus. Such a finding would weaken the activation-orientation hypothesis explanation of the effects documented in these studies, since it has no basis for predicting biases in the vertical dimension. Finally, if such biases were found, and if they correlated with verbal ability, it would tend to dissociate the effects of verbal ability from rightward bias. The proposed experiment is not made implausible by the failure to find leftward bias, moreover, since the absence of leftward bias in Experiment 2 could itself have been due to a unilateral rightward bias.

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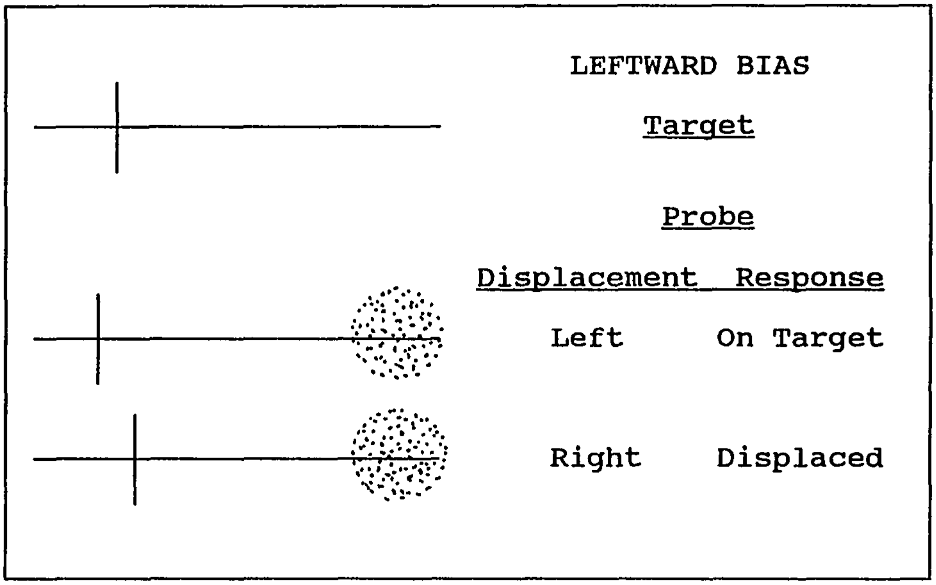
APPENDIX A

FIGURES 1-3

Figure 1. Diagram demonstrating the perceptual distortion that results from either a leftward or rightward attentional shift. This shift causes the subject to underestimate the contralateral end of the line and, thus, to misjudge probe placement.


LEFTWARD BIAS
Target
Probe
Displacement
Response
Left
On Target
Right
Displaced

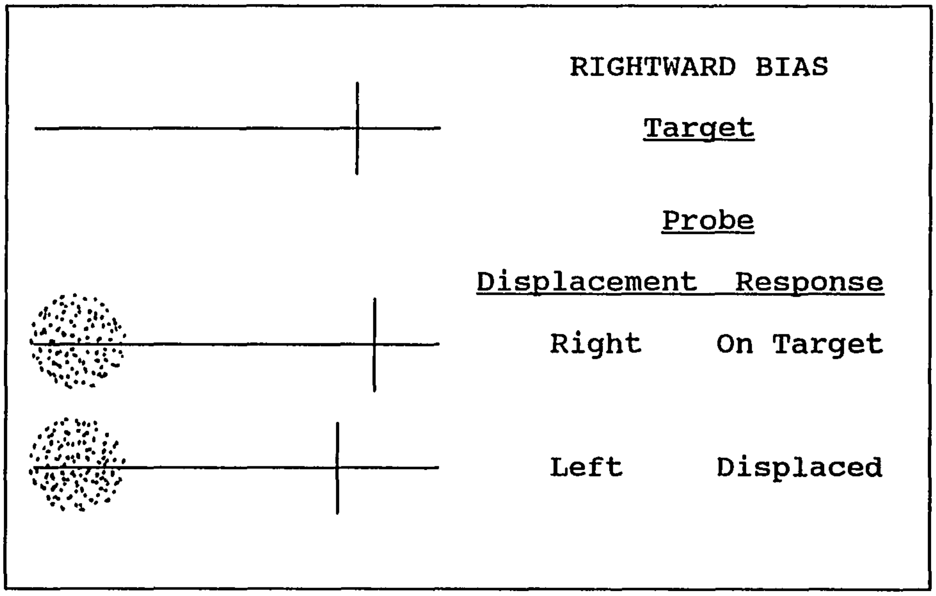
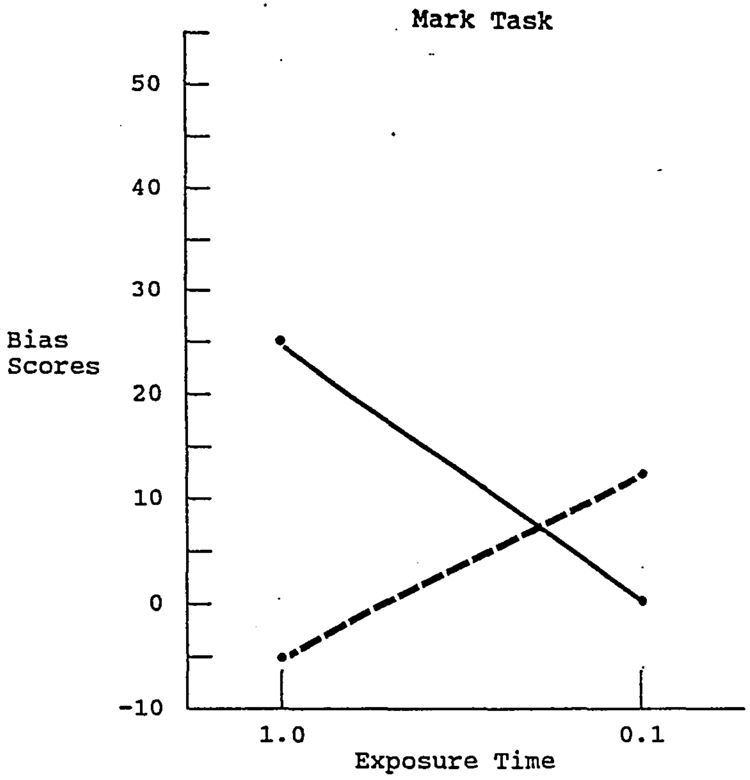
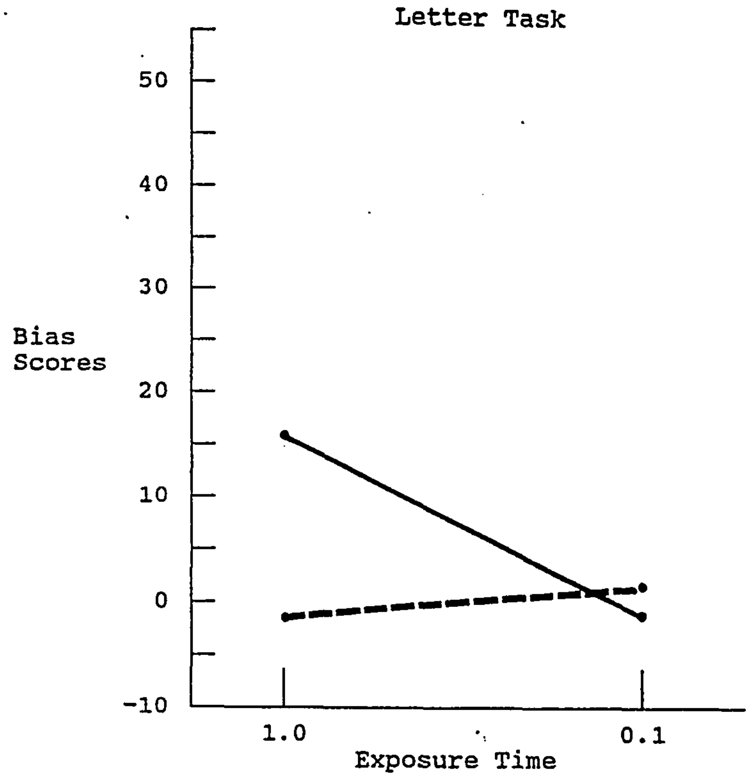
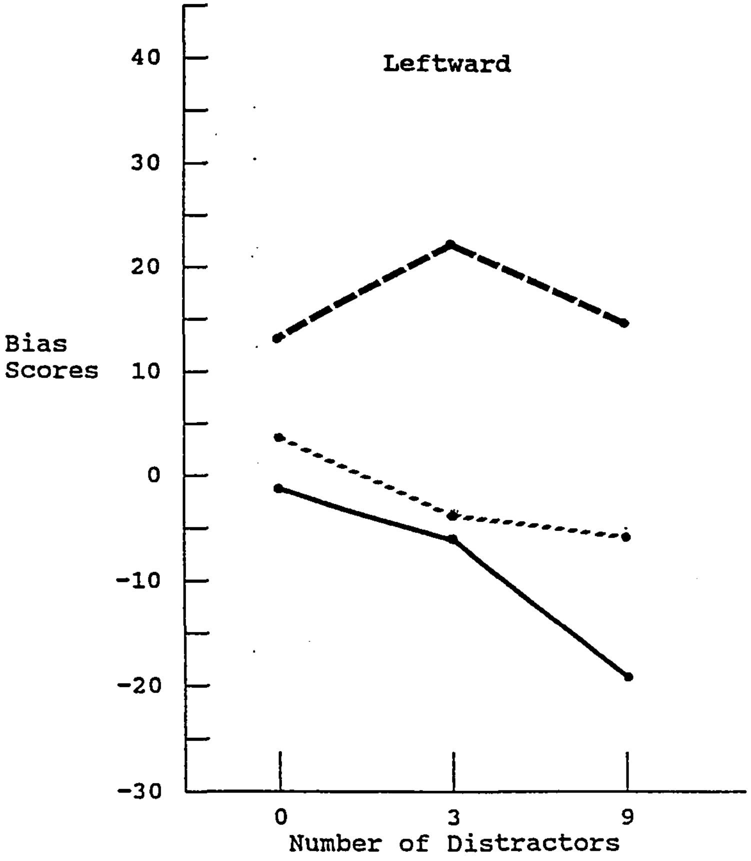

RIGHTWARD BIAS
Target
Probe
Displacement
Response
Right
On Target
Left
Displaced

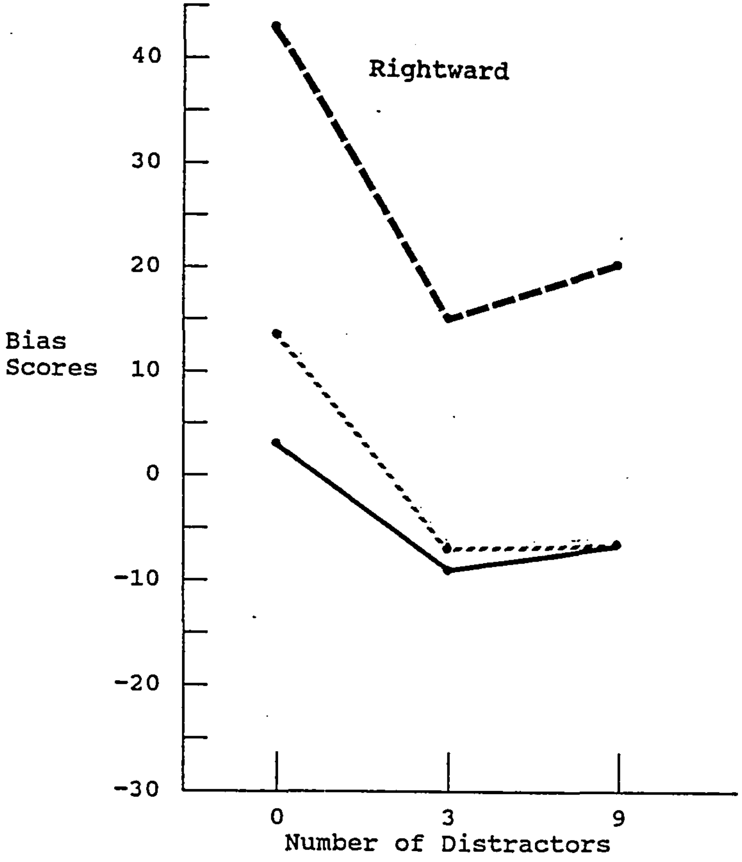
Figure 2. Bias scores by gender and exposure time for the Mark and Letter tasks (Females-hached line; Males-solid line).


Mark Task
50
40
30
20
10
0
-10
Bias Scores
1.0
0.1
Exposure Time


Letter Task
50
40
30
20
10
0
-10
Bias Scores
1.0
0.1
Exposure Time

<u>Figure 5.</u> Bias scores for Females (dashed line), NRD Males (hatched line) and RD Males (solid line) for each distractor condition.


Leftward
Bias Scores
40
30
20
10
0
-10
-20
-30
0
3
9
Number of Distractors


Rightward
Bias Scores
40
30
20
10
0
-10
-20
-30
0
3
9
Number of Distractors

APPENDIX B

DISTRACTOR TASK ITEMS

Distractor Task Items

Real Words		Nonsense Words	
APT	BOG	TPA	OGB
DEW	MOW	EWD	WOM
ERA	SUM	AER	UMS
HUT	BET	UTH	TEB
MAR	HOP	MRA	OPH
LAG	WAX	ALG	AWX
PRY	FOG	YRP	OFG
TIN	RUT	INT	UTR
SLY	SKI	YSL	KIS
VAN	JAR	ANV	ARJ
PLY	RIP	YPL	PIR
WED	DOE	EDW	DEO
ADO	KIT	DOA	ITK
ARK	EEL	RAK	ELE
VAT	AFT	TAV	TAF
COB	GAG	BOC	AGG
DIN	SEW	IND	WES
ROW	HAP	WRO	PAH
ORE	JAM	REO	AMJ
URN	POD	NUR	DOP

Note. Words chosen from The Teacher's Word Book by Edward L. Thorndike, 1927.