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THE EFFECTS OF ATTENTIONAL BIAS AND SUBJECTS' STRATEGIES: A PURE VERSUS MIXED PRESENTATION COMPARISON

by

Conrad Bowden

B.A., Antioch University, 1978

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ABSTRACT

Attentional bias theory was tested by presenting two perceptual tasks of known and opposite asymmetry, in both a pure and in a mixed fashion. Forty right handed males, with no known sinistrality in their immediate family, participated in a reaction time experiment which involved naming either a shown color or the angle at which a line was orientated. Subject strategies were explored by assigning subjects to groups on the basis of the cognitive strategy they reported employing for the line orientation task.

Data analysis revealed no significant hemispheric differences with either stimulus type. This result is surprising, since the color naming task is postulated to be the best non alpha-numeric left lateralized stimulus available. Further, no significant changes in asymmetry were noted for either stimulus in a pure versus mixed presentation comparison. The initial lack of asymmetries precluded comment on attentional bias theory based upon an absence of change in perceptual asymmetries. Inclusion of strategy groups into the analysis revealed significant differences between groups in response time but not in pattern of hemispheric asymmetries. The comparative strategy group reported significantly longer response times than did the recognition strategy group on the line task. Finally, a "within subjects" data analysis was made impossible by order

effects. It is recommended that only "between group" designs be used in future pure versus mixed presentation comparisons. In the between group analysis colors presented first produced faster response times on both lines and colors. This result may be due to an increase in confidence due to different task difficulty.

Discussion focuses upon competing explanations of the results with emphasis upon attentional bias and subject strategy effects. The lack of hemispheric differences and presence of order effects are seen as indicative of the fragility of perceptual asymmetry effects.

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I. Introduction

Significant differences in function and capability have been demonstrated between the cerebral hemispheres (Springer & Deutsch, 1981; Segalowitz, 1983.) For most people, the left side of the brain has a sequential and analytic cognitive style that makes it efficient at processing verbal information. The right side of the brain has a global and synthetic style that makes it efficient at visual-spatial tasks. The bicameral nature of the brain has been known since Broca's and Jackson's work in the nineteeth century. Extensive study of the properties of the separate halves of the brain has been carried out primarily over the last twenty years.

Recent laterality research has primarily demonstrated perceptual asymmetries for various cognitive tasks. These tasks are usually classed as verbal or visual-spatial in nature. For example, a left hemisphere advantage has been found for the recognition of consonant-vowel pairs (cv) (cf. Kimura, 1960), while a right hemisphere advantage has been found for the localization of a dot in space. It should be noted that it is the spatial qualities of the task and the ease with which the task is labelled which determines which hemisphere will have the processing advantage. For example, letters drawn elaborately can be construed as a pattern recognition task (Bryden, 1978), while a line recognition task involving easily labelled horizontal and vertical lines can be construed as a labelling task (Unilta, Rizzolatti, Marzi, Zamboni, Franzini, Camarda, & Berlucchi; 1974). Because a great deal is known about the processing of cognitive-perceptual tasks it is now possible to select tasks of a known functional asymmetry.

A functional asymmetry exists when, for most people, one hemisphere performs "better" (i.e., faster or more accurately) than the other hemisphere at a particular task. In spite of many studies demonstrating such performance asymmetries our knowledge of their relationship to the brain's organization remains relatively limited. One theory of the relationship between perceptual asymmetries and the brain's organization is that a perceptual asymmetry directly informs us about the location of the involved processing unit. That is, a left hemisphere (LH) advantage on a particular task tells us that the majority of processing for that task is carried out by the left hemisphere. However, alternate explanations for many of these perceptual asymmetries exist. For example, it may be that individual subjects' strategies could determine the observed asymmetries (Bryden, 1963). For instance, Gazzaniga (1978) found that instructing subjects to use either a verbal or a visual strategy for deciding whether a unilaterally presented probe was part of a memorized set influenced the observed asymmetries. Alternately, it could be that perceptual asymmetries reflect an attentional bias, as theorized by Kinsbourne(1970, 1973). In brief, Kinsbourne proposed that the activation of a particular processor would differentially activate the contra-lateral sensory fields predisposing them to perceive subsequent stimuli more efficiently. (e.g., activating the verbal processor in the left hemisphere would increase attention to the right visual field). Because of the existence of these competing explanations, one cannot conclude that demonstrated asymmetries reflect cortical organization.

Better understanding of cortical organization can be achieved by controlling for subjects' strategy effects and attentional bias. One such approach would be to study the interrelationships of performance on more than one asymmetrical task. To date most experiments in laterality research have investigated functional asymmetries on only one task per subject group. Some experiments have investigated performance on two or more asymmetrical tasks, but usually with the tasks presented seperately as pure blocks of experimental trials. However, presenting pure blocks of trials does not rule out either strategy effects or attentional bias as explanations for any observed asymmetries. It is conceivable that a subject changes cognitive strategy or bias for each different block of stimuli. A few studies have controlled for these effects by randomizing the order of presentation of the stimuli. Randomization made it impossible for subjects to predict the type of subsequent stimuli and develop a systematic bias or strategy. The present experiment adopted a similar randomized strategy.

The present experiment was undertaken with the following goals in mind. First, the experiment would provide information about the individual asymmetries of the perceptual tasks. Reliable right hemisphere cognitive tasks have been notoriously hard to find and some promising studies have proved less useful than anticipated because no right hemisphere asymmetry was achieved with the task in question (cf. Hellige, 1978). Second, the experiment would provide information about attentional bias and subject strategy effects. Third, the experiment would provide information about the relation of one asymmetry to another and inferentially about cortical organization.

The background to the issues and experimental purposes raised above is considered in the following sections. The first looks at attentional bias theory and the evidence for and against it. The second looks at subject strategy effects. Following these sections the hypotheses are presented.

Attentional Bias Theory

One of the most important advances in laterality research was the application of the dichotic listening technique to the study of hemispheric specialization (Kimura, 1960). From results obtained using this technique arose an alternate explanation for the perceptual asymmetries which had been obtained with visual presentations since the early 1950's. Previously it had been proposed that the left hemisphere advantage for the perception and identification of language was due to the fact we read from left to right. This proposition was known as the directional scanning theory. When, however, Kimura (1960) found a right ear advantage for auditorally presented verbal material the directional scanning theory proved inadequate to explain the results. Consequently, she proposed what came to be known as the structural theory of perceptual asymmetries, which states that the observed asymmetries were present because of a more direct linkage of the right ear to the verbal processor in the left hemisphere. When music and later emotional tone were discovered to be more readily comprehended through the left ear, the structural theory was also found explanatory (i.e., the left ear is more directly connected anatomically with the right hemisphere). Thus, when Kinsbourne (1970) proposed the attentional bias theory it was commonly held that perceptual asymmetries were due to a lateralized processor which had the most direct links with the contralateral sensory systems.

While accepting the localization of specific functional abilities, Kinsbourne argued against the belief that asymmetries were due to a more direct anatomical link. His refutation of the structural theory was based on the fact that the additional time for stimuli to be rerouted through the other hemisphere was only a few microseconds and hence could not account for the much longer asymmetrical delays. According to attentional bias theory, stimulation of a particular part of a hemisphere produces a more general activation that spreads within that hemisphere, and at the same time results in an inhibition of the contralateral hemisphere. The general activation within a hemisphere has various manifestations. One consequence of such activity is that an orientating response, such as turning the head, occurs contralateral to an activated hemisphere. Thus, verbal thought (a left hemisphere process) results in a spontaneous movement of the head towards the right. Another result of a general hemispheric activation is that saccadic eye movements proceed contralateral to the activated hemisphere.

The most important prediction from Kinsbourne's theory is that the visual field or ear opposite to the activated hemisphere would be differentially sensitive to incoming stimuli. Thus stimuli presented to the right visual field or right ear during or just after verbal processing would be better perceived because that visual field or ear would be more activated than the other. Similarly, material presented to the left visual field or left ear would be better received during or just after right hemisphere activation. Thus, regardless of the type of stimuli being presented, a visual field advantage is obtained by the differentially activated hemisphere.

One consequence of attentional bias theory is, that if stimuli are presented in pure blocks of trials, an asymmetry is obtained not because of a structurally "shorter" distance travelled to the processor, but because the processor differentially prepares the contralateral sensory systems. Thus, presenting stimuli in blocks perpetuates an advantage for one visual field over the other.

Kinsbourne's theory then, differs considerably from Kimura's, principally in its emphasis that perceptual asymmetries are a product of brain function rather than structure. Two major implications of structural theory are inconsistent with attentional bias theory. The first of these is that the direction of the visual field (VF) difference indicates which hemisphere is specialized for that task stimuli. The second major implication is that the magnitude of the VF difference is significant and reflects the degree to which a hemisphere is specialized. Because the implications of Kinsbourne's and Kimura's theory are so different and provide for such differing interpretations of existing data, the degree to which either is correct is of considerable interest.

Kinsbourne's original formulation of attentional bias theory in 1970, was accompanied by a series of experiments based on a concurrent memory load paradigm. This strategy requires subjects to memorize a series of words; it is assumed that such verbal memory activates the left hemisphere. Kinsbourne tachistoscopically presented small squares, such that one side was always centered on a central fixation point. On one-half of the experimental presentations a gap would be present, with the location appearing equally often on each side of the square. On each trial subjects were required to say whether or not a gap was present. Two conditions of the experiment were run: one with a memory load, one without. The results of the no memory load condition showed no VF advantage in accuracy at gap detection. The results in the memory load condition showed a RVF advantage, supporting the proposition that the verbal task activated the left hemisphere and and created a bias towards the RVF.

Subsequent replications of Kinsbourne's memory load experiment have been equivocal. The results obtained seem to depend at least partly on the degree to which the experimental task was previously lateralized. Results were generally favorable when the task was neutral (cf. Spellacy & Blumstein, 1970) and contrary when a more clearly lateralized task was used (cf. Rosen, 1973), suggesting that an asymmetry due to attentional bias is less powerful than an asymmetry due to a lateralized processor.

In other replications, results within an experiment were equivocal. For example, Hellige and Cox (1976), found increased performance on a spatial task while holding nouns in memory but better performance in both VF's when the task was verbal. Further, some attempts to directly replicate Kinsbourne's procedure were not successful (Boles,1977).

The size and direction of an attentional bias effect was also found to be influenced by the amount and type of memory load. Hellige, Cox, & Litvac (1979) conducted a series of experiments to explore the effects of different memory loads. They found no effect due to a concurrent visual-spatial load and variable effects with different verbal loads. Of two, four, and six noun memory loads, the six noun load produced the results most consistent with attentional bias theory. Hellige et al. concluded that memory load was a complex factor, the effects of which could not be delineated simply. Other researchers have concluded that concurrent memory was, perhaps, not the best way to test attentional bias theory (Allard & Bryden, 1978). One reason for this assertion may be that the task demands are so different in the load versus no-load conditions.

Priming the hemispheres by using fixation points characterized as verbal or spatial is another strategy used to test attentional bias theory. Differential priming is accomplished by requiring a report of the fixation point before a response to the perceptual task. For example, a change of fixation type resulted in a change in the asymmetry for preceiving two digit numbers (Kershner, Thomae, Callaway,1977). The task before manipulation had a right visual field advantage, yet, with a shape identification as a fixation task the visual field advantage reversed.

Researchers attempting to test Kinsbourne's theory have also used mixed and mixed versus pure presentations of cognitive-peceptual stimuli. In a pure presentation only one stimulus type is shown in a block of experimental trials, while in a mixed presentation two or more stimulus types are shown interspersed in each block of trials. The mixed versus pure presentation comparison is a technique which holds promise for laterality research as a whole. Mixed versus pure presentations provide more information than mixed presentations alone, since they allow a comparison between the results of two methods of presentation.

However, mixed versus pure presentations have not been undertaken as often as mixed presentations alone. One reason for only using a mixed presentation is because of the additional time necessary to run the comparison set of stimuli. Another reason is the manner in which Kinsbourne originally stated his attentional bias hypothesis. At the time, he emphasized that in a mixed list presentation only one visual field advantage would be present, since only one hemisphere would be dominant (the other hemisphere being inhibited), or else no dominace would emerge. Therefore, much of the subsequent research using mixed presentations, focused only on demonstrating that two asymmetries could be simultaneously obtained. Thus Day (1977), Kallman (1977), and Haun (1978) all demonstrated dual asymmetries, dissociating verbal and visual-spatial effects within a mixed presentation.

It is important to note however, that in no case did Day (1977), Kallman (1977) or Haun (1978) use pure trials as well as mixed trials. Therefore, no comparisons were possible between the size of the asymmetries in the mixed trials and the size of the asymmetries in the pure trials. The studies by Day (1977), Kallman (1977), and Haun (1978) effectively challenged Kinsbourne's strawman hypothesis that all perceptual asymmetries are caused by attentional bias. They did not rule out the possibility that attentional bias may contribute, at least partially, to an observed asymmetry.

One study using both mixed and pure trials found a left visual field advantage for the recognition of forms with pure presentation and a right visual field advantage for the same task with a mixed presentation (Hellige, 1978). Thus Hellige's experiment supports attentional bias theory by reporting a change in asymmetry with a change from pure to mixed list presentation. It should be noted that upon examination of the results of the mixed trials only, no dissociation of verbal and visual effects can be seen. No right hemisphere asymmetry with the visual-spatial stimuli exists with the mixed list presentation.

Researchers in general have often had difficulty in achieving consistent visual-spatial asymmetries. Therefore, it is possible other researchers using only mixed lists also failed to dissociate verbal and visual-spatial asymmetries and decided they had failed to use a sufficiently lateralized stimulus. Had they also used a pure presentation they might have found that they were recording a change in the direction of asymmetry predicted by attentional bias theory.

In summary, concurrent memory load, priming and mixed presentations have all been used to investigate attentional bias theory. The demonstration of opposing asymmetries in mixed presentations has disproven Kinsbourne's strawman hypothesis that attentional bias is the only factor contributing to perceptual asymmetries. On the other hand, with non-lateralized stimuli and with some types of memory load, attentional bias is a valuable explanatory theory.

The results of studies using mixed presentations have challenged Kinsbourne's theory, although the only study to have used both pure and mixed presntations did find evidence of a directional shift in keeping with Kinsboune's predictions. Therefore, it is possible that directional shifts occurring in the other experiments using mixed presentations were undetected owing to the lack of a pure presentation comparison.

Many attempts are now underway to relate perceptual asymmetries to secondary variables such as degree of pathology or cognitive ability, as well as to brain organization itself. Therefore, it is important to know to what extent attentional bias influences the measurement of perceptual asymmetries. To partly answer this question the present experiment sought to detect any shift in asymmetries from a pure to a mixed presentation. This research is consistent with a model of brain processes which considers an explanation based on a combination of structural and functional factors to be more accurate than either alone.

Subject Strategy Effects

Subjects employ "strategies" to solve perceptual tasks. Such strategies affect perceptual asymmetries. A strategy can be defined as any non-universal aspect of cognitive-perceptual processing. This definition includes both physiologically based, hence consciously uncontrollable differences in approach as well as consciously manipulable mind sets. The above definition may be controversial, as some psychologists may prefer to reserve the term subject strategy only for consciously manipulable task approaches. The more general definition used here reflects the difficulty in distinguishing between physiologically and consciously ordained strategies.

In considering subject strategies one can begin with extensions of the surmised cognitive style of each hemisphere. Thus there is a basic duality of strategies. One being holistic, simultaneous, global and visual-spatial; the other being analytical, linear, piecemeal and verbal. Other characterizations of the left and right hemispheres have also been suggested. Kinsbourne (1983) recently suggested that the left hemisphere was specialized for approach and the right hemisphere specialized for avoidance. Kosslyn (note 2) suggested the left hemisphere identified parts while the right hemisphere located the parts on a spatial map relative to one another. Day (1977, 1979) has extended Pavio's work on high and low imagery memory to a laterality paradigm (Pavio, 1968). Others have extrapolated from a duality of information processing styles to a duality of behaviors, beliefs, and even types of consciousness (Bogan, 1969; Ornstein, 1972). Consider, for example, the concept of hemisphericity.

Hemisphericity is defined as the tendency to rely predictably and predominantly on the processes of one-half of the brain (Bogan, 1969; Bakan, 1969). Prototypical thinking styles or strategies corresponding to a right brain, left brain, or balanced brain are hypothesized. Evidence of hemisphericity has been sought at the cultural, professional and individual levels. Thus western culture is hypothesized to be predominantly left brain, while the Hopi Indian and Turkese (Polynesian) cultures are hypothesized to be predominantly right brain. Western culture is often described as highly verbal and analytical while the Hopi and Turkese cultures are highly spatial. In a professional and educational context, engineers and science majors are hypothesized to be more left hemisphere, while literature and humanities majors are hypothesized to be more right hemsiphere. And, on an individual level, some individuals are presumed to use a right hemisphere thinking style or strategy, while others use a left hemisphere thinking style or strategy. It should be noted that the concept of hemisphericity, at all its levels, is controversial and perhaps represents simply the metaphoric extension of functional hemispheric differences.

Traditional conceptions of individual diffences have also been related to specific patterns of hemispheric activation or utilization. Flor-Henry (1978), Gruzelier (1981), and others have proposed relationships between the major psychoses and laterality. One such theory argues that schizophenia is associated with an overactivated left hemisphere, while mania is associated with an overactivated right hemisphere. Related research by Johnson & Crockett (1982) explored the change in cognitive performance associated with an improvement in psychiatric illness. Several personality variables have also been related to laterality. Obsessivness was associated with the left hemisphere and hysteria with the right hemisphere by Smokler and Shevrin (1979) while field dependence / independence has been associated with right and left hemispheres respectively (Carlton, note 1). In addition both chronic and acute anxiety have been associated with a rise in the level of activation of the left hemisphere (Tucker, 1981; Tyler & Tucker, 1982).

Thus a large number of variables (e.g., anxiety) are hypothesized to be associated with some particular pattern of hemispheric activation (e.g., differential right-left alpha ratios). Yet, in general, postulated relationships between a grouping variable and a measure of brain organization remain questionable with no consistent pattern of results emerging. Subjects selected on the basis of any of these variables are assumed to result in groups differing on their approach (strategy) and hence performance on cognitive-perceptual tasks. For instance, the relationship between field dependence and laterality is the most researched of all the personality dimensions. A recent review of all of the available evidence finds that no systematic relationship can be discerned; although, several individual studies report significant and contradictory results (Carlton, note 1).

The relationships between many of these subject strategy variables (such as field dependence) and brain organization are questionable. Likewise, the nature of the relationships between subjects' strategies and perceptual asymmetries is unknown. However, there have been some perceptual asymmetry experiments that have also directly investigated subject strategies.

Hellige (1978) sums up half a dozen such studies by noting that groups of subjects who were more efficient at some aspect of verbal processing showed either no visual field effects or a reversal of the expected RVF advantage for verbal material and LVF advantage for visual-spatial material. The group of subjects weaker on some verbal processing criteria showed the prototypical pattern of results. Hellige's summary provides evidence for the assertion that cognitive-perceptual asymmetries vary according to the strategy used. That is increased verbal ability and an inferred increase use of verbal strategies, resulted in different perceptual asymmetries than those shown by subjects less likely to be using verbal strategies.

The subject strategies considered above have been identified according to behavioral criteria. That is, a particular strategy is associated with a particular set of behaviors. For example, prototypical asymmetries are associated with lower verbal ability. By and large these behavioral markers are assumed to be products, that is, a result of the individual's brain functioning. However, relationships between hemispheric asymmetries and the level of process can also be explored. In contrast to the products of a brain's functioning the process of a brain's functioning is immediate and directly related to an ongoing task. As an illustration of the difference between process and product, consider the behavioral manifestations of an obsessive personality and the thinking style of that personality as delineated by Shapiro (1975). Thus different hemispheric asymmetries may manifest themselves not only through behavioral markers, but through the type of cognitive process which is reported. However to date, little evidence has been gathered of an individual's conscious processes as they relate to hemispheric asymmetries.

Thus, it may be instructive at this point to consider the manifestation of subject strategies at a process level.

Subject strategy effects can generally be divided into volitional and nonvolitional types. Nonvolitional effects are those in which a hemisphere is differentially activated through an intentional or unintentional act not deliberatly designed to influence the experimental outcome. For example, if anxiety affects asymmetries, it follows that a person having undue performance expectations, is likely to become anxious in an experimental situation, which will influence the observed asymmetries.

Volitional strategy affects are those in which a more or less conscious orientation directly effects how the stimulus is processed. Thus a subject might decide to look at an isolated facial detail on a face recognition task rather than at the entire gestalt. The following example illustrates both volitional and nonvolitional effects for the same task. For a line orientation naming task a nonvolitional effect would occur if the subject mentally rehearsed the names of the lines to be reported. A volitional effect for the same task would result from deciding whether to compare the shown line with a memorized line or with a grid constructed with a mental protractor.

A few studies have experimentally manipulated volitional strategy effects with mixed results. One study that did so investigated whether subjects can consciously adopt alternate strategies. Subjects were instructed to use either an imagery or a verbal strategy for deciding whether a unilateraly presented probe was part of a previously memorized set (Gazzaniga, 1978). Cognitive set influenced the observed asymmetry. For example, when subjects were instructed to use a visual strategy a left visual field advantage was found, while those instructed to use a verbal strategy showed a right visual field advantage. These results indicate subjects were freely able to adopt either a visual or a verbal strategy as instructed. In contrast, Bryden (1983), demonstrated that subjects also might not be able to deploy strategies they are instructed to use. He used sentences such as, "The circle is to the right of the square and below the triangle" as well as visual representations of the same relationships. Bryden reports that regardless of the instructions given, and the manner in which the stimuli were presented, subjects changed the task to make it visual or verbal as they preferred. Individual preference for a strategy overrode the instructions they were given. Perhaps the greater difficulty of Bryden's task was a factor in the different outcomes of the two experiments. His task demanded that relationships rather than simple identities be maintained in memory. The greater difficulty may have increased subjects' needs to use a characteristic way of dealing with information. Interestingly, in both experiments conscious strategies were associated with the differing visual field advantages.

Other researchers have postulated that different visual field advantages may depend upon the ease with which a stimulus may be verbally labelled. For instance, a line orientation task using horizontal and vertical lines yielded a RVF effect, while a similiar task using lines of 15 to 60 degrees produced a LVF effect (Umilta et al., 1974). Presumably the horizontal and vertical lines are much easier to label and hence more readily processed by the left hemisphere. As in the studies by Bryden and Gazzaniga mentioned above, it is possible that in the line orientation experiments different conscious strategies were operational and corresponded to particular hemispheric advantages. Different VF advantages are generally accepted as having different processing styles associated with them. Different VF advantages on a task may also be associated with quite different consciously accessible strategies.

Although few studies have investigated subject strategy effects directly and fewer have investigated subjects' reports of their strategies, several researchers have suggested that subjects' strategies may explain ubiquitous hemispheric patterns. For example, sex differences in asymmetrical tasks are often observed. In this regard, Kimura (1969) proposed women might approach a dot localization task as a verbal rather than a visual-spatial task. Her view has been accepted by others as an explanation of why LVF advantages for visual-spatial tasks are often not found with women (cf. Bryden, 1983). Thus, although little is known about subjects' strategies, they are advanced as major explanations of perceptual asymmetry results.

The relationship between consciously held subjects' strategies, perceptual asymmetries and brain organization remains unclear. Two possibilites exist: either strategies can be chosen irrespective of the brain's cortical organization or strategies are dictated by a particular brain organization.

Taken to an extreme, the question is whether consciously held strategies are physiologically determined (i.e., through anatomically located processing units) or are consciously alterable. Subject strategies becomes another behavior about which the question can be asked, "Can it be self-controlled, or is it biologically determined?".

The first step in ascertaining the relationship between strategies, organization and asymmetries is to try and identify the strategies associated with different asymmetries. One obvious way to do this is to ask the subjects how they have approached a particular perceptual task. Patterns of response can be used to predict trends in the perceptual asymmetry data. Although this method of approach is straightforward, few studies have directly asked subjects how they carried out a particular asymmetrical task. The disuse of subject self-reports may be a carry over from the early 20th century backlash against introspection, although subjects' self reports form the basis of most computer analog programs developed in the field of artificial intelligence (cf. Ericsson & Simon; 1978, 1979).

Another way to study subjects' strategy effects is to manipulate the type of stimulus presentation, for example, switching from pure to mixed. Pure presentation consists of blocks of similiar stimuli, while mixed presentation intersperses two or more different stimulus types. In changing from a pure to a mixed presentation, either individuals' strategies will remain the same or the different task demands will invoke new strategies. In a pure presentation, approaches can be developed based on the expectancy of which stimulus will appear. In a mixed presentation this is not possible.

The results of the pilot study for the present experiment suggested that subjects approached the line task in one of two ways. Subject strategies were obtained through post-experiment interviews. Initial attempts to relate the trends in the data to the reported strategies were encouraging. Therefore, a post experiment interview to obtain subjects' strategies was incorporated into the experimental design. Subjects' data was assigned to groups on the basis of their reported strategies.

In summary, the area of subject strategy effects is ill defined. Most concepts of subject strategies begin as extensions of the information processing styles commonly associated with each hemisphere. Many behavioral styles are related to measures of hemispheric asymmetry. Yet, the evidence for most of these variables is weak. Few perceptual asymmetry studies have examined the relationship between subjects' reports of consciously accessible processes and performance on asymmetrical tasks. The present study did so by incorporating groups based on similar subject strategies into the data analyses.

II. Hypotheses

In the above it has been argued that both attentional bias and subject strategy effcts influence the measurement of perceptual asymmetries. The present experiment used a pure versus mixed presentation comparison to detect any contribution to an asymmetry due to attentional bias. As well, a post experiment interview based on a pilot study provided information about subject strategies. Each subject was assigned, before data analysis, to a strategy group on the basis of their responses.

Four groups were formed: a comparative strategy group, a recognition strategy group, a comparative change group and a recognition change group. The comparative strategy group reported consistantly using comparisons to determine the orientation of the line stimuli, while the recognition strategy group reported that they consistantly "just knew" or recognized the angle of orientation. The comparative change group reported using a comparative strategy for the pure presentation and a recognition strategy for the mixed presentation. Conversely, the recognition change group reported using a recognition strategy for the pure presentation of the line stimuli and a comparative strategy for the mixed presentation.

Specific hypotheses were as follows:

Subject Strategy Hypotheses

1. The comparative strategy group and comparative change group would show a right hemisphere (RH) advantage on the pure presentation of the line task.

2. The recognition strategy group and recognition change group would show a left hemisphere (LH) advantage on the pure presentation of the line task.

3. The comparative strategy group and the recognition strategy group would show a RH advantage on the mixed presentation of the line task.

4. The recognition strategy group and the comparative change group would show a LH advantage on the mixed presentation of the line task.

Attentional Bias Hypotheses

Kinsbourne (1970) predicts that a change from pure to mixed presentation results in either one asymmetry predominating while the other weakens or else that both weaken. Hellige (1978) suggests that the more difficult cognitive-perceptual task produces the predominant asymmetry. Since subjects take longer to respond to the line orientation task, it would seem to be the more difficult of the two tasks used in the experiment. Therefore, the asymmetry for the color task for each group in this experiment should shift to be more similiar to the asymmetry for the line task.

5. In the pure condition all groups would show a LH advantage on the color task.

6. In the mixed condition the comparative strategy group and the recognition change group would show a shift toward a RH advantage for the color task.

7. In the mixed condition the recognition strategy group and comparative change group would maintain or increase a LH advantage for the color task.

III. Method

Subjects

The subjects were forty males, primarily Simon Fraser University undergraduates. All subjects were right handed as determined by the handedness questionnaire (see Appendix B) recommended by Bryden (1983). The handedness questionnaire consists of five questions determining hand use for common activities such as writing and brushing teeth. All subjects also reported no left handedness among their parents, brothers and sisters. Subjects selected on this basis are most likely to have language in their LH and visual-spatial abilities in their RH. All subjects also reported no color blindness or uncorrected visual deficits. One subject reporting no color blindness could not distinguish between the blue and green stimuli during the experiment. His data was removed and an additional subject run.

Stimuli and Apparatus

Two cognitive-perceptual tasks were used: a color naming task (McKeever & Jackson, 1979), and a modification of a line orientation task (Umilta et al., 1974). The color naming task is regarded by McKeever and Jackson as the best non-alphanumeric task for determining the language dominant hemisphere. Four colored squares, purple, green, red and blue were presented. On the projection screen they measured 4.5 by 4.5 cms , subtending 2.25 degrees of horizontal visual field. The near point to fixation was 1.5 degrees in either visual field. The original colors chosen were Munsell color chips of hue 5, value (lightness) 4 and chroma (strength) 8 . They were transformed into slides, but because of the composition of the emulsions of the color films being used, the colors did not photograph pristinely. In particular the green was mistaken for a blue. As an alternative, the green Munsell color chip of hue 2.5, value 5, and chroma 12 was used (see Appendix C). This resulted in all colors being easily identifiable. Although there is increasing evidence that luminescence is a factor affecting lateralization, reflecting as it does the energy being transmitted, no attempts were made to equate the slides on this basis; since, in the data analysis the colors are collapsed and treated as one factor in seeking the color by visual field interaction (Sergent, 1983).

The line orientation task is regarded as a relatively reliable right hemisphere task (Bryden, 1983). Originally, Umilta et al.(1974) required subjects to specify whether or not the line orientation shown was a member of a previously memorized set. In the present experiment, the task was simplified in order to reduce both the number of errors and the length of training involved. The subject's task was to name the angle of the line orientation. Four angles, 15, 30, 45 and 60 degrees were used. Similiar to Umilta et al. (1974) the angles were orientated clockwise from the vertical in the left visual field and counterclockwise from the vertical in the right visual field (see Appendix D). It should be noted that this results in different information being presented to each visual field. Therefore, it is possible that part of the right hemisphere asymmetry is an artifact of a greater ease in processing clockwise measured angles compared to counterclockwise measured angles. However, no pilot subjects reported one set of angles as being easier than the other set. Other orientations were considered including all angles leaning to the subject's right or left. However, in both of these cases, it was felt that the angles were then differentially located with respect to the fixation point. It was decided to retain Umilta's original design because of the symmetry between visual fields.

The line stimuli were drawn, photographed and made into 35mm slides. There were four angles appearing in each of the visual fields. All the slides were shown from one centrally located projector. Each slide had a stimulus appearing in only its left or right portion. When projected on the screen the stimuli were all 4.5 cms long and .5 cms wide, and subtended 2.25 degrees of horizontal visual field. The near point to fixation in either half field is 1.5 degrees.

Slides were projected for 120 msecs, a time determined through pilot study to permit a high recognition rate (approximately 90%) for the line stimuli. A high recognition rate was important since too difficult a task might have encouraged random guessing and reduced any actual cognitive processing. Faster presentation times produced either greater errors or demanded greater subject training. Upon the end of projection the microsecond clock of the computer began. The subject's verbal responses (into a microphone) triggered a Lafeyette audio detection device model 18010 and stopped the timer. Response times and trial number were automatically machine recorded.

The stimuli were back projected onto a translucent screen via a Kodac Ektagraphic projector, model B-2. Time of presentation was controlled by a Data General Nova 3 computer initiated and terminated electronic shutter. The screen had a centrally located fixation point, 117 cms off the ground. The importance of fixation in response to a warning tone was emphasized in the introduction to the experiment and midway during the experiment itself. Fixation control (cf. McKeever & Jackson, 1979) was not used for two reasons. First, the individual subject's tendency to be biased to either the right or left of fixation is regarded as a subject strategy effect and hence will be controlled and measured in the pure versus mixed list comparison. Second, there is strong evidence that the nature of the fixation control can affect the asymmetries measured subsequently, via a selective activation mechanism (Kershner, Thomae, & Callaway; 1977). Thus, for example, Mckeever's and Jackson's use of a digit recognition task for fixation control can be conjectured to contribute to the left hemisphere asymmetry they subsequently found for their color naming task.

There were a total of 192 slides (96 color slides, 96 line slides) prepared for the experimental trials. Each color and each line orientation occured 6 times in each visual field, in both the pure and mixed sequences. A single, quasi-randomized order existed for each block of pure stimuli and for the blocks of mixed stimuli. In pilot work, it was noted that identical angles which followed each other, although in different visual fields, resulted in easier recognition and shorter reaction times for the second slide. Thus, in order to maximize unpredictability and maximize the perceptual aspects of the task no two identical angles followed one another. Other constraints included: no more than three slides presented sequentially to one visual field, and no more than three of the same stimulus type (i.e., colors or lines) presented sequentially.

The slides were presented in blocks of 24 trials. Within each block the number of slides presented to each visual field was always either 12/12 or 11/13. In the pure blocks, each particular stimulus type (i.e., 15LVF) was presented two, three, or four times. To have made all the blocks identical would have have made some slides in each block predictable. There were eight blocks of 24 slides, two each of the pure blocks of lines and colors and four of mixed lines and colors.

Subjects were randomly divided into four groups, each receiving one of four possible orders of presentation of lines (L), colors (C), and mixed (M): M,C,L; M,L,C; C,L,M; L,C,M. Thus order effects were controlled for by incorporating two between factors, (colors & line stimuli, and mixed & pure presentation) into the experimental design. This was necessary because Sergent(1983) indicates that the laterality of some tasks changes as a function of familiarality.

Procedure

Subjects were seated in front of the screen onto which the slides were back projected. Subjects were approximately 90 cms from the screen and directly in line with the fixation point. The experiment was introduced as a perception experiment in which two kinds of stimuli, squares of colors and lines orientated at different angles, would be shown both in blocks of similiar stimuli and in blocks of mixed stimuli. Subjects were told to focus on the fixation point marked on the screen in front of them. They were to fixate upon hearing the warning tone. Shortly after the tone a stimulus was briefly presented unilaterally. Subjects were told to verbally identify the stimulus. The verbal response served both to stop the clock and to begin the next trial sequence. The importance of responding as quickly as possible without sacrificing accuracy was emphasized in the instructions to the subjects.

Following the initial introduction to the experiment, the subjects were familiarized with the stimuli. Subjects were shown one slide on which the four colors were represnted. The experimenter ensured that each color could be correctly identified and it was explained to the subject that their task was to name the color as quickly and accurately as possible.

Training subjects for the line orientation task was more complex because of the greater difficulty of the task. Subjects were initially shown two slides, one containing the four LVF angles and the other the four RVF angles. Subjects were told that their task was to name each angle that was projected onto the screen. The subject was asked to study the lines and was told the angle of orientation of each one. Following this familiarization period, a training block of ten slides was given in random sequence. Each stimuli was exposed for 800 msecs. The experimenter stood by each subject and provided feedback as to the correctness of each response. The training period continued at this exposure duration until a criterion of one error in ten trials was achieved. After the subject obtained the criterion, another block of training trials was given with the exposure time reduced to 250 msecs. Once again there were ten trials with feedback which continued until only one error in ten was made. The final training exposure was 120 msecs which was the experimental exposure time. Again the criterion to be reached was one error in ten.

Pilot study results had indicated that subjects differed on the number of training trials required to achieve the criterion. Consequently,a ceiling was placed on the amount of training any subject might receive, limiting the amount of familiarity and fatigue that might occur. It was decided that subjects would be advanced to the next exposure duration if they did not reach criterion in three training blocks at the greater exposure duration. duration. During the training trials some subjects were advanced from 800 msecs to 250 msecs exposure, although none were advanced from 250 msecs to 120 msecs exposure because all subjects reached criterion at the 250 msecs exposure.

The experiment consisted of eight blocks of trials, two line, two color , and four mixed, in counterbalanced order. Each block contained 24 experimental trials. A typical trial consisted of a 3 sec intertrial delay, a .5 sec warning tone, a 1.4 sec delay, a .12 sec slide presentation and the subjects response. Each block of 24 trials took approximately 2 mins to complete. This was followed by a short break of 30 secs before the next block was presented. The experimenter manually recorded any errors in identification of angles or colors on the experimental trials. A rest period of 1 min was given after four blocks. The total time to run the 192 experimental trials was less than 20 mins. Training times varied and the number of training trials to criteria was recorded. The entire experimental procedure took approximately 50 mins.

Strategy Group Assignment

After the experiment, subjects were asked to answer a few questions. A structured interview based on the results of the pilot study (n=11) was then initiated. During the pilot study, some subjects had shown a left hemisphere advantage on the line task in both the pure and the mixed conditions, while other subjects had shown a right hemisphere advantage. Still others had shown different advantages in the different conditions. These differing patterns of asymmetries could have been due to chance. However, the subjects reports of how they approached the line task seemed to be related to the hemispheric advantages shown. Since subject strategies are recognized as important determinants of asymmetries, it was decided to incorporate the differences in reported strategies as a variable in the experimental analysis. Therefore, criteria were developed which categorized subjects into groups on the basis of their reported strategies.

The criteria for group assignment were made as simple as possible. The pilot study had identified two different approaches to the line task. Each subject was asked to specify what proportion of the time each approach was used. On the basis of their reports, subjects were placed into strategy groups. All group placement was done by the experimenter and no reliability checks were made. Although the assignment of subjects into groups was not open to experimenter bias, since assignment was made solely on the proportions reported by each subject, the selection of the group criteria was the subjective decision of the experimenter. The two reported methods of identifying the shown angle are as follows. Subjects always reported some recognizable variation of the these strategies. Strategy names describe the style associated with each group.

Comparative strategy - subjects comment extensively about angles, state that they are swayed or otherwise affected by previously shown angles, say they set up horizontals, or verticals, and used dials and triangles in order to compare a shown line or to gauge its' angle.

Recognition strategy - subjects comment about lines, and have few comments about how they decided which line was which, they tend to report using memory and will say they had a "that's it" feeling.

After specifying what proportion of the time they "knew" the answer and what proportion of the time they "figured it out", subjects were asked if those proportions were any different in the mixed versus the pure presentations, and if so to specify how the proportions had changed.

From subjects reponses to these questions, subjects were placed into four groups. The groups and membership criteria were as follows:

Comparative strategy group - greater than 50% of a comparative strategy with less than a 25% change reported from the pure to the mixed conditions.

Recognition strategy group - greater than 50% of a recognition strategy with less than a 25% change reported from the pure to the mixed conditions.

Comparative change group - greater than 50% of a comparative strategy reported for the pure condition with more than 25% change toward a recognition strategy reported for the mixed condition.

Recognition change group - greater than 50% of a recognition strategy reported for the pure condition with more than 25% change toward a comparative strategy reported for the mixed condition.

If subjects would not specify proportions of two types of strategies, group membership was assigned on the basis of the subject's report and the general stylistic descriptions given above. In no case was a subject second guessed if his description of how he did the task seemed not to fit with his reported proportions. All attempts were made to stay with as simple criteria as possible. It was felt that should the groupings have some predictive validity, they would be of use to others only if the criteria were straight-forward and easily operational.

In summary, subjects were shown 8 blocks of trials, 2 line, 2 color, and 4 mixed in counterbalanced order. Each block contained 24 experimental trials. After the experiment, subjects were interviewed in order to determine how they approached the line orientation task. On the basis of what they reported doing, subjects were assigned to different strategy groups for the purposes of data analysis.

Data Analysis

The response times were recorded by a Nova 2 computing system and outputted in their order of occurence. Then, response times to similiar stimuli were grouped together by hand, and a geometric mean calculated for each stimuli set. These geometric means were entered into Simon Fraser University's computing system for analysis with Biomedical programs (BMDP).

IV. Results

Descriptive analyses were undertaken of subect's age, number of training trials, and number of errors (Table 1). The average age was 28 with a standard deviation of 7.8. Three subjects were aged 40 or older, however their response times were indistinquishable from those of the younger subjects. The average number of training trials was 4.9 with a standard deviation of 1.1. Errors rarely occured on the color task and are not summarized. The overall average number of line errors was 10.9%. More errors were made in the mixed than in the pure condition, 12.3% versus 9.5%. The number of line errors made ranged from an average of 5.4% on the left 15 degree angle in the pure condition to an average of 18.8% on the left 60 and right 15 in the mixed condition. The number of errors were judged to be within acceptable limits and were close to the 10% achieved by Umilta et al..

The geometric means for each stimulus were subjected to an analysis of variance (ANOVA) by means of a BMDP8V program. This program is suitable for repeated measures designs with nested factors. In the present experiment stimuli are nested within type; individual lines being nested within lines and individual colors within colors.

Stimuli are treated as fixed factors. Stimuli were initially chosen to be seperate and distinct from one another, in order to standardize to some degree the processing requirements for each stimulus. Treating the stimuli as random factors suggests that they were randomly chosen from a population of stimuli. In principle, generalizations cannot be made from fixed factors to other than those factors, while inferences can be made from random factors to a general population.

The ANOVA design was 2 X 2 X 10 X 2 X 2 X 2 X 4; ORDER1 X ORDER2 X SUBJECTS X PRESENTATION X HEMISPHERE X TYPE X STIMULI (within TYPE), with subjects being the only random factor. The variables are defined as follows. ORDER1 AND ORDER2 are the two order factors. ORDER1 specifies whether the mixed condition was presented first or second, while ORDER2 specifies whether, within the pure condition, the blocks of lines or the blocks of colors were shown first. PRESENTATION refers to whether the stimuli were presented as pure blocks or as mixed blocks. HEMISPHERE refers to whether the stimuli were presented to the left or right hemisphere. TYPE refers to either color or line, while STIMULI refers to the variation within either color or line.

The ANOVA revealed several significant results including main effects due to PRESENTATION ($F(1,36)= 55.5$, $n=0.000$), HEMISPHERE ($F(1,36)= 5.38$, $p=.026$), TYPE ($F(1,36)= 545.46$, $p=.000$), and STIMULI ($F(1,216)= 20.41$, $p=.000$). These effects are all as expected. Significant amounts of variance are accounted for by mode of presentation, either pure or mixed; by type of stimuli, either color or line; and by differences between individual stimuli. The significant effects due to hemisphere indicate that overall, projection to the left hemisphere results in faster response times than projection to the right hemisphere. The ANOVA uncovered several other significant results, the most important of which is the ORDER1 X ORDER2 X PRESENTATION X HEMISPHERE X TYPE interaction ($F(1,36)= 8.2$, $p=.007$), (Table 2). The presence of this significant 5 way interaction makes examination of significant lower order interactions whose components are contained in the 5 way interaction impossible. The data was log transformed in an attempt to remove the 5 way interaction, and the ANOVA was rerun, but the effect remained ($F(1,36)= 6.7$, $p=.01$) (Table 3). Visual examination of the logged interaction reveals no easily interpretable explanation of the results (Figure 1).

The 5 way interaction is presented first because its presence determined the way in which the remaining analyses were undertaken. Its presence meant no further within subjects analyses were done. Therefore, the experimental hypotheses were explored using only between group comparisons, thus removing order effects. To do the between group comparisons, the second half of the data for each subject was discarded. Three groups were used in the analysis. The Mixed group consisted of those 20 subjects who had received the mixed condition first. The Lines1 group consisted of those ten subjects who had received the line block first and the color block second and the Colors1 group consisted of those subjects who had received the colors first and the lines second. The Lines1 and Colors1 groups had their "mixed" presentation data discarded while the Mixed group had their "pure" presentation data discarded. A BMDP2V progam was used because it was capable of handling the unequal numbers of subjects in the three groups. Averaging was carried out over the individual stimuli, since P2V cannot handle nested factors in a repeated measures design. An ANOVA was done on the 3 X 2 X 2 design, *GROUP X HEMISPHERE X TYPE* (Table 3).

A significant 3 way GROUP X HEMISPHERE X TYPE interaction was found ($F(2,37)= 4.13$, $P=.024$), (Table 4). The interaction is plotted in Figure 2. In order to determine more about the interaction comparisons between means were undertaken. Left-right differences were calculated for the line and color stimuli for each group as well as the value of the line differences minus the color differences (Table 5). Because the number of possible comparisons was 15, Bonferonni's fudge factor was used. The significance level adopted for each comparison was .05/15 =.0033.

First, line and color difference scores were each tested in a single T test to detect any difference from zero. Second, matched group T tests were conducted to see whether any line differences were different from the corresponding color differences (Table 5). In ho group were the line and color differences significantly different, as they would have been if the stimuli were showing opposite hemispheric advantages.

Finally, T tests for independent samples were conducted between the line or color difference in any group and the line or color difference in any other group. Again none of these comparisons were significant, suggesting that none of the groups performed differently from one another on either the line or color stimuli. Thus, although a significant HEMISPHERE X TYPE X GROUP interaction was found, no single set of left-right differences was significant.

In the same analysis of the partial data the significant main effect due to hemisphere from the overall analysis dropped out ($F(1,37)=1.09$, $P=.30$). In addition, the HEMISPHERE X TYPE interaction was not significant ($F(1,37)= .47$, $P=.49$), indicating that the stimuli were not lateralized as expected. Further details of the lateralization of the individual stimuli were not available from the above analysis.

To find out more about the lateralization of the individual stimuli a P8V program was used. The P8V program can analyse repeated measures, and nested variables, but requires equal size groups. Therefore, it was necessary to divide the mixed group (n = 20) into two groups, Mixed1, and Mixed2. This division of the mixed group resulted in a total of four groups each of 10 subjects. The results of the subsequent analysis indicated a significant STIMULI X TYPE X HEMISPHERE interaction ($F(3,216)= 2.60$, $P=.019$), (Table 7, Figure 3). It can be seen that for both colors and lines, two of the stimuli show a right hemisphere advantage (blue, purple, 15, 30), while two show a left hemisphere advantage (red, green, 45, 60). T tests were performed to determine the significance of the hemispheric differences. No significant differences were found.

At this point in the data analysis the strategy groups were introduced as a grouping factor. Subjects had been categorized as follows: 19 were placed in the comparative strategy group, 4 in the comparative change group, 14 into the recogition strategy group and 3 into the recognition change group. Thus 23 people, in total, were placed into a comparative strategy group on the basis of performance on the pure condition and 17 into the recognition strategy group, while 22 subjects were placed into a comparative strategy group on the basis of performance on the mixed task and 18 into the recognition strategy group (Table 8).

As mentioned previously, an analysis of the total data not involving strategy groups produced a 5 way interaction. This analysis was rerun with strategy groups as a factor. Inclusion of the strategy groups made no appreciable difference to the results of the analysis (Table 9). A 5 way interaction still appeared. Further, no main effects due to strategy groups were found.

Strategy groups were then considered as a variable in the analysis of the partial data. All of the analyses of the partial data used only the grouping variable relevant to the part of the data retained. For instance, those subjects whose "mixed data" was retained were grouped on the basis of the mixed data. Strategy groups did not appear as a significant main effect in an analysis of the partial data (Table 9). However, there were significant differences in reponse times between the Mixed, Lines1, and Colors1 groups ($F(2,34) = 3.81$, $P = .032$).

Since the strategy grouping was based solely upon performance on the line task, a further analysis was undertaken using only the line data and discarding the color data for each individual. A significant main effect for strategy groups was found, indicating that the recognition strategy group responded faster than did the comparative strategy group ($F(1,34) = 6.25$, $P = .017$), (Table 10, Figure 4).

In summary, a significant 5 way interaction involving both order factors was found necessitating the removal of the data contaminated with order effects. Analysis of the remaining data found a significant interaction between stimulus, type, and hemisphere, although T tests did not identify any single significant difference between means. Further analysis of the stimuli showed two of each stimulus type to be left lateralized and the other two right lateralized. T tests did not identify significant differences between pairs of stimuli. When strategy groups were inserted into the analysis and only the line data was used, a main effect for strategy groups was found.

V. Discussion

The present experiment consisted of presenting two cognitive-perceptual tasks in both a pure and a mixed fashion. Previous research permitted anticipation of each task's hemispheric advantages. A post-experiment interview assigned subjects to strategy groups. Data analysis included group assignment as a factor.

The most important result influencing the interpretation of the experimental hypotheses was the absence of anticipated asymmetries. As a result, many of the experimental hypotheses could not be tested.

In the following section, different aspects of the experimental results are discussed. Particular attention is paid to factors influencing the measurement of asymmetries. First, the results are discussed without including the strategy groups as factors, then strategy groups are included. Next, attentional bias and subject strategies are considered as explanations for the observed results. Finally a conclusion is offered.

The present experiment used a pure versus mixed presentation comparison suggested by Kinsbourne (1971) and recommended by Bryden (1983) as a method possibly superior to that of concurrent memory load for testing attentional bias theory. A pure versus mixed presentation comparison can be carried out as a within subjects or a between groups design. A within subjects design advantageously increases statistical sensitivity by reducing variance due to individual subject differences, thus requiring a smaller N to reach significance than a between groups design. However, a within subjects design, unlike a between groups design, may be influenced by order effects.

Although order effects are problematic in within subjects designs,these problems are seldom addressed by researchers recommending or reporting pure versus mixed presentation comparisons. Another problem with within subjects designs is that hemispheric effects may reverse as a function of subjects' exposure to the experimental stimuli (Sergent, 1983). Sergent argues that less familiar stimuli (i.e., random shapes) are more likely to produce a right hemisphere effect while more familiar stimuli (i.e., letters) are more likely to produce a left hemisphere effect. Therefore, in the present experiment it was decided a priori, to use a within subjects design to obtain maximum sensitivity should order and familiarity effects not occur and to use a between groups design to permit data analysis should order effects occur.

Statistical analyses indicated the presence of significant order effects. These order effects emerged as part of a 5 way interaction for both the raw and for the log transformed data and therefore could not be partialled out. This interaction included both order variables: order1 specified the order in which the mixed and pure blocks were presented; order2 specified, within the pure block, the order in which lines and colors were presented. The other components of this complex 5 way interaction were presentation, hemisphere and type. The presence of this interaction meant that significant lesser effects within the 5 way interaction could not be examined.

Examination of the 5 way interaction (Figure 1) revealed no plausible explantions for the result. Therefore, it can only be concluded that the relation between order and response times is complex. Subjects' fatigue may be offered as one explanation for these results. However, this explanation is unlikely because the duration of the experimental procedures and the number of experimental trials was no greater than the majority of other experiments in this domain. The results obtained here suggest that within subject comparisons of pure versus mixed presentations are ill-advised because of the likelihood of order effects contaminating the comparison.

The presence of the 5 way interaction resulted in half of each subject's data being discarded and the experiment being considered solely as a between groups design. For subsequent analyses, log transformed data was used in order to remove the correlation between the means and standard deviations of the response times. Using a between subjects data analysis, no main effects were found for HEMISPHERE or HEMISPHERE X TYPE. A main effect for hemisphere would have indicated that one hemisphere had either an overpowering advantage for processing one stimulus type or that one hemisphere had minor advantages for processing both stimulus types. A hemisphere by type interaction would have indicated one stimulus type, such as colors, was processed better by one hemisphere and the other type, lines, better by the other. Since the stimuli were selected because the line task was expected to give a right hemisphere advantage and the color task a left hemisphere advantage, the absence of this interaction indicates that no such hemispheric advantages existed.

In the same between groups data analysis, a significant GROUP X HEMISPHERE X TYPE interaction was found ($F(2,37) = 4.13$, $P=.02$), indicating that different groups had different patterns of hemisphere by type interactions. This analysis compared a "Mixed" group (n=20) who received lines and colors intermingled, a "Lines1" group (n=10) who received blocks of lines followed by blocks of colors, and a "Colors1" group (n=10) who received blocks of colors followed by blocks of lines. The Mixed group is a mixed group and the Lines1 and Colors1 groups are pure groups in a mixed versus pure presentation comparison. Attentional bias theory predicts different presentations (pure or mixed) will result in different patterns of asymmetries. Thus, initially the significant hemisphere by type by group interaction appears supportive of attentional bias theory. However, further examination of the interaction (Figure 2), reveals little support for the theory. Statistically (Table 4) no difference was found for any of the mean comparisons either within a group or between groups. Thus, the exact nature of the interaction is difficult to determine. Because no clear hemispheric advantages were obtained it is difficult to evaluate the changes in direction of asymmetry that can be visually observed. Thus, while a significant group by hemisphere by type interaction exists, the result cannot be used to either confirm or refute attentional bias theory.

As was mentioned above, no hemisphere by type interaction was obtained, in either the primary (within subject) or secondary (between group) analyses. This indicates that the stimuli were not lateralized as expected. This outcome was especially surprising for the color naming task, which has been described as the best non-alphanumeric task available for identifying the language hemisphere (Mckeever & Jackson, 1979). Since the subject group of right handed males was selected because of the liklihood of left hemisphere dominance for language, the present experiment predicted a left hemisphere advantage on the color task.

In the present experiment, three departures from Mckeever and Jacksons' methodology were made. These differences might account for the failure to find a left hemisphere advantage for the color naming task. A first difference was that the exposure time for the experimental stimuli was increased from 100 msecs to 120 msecs. However, Sergent (1983) suggests that an increase in exposure time for most stimuli will tend, if anything to increase a LH advantage. Thus, it is unlikely that the nonexistance of a left hemisphere advantage for color naming can be attributed to an increase in exposure time. A second difference was that Mckeever and Jackson used tachistoscopic projection, while the present experiment used back projection. Tachistoscopic projection is more often used in visual laterality experiments than is back projection and offers greater control of extraneous visual distractions. However, in the present experiment a relatively distraction free experimental room was used. A door to the subject's left meant the room was not completely symmetrical, yet no consistant bias was found that would indicate subjects were distracted. The back projection technique has been used successfully in numerous other studies (cf., Sperry, 1968). Thus, it is unlikely that the lack of a left hemisphere advantage for color naming can be attributed to the difference in projection techniques. A third difference between the McKeever and Jackson study and the present study is in the use of a fixation control. McKeever and Jackson's study required subjects to report a centrally projected digit before responding to the stimuli. This procedure while controlling for wandering gaze has been postulated to differentiatly activate the left hemisphere immediately before the stimuli are shown. Thus part of McKeever and Jackson's reported asymmeties may be an artifact of their procedures. In that case, not using a fixation control made achieving a left hemisphere advantage on the color naming task less likely.

An examination of the lateralization of the individual color stimuli (Figure 3), shows that left hemisphere advantages were obtained for only the red and green stimuli, while a right hemisphere advantage was obtained for the blue and purple stimuli. However, none of these hemispheric advantages were significant. Likewise, the overall means for the right and left hemispheres were not significantly different. Thus the color stimuli, considered both as a group and individually, failed to show significant hemispheric asymmetries.

The lack of lateralization of the line stimuli was less unexpected than that of the color stimuli. Both because the experimental task used was modified from the task used by Umilta et al. and because right hemisphere asymmetries are generally harder to achieve than are left hemisphere asymmetries. The experimental task was modified from requiring subjects to specify whether the line was part of a previously memorized set, to naming the angle of the line orientation. In an analysis of the lateralization of the individual lines, the 15 and 30 degree lines showed right hemisphere advantages, while the 45 and 60 degree lines showed left hemisphere advantages. Significance tests of the right-left differences for a particular stimulus and comparisons of the right -left differences for one stimulus compared with another revealed no significant differences.

Umilta et al's. previous work demonstrated easily labelled horizontal and vertical lines had a left hemisphere advantage, while less easily labelled lines had a right hemisphere advantage. They concluded that the ease of labelling directly influences the direction of the asymmetry. Thus the more specific labelling requirement of the present experiment likely attenuated the usual right hemisphere asymmetry for the line stimuli.

Two further explanations may clarify why no laterality effects were found for either colors or lines. The first is that not enough presentations of each stimulus were made to each visual field. Too few presentations might have resulted in response time means that had not reached their asymptote. Thus, random variation in response time means, induced by outliers, may have hidden asymmetries discernable with greater numbers of presentations and more stable response time means. In the present experiment, analyses were based on twenty four presentations per stimulus type, per visual field. A priori, this number was considered large enough to result in stable response time means.

A second explanation for the lack of asymmetries is that lateralized effects were masked by the statistical analyses. Indeed, much less is known about the analysis of reponse times than is known about accuracy analysis (cf. Bryden and Sprott, 1983). In the present experiment a geometric mean was used in order to reduce the effect of outliers. However, there is a danger in reducing the effects of outliers too far, because the natural distribution of scores may not be normal. Most researchers would agree that the distribution of response times is skewed to the right with more exceptionally slow response times than exceptionally fast response times. Response times may actually be bimodally or multimodally distributed. Within a laterality paradigm, a bimodal distribution of response times makes sense. The reason for this is that a stimulus that fails to be processed one way by one hemisphere may then be processed another way by the other hemisphere. Thus a bimodal distribution which includes a significant clustering of high scores could conceivably appear.

The point is that the conception of the reponse time distribution influences the kind of statistics chosen and fundamentally affects the results that may be found. Some kind of transformation must be undertaken because a single outlier can affect an entire data set. A geometric mean was used here, because the ratio of outliers to typical responses was high enough to cause concern, while at the same time the possibility of a bimodal distribution meant rules for discarding outliers were difficult to develop.

Up until this point, discussion has centered on an examination of the results without considering the strategy groups in which subjects were placed after completing the experimental procedures. The results of incorporating the strategy groups as a factor in the analysis are considered below.

When added to an analysis of the complete data strategy groups did not produce main effects, either when the groups were formed on the basis of the pure presentation ($F(1,26)=.40$, $p=.53$) or when the groups were formed on the basis of the mixed presentation (F(1,26)=2.69, p=.114). Strategy groups did appear to interact with the order variables, suggesting that categories were not confounded with order.

No main effects for strategy groups were revealed when the order effects were removed by analysing only the partial data (F(1,34)=1.93, p=.173). However, when only the line data was analysed a significant main effect due to strategy groups was found (F(1,34)=6.25, p=.017). An examination of Figure 4 shows that the effect is consistent across the three groups (Mixed, Lines1, Colors1) in the analysis. Thus, subjects who reported using a complex, more analytical strategy, had significantly longer response times.

This same analysis produced no main or interactional effects for hemispheres. Strategy groups did not differ on hemispheric advantage (F(2,34)=.03, p=.872). Thus, the trends observed in the pilot data, in which the comparative strategy group seemed to have a RH advantage and the recognition strategy group seemed to have a LH advantage, were not substantiated.

Three explanations exist for the lack of effects due to strategy groups. The first is that cognitive strategies were an unimportant variable not affecting hemisphereic asymmetries. The second explanation is that the categories were defined inaccurately and that different patterns of asymmetries would have characterized more appropriately selected groups. The third explanation is that the groups were defined adequately and would have shown different patterns of asymmetries had the experimental stimuli proved to be differentially lateralized.

An incidental finding in the analysis of the strategy groups data is of interest. Strategy groups differed on their response times, with the recognition strategy group responding faster than the comparative strategy group. The importance of this finding is that subjects' introspection about the complexities of their strategies is correlated with their response times. Thus it may be possible, before data analysis, to predict at least one characteristic of a subject's response time. However, in this experiment subjects' self report of cognitive strategies did not predict anything other than response times. Strategy groups did not predict performance on the color stimuli, nor did they predict size or direction of hemispheric asymmetries. Had hemispheric differences been found, it is conceivable that they may have differed from one strategy group to another. The method of interviewing subjects to ascertain conscious correlates of asymmetries remains plausible.

As previously mentioned, order effects appeared in the analysis of the total data. Although these were removed by discarding half of the data, an order variable was still present as a grouping factor in the analysis of the partial data. Although the groups, Lines1 and Colors1, were both shown pure blocks of stimuli, Lines1 was shown lines first and colors second while, Colors1 was shown colors first and lines second. Examination of Figure 2 shows that there are significant differences in the pattern of response times between the two groups. The Colors1 group is significantly faster than either the Lines1 or the Mixed groups, on both the line and color stimuli.

At least two possible explanations exist for these differences in response time. The first is that since the recognition strategy group was faster, the Colors1 group simply contained more subjects who used a recognition strategy. In this case the difference in response times would be a result of subjects' strategies. However, this explanation is unlikely to be correct for two reasons. First, the Colors1 group is faster on both lines and colors, while the recognition strategy group was predictive of faster response times only on the lines. Second, reference to Figure 4 shows that both recognition and comparative strategy groups were faster in the Colors1 group. Therefore, the quicker response times of the Colors1 group cannot be explained by a greater use of the recognition strategy. The second explanation for the quicker response times of the Colors1 group relies on the fact that subjects universally reported the color task to be easier than the line task. Therefore, presenting the color task first may have enhanced subject's confidence, thereby facilitating subsequent performance on the line task.

The foregoing discussion may be summarized in the following five points. First, order effects were present and resulted in a significant 5 way interaction which precluded the interpretation of lower order interactions. Thus it is recommended that in future applications of a pure versus mixed presentation comparison only a between group experimental design be used.

Second, an analysis of the between groups section of the experiment revealed, as predicted, a significant group by hemisphere by type interaction. However, statistical and visual analysis of the results revealed no significant differences between hemispheres for either the color or line stimuli for any of the subject groupings. Thus, it is difficult to interpret the nature of the 3 way interaction in light of attentional bias theory.

Third, no main effects for hemisphere or hemisphere by stimulus type interaction were found. An examination of the asymmetry of each stimulus type (e.g., line, color) revealed two of each type had a left hemisphere advantage while the other two of each type had a right hemisphere advantage. However, none of these advantages were significant. Thus, the stimuli failed to be lateralized as expected. This result is particularly surprising for the color stimuli, since they are regarded as the best non-alphanumeric left lateralized stimuli available.

Fourth, the grouping of subjects by strategy, on the basis of post experiment interviews was partially successful. The recognition strategy group had significantly quicker response times than the comparative strategy group. However, because no hemispheric asymmetries were found for the stimuli, it is impossible to say whether the groups would have shown different patterns of asymmetries had hemispheric advantages been obtained. The strategy groups were only significant in an analysis of the line stimuli and not of the color stimuli.

Fifth, significant differences in speed of response were found when the color blocks were presented before the line blocks. The most plausible explanation for this result is that subjects felt more confident by virtue of completing the easier task first (color stimuli). Subsequently, subjects' increased confidence enabled quicker responses to the line task.

Attentional Bias and Subjects' Strategies

Generalizations based on the results of the present experiment, concerning the contribution of attentional bias to observed asymmetries cannot be made. However, attentional bias can be considered as an explanation for the lack of hemispheric asymmetries in the present experiment.

Verbal responses may have induced an attentional bias, hence affecting the observed asymmetries. Attentional bias theory predicts that verbal responses would differentially activate the left hemisphere, subsequently bringing attention to the RVF. Consequently, the line identification task, a supposedly right hemisphere lateralized task, should show a left hemisphere advantage or more probably a reduced right hemisphere advantage. Similarly, the color naming task, a left hemisphere lateralized task should either retain or increase its left hemisphere advantage. However, in contradiction to the predicted patterns of asymmetries, the color naming task showed no left hemisphere advantage. Therefore, attentional bias caused by verbal responses is not an adequate explanation of the results.

What are some reasons for this inadequacy? Fundamentally, attentional bias theory deals with small effects occuring over short time spans. There is no evidence that the effects of previous cognitive-perceptual processing linger for other than microseconds. Concurrent memory load and fixation manipulation are two experimental paradigms used for the study of attentional bias. They both place the "biaser" and the "biased" in immediate temporal proximity. On the other hand, mixed presentation studies generally have substantial intervals between the presentation of consecutive stimuli. For example the intertrial interval used by Day(1979) was 3 secs and that used by Hellige(1978) was 15 secs. The present experiment used a 3.5 sec intertrial interval. All of these times are long relative to the typical processing and response times of cognitive-perceptual experiments. Therefore, attentional bias effects may not extend from the presentation of one stimulus to the next. Subject's abilities to disconnect from a task can be measured alternately by EEG and cerebral blood flow experiments. Perhaps these methodologies can inform us as to the duration of bias due to previous cognitive-perceptual processing.

The author feels that subject strategies are more likely than attentional bias to account for certain aspects of the data. Subject strategies are assumed to result in consistent biases over time and hence can be more easily conceptualized as having an influence stretching from one stimulus presentation to the next. Subject strategies may explain the faster response times recorded by the Colors1 group. This group, presented colors before lines, had significantly faster times on both colors and lines compared to both the Mixed and Lines1 groups. Faster times may just represent a type 1 error, in that, although statistically significant the result may be measuring random variance rather than indicating the presence of an underlying pattern. Alternatively, as suggested earlier, the faster reaction times for the Colors1 group may be due to confidence induced by a change from an easier to a more difficult experimental task.

Confidence can perhaps be construed as a strategy variable. Unlike the strategy variables disccussed above, confidence is more closely akin to an affective state than to a cognitive state. The recent studies by Tucker (1981) and Tyler & Tucker (1982), have shown that mood, and anxiety can affect asymmetries. Depressive affect, and hence lower confidence, are associated with a decrement of right hemisphere activity while euphoria, at least in mania, is associated with an increment of right hemisphere activity relative to the left hemisphere. Confident subjects then, might be expected to have a relatively greater right hemisphere arousal. The results of one study show that right hemisphere arousal may lead to better performance by both hemispheres on a perceptual task (Heilman & Abell, 1979).

Hence confidence may speculatively lead to overall better preparedness and performance on cognitive-perceptual tasks.

Although, the energy of the presented stimuli, measured in luminescence, has been demonstrated to alter and even reverse asymmetries, the effect of a subject's energy has not. Consider for a moment whether subjects' energy , interest, motivation, confidence, or expectations, might not be a crucial element in producing differential results from one laboratory to another. For example, Kinsbourne's latest theoretical formulation associates the left hemisphere with approach and the right hemisphere with avoidance (Kinsbourne, 1983). Should this be so, then subjects' willingness to do the task and their sense of its pleasantness or unpleasantnes might well effect the measured asymmetries, by shifting the differential activation of the hemispheres.

Besides offering an explanation of the faster response times of the Colors1 group, subject strategies may speculatively explain why the strategy groups were significantly different in response times.

Examination of the individual line stimuli, plotted by strategy group (Figure 5), shows an interesting though nonsignificant trend in the data. It can be seen that both strategy groups, show a left hemisphere advantage for some of the lines, and a right hemisphere advantage for others. For the slower, comparative strategy group the right hemisphere advantaged line is the 60, while for the faster, recognition strategy group, the right hemisphere advantaged lines are the 45 and 60. Possibly, the 45 and 60 degree lines are key lines: the 60 being the most important for the comparative group; the 45 being the most important for the recognition group. Hypothetically, a mental image of the key line for each group was prominent in visual memory and formed the basis for judgements of line orientations. When a line similar to the line most prominent in visual memory was projected onto the screen, faster right hemisphere response times were achieved because an imaginal strategy was used. Evidence that points to the location of imaginal processes in the right hemisphere would suggest that imaginal strategies would produce right hemisphere effects (cf., Ley, 1983). When a line other than that held prominently in visual memory was projected, the initial processing was done by the right hemisphere, while later processing involving a more analytical comparison with the memorized line was carried out by the left hemisphere. The consequences of a projected line being judged different from the line held in visual memory differed depending upon whether the key line was a 45 or a 60 degree line. If memory contained a 45 degree line then it was easy subsequently, to recognize a 60, it being the only line less than a 45, leaving the greatest amount of decision making to be done between the 15 and 30. If memory contained a 60 degree angle, then it was much harder subsequently to discriminate between 15s, 30s, and 45s. The latter condition would thus require more analysing, and hence produce the longer response times characteristic of the comparative strategy group.

Thus, it would seem that the angle which subjects chose to be most aware of or felt was easiest for them to recognize would have important consequences, both in terms of resulting asymmetries and average response times.

Support for the notion that initial processing may be accomplished by the right hemisphere and subsequent processing by the left hemisphere comes from Sergent (1983), who theorizes that the right hemisphere may be more competent in preliminary processing and the left hemisphere more competent in detailed operations.

Support of a different nature comes from Kosslyn (note 2) who recently developed a three part computer simulation model of imaginal processing. The first part of his simulation model explains the production and organization of an image. Kosslyn (1975) maintains that the perception of an internal image is similiar to the perception of an external image. For instance, in both real life and in imagination, it takes longer to say if a german shepard has pointed ears if one was previously looking at its tail than if one was looking at its stomach. In imagination as in real life, only part of an image is in focus at any moment. The second part of Kosslyn's computer imagery model simulates the making of global comparisons, for example, deciding whether an elephant is larger than a goat. The third part of Kosslyn's model simulates the making of comparisons made on the features of an image. For example, Kosslyn asked subjects to specify whether the ears of imagined animals protruded above the curves of their skulls (they do in the case of a german shepard and don't in the case of a person). Kosslyn maintains that the first two parts of imaginal processing involve right hemisphere functioning, while part three involves left hemisphere functioning. Kosslyn, working with a single split brain subject received striking support for his hypothesis that part two is a right hemisphere function while part three is a left hemisphere function. The subject was equally able to handle part two, global comaprisons, with either hemisphere. However, with part three, feature comparisons, the right hemisphere performed at chance level, while the left hemisphere performed extremely well.

Comparing Kosslyn's model of imaginal processing and the line processing that occured during the present experiment, it would seem that deciding whether a target line is similiar to a memorized line is a global comparison akin to a part two comparison, while deciding on the degree of difference between a target line and a memorized line is a feature analysis most similiar to Kosslyn's part three. Thus, the initial recognition of the 45 or 60 degree line would be a right hemisphere task and the subsequent labelling of the other angles a left hemisphere task.

Conclusion

This study was undertaken to further clarify the relationship between two variables (attentional bias and subject strategies) and the measurement of perceptual asymmetries. Perceptual asymmetries are studied in order to increase knowledge of the brain's structural and functional organization. The presence of a perceptual asymmetry is commonly assumed to indicate the greater contribution of one hemisphere to the processing of the presented stimulus. Specific cognitive-perceptual processors are thus localized to one hemisphere or the other.

Both subject strategies and attentional bias are hypothesized to affect perceptual asymmetries. Attentional bias effects in the present experiment were assumed to be contributory, but not predominant, to the creation of a perceptual asymmetry. However, in the data analysis, as no evidence of significant hemispheric asymmetries was found, no conclusions about attentional bias effects were possible. Subject strategies, an infrequently studied and poorly understood variable, is often postulated to be a major factor in the determination of perceptual asymmeries. In the data analysis, strategy groups were not characterised by different patterns of asymmetries, although significant differences in response times were found between groups. Significant effects due to the order of presentation of the stimuli were also found.

An analysis of the complete data revealed a compex interaction among order, hemisphere, stimulus type and presentation (pure or mixed). An analysis of the partial data, revealed faster response times for both the color and the line stimuli, when the color stimuli were presented first. Presenting the color stimuli first may have enhanced subjects' confidence, thereby facilitating subsequent performance with the line stimuli. In summary then, when compared to the effects of order and strategy groups, the asymmetrical properties of the stimuli were found to be weak.

The relative instability of asymmetries is well known (cf. Bryden, 1983), so that conclusions concerning the multitude of factors influencing asymmetries are only slowly being unravelled. The present results indicating a complex effect due to order of presentation are consistent with Sergent's observation of the fragility of cognitive-perceptual effects. For example, she reports changes in asymmetries due to minor changes in such variables as exposure time and luminesence. Further, in this experiment, differences in response times due to the lateralization of perceptual processes were found to be less robust than differences in reponse time due to subjects' strategies. Therefore, the relative strength of subjects' strategies highlights their importance as a variable, which needs to be more fully understood and warrants further investigation.

VI. Bibliography

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FIGURE 1

5 WAY INTERACTION: ORDER1 X ORDER2 X PRESENTATION X TYPE X HEMISPHERE

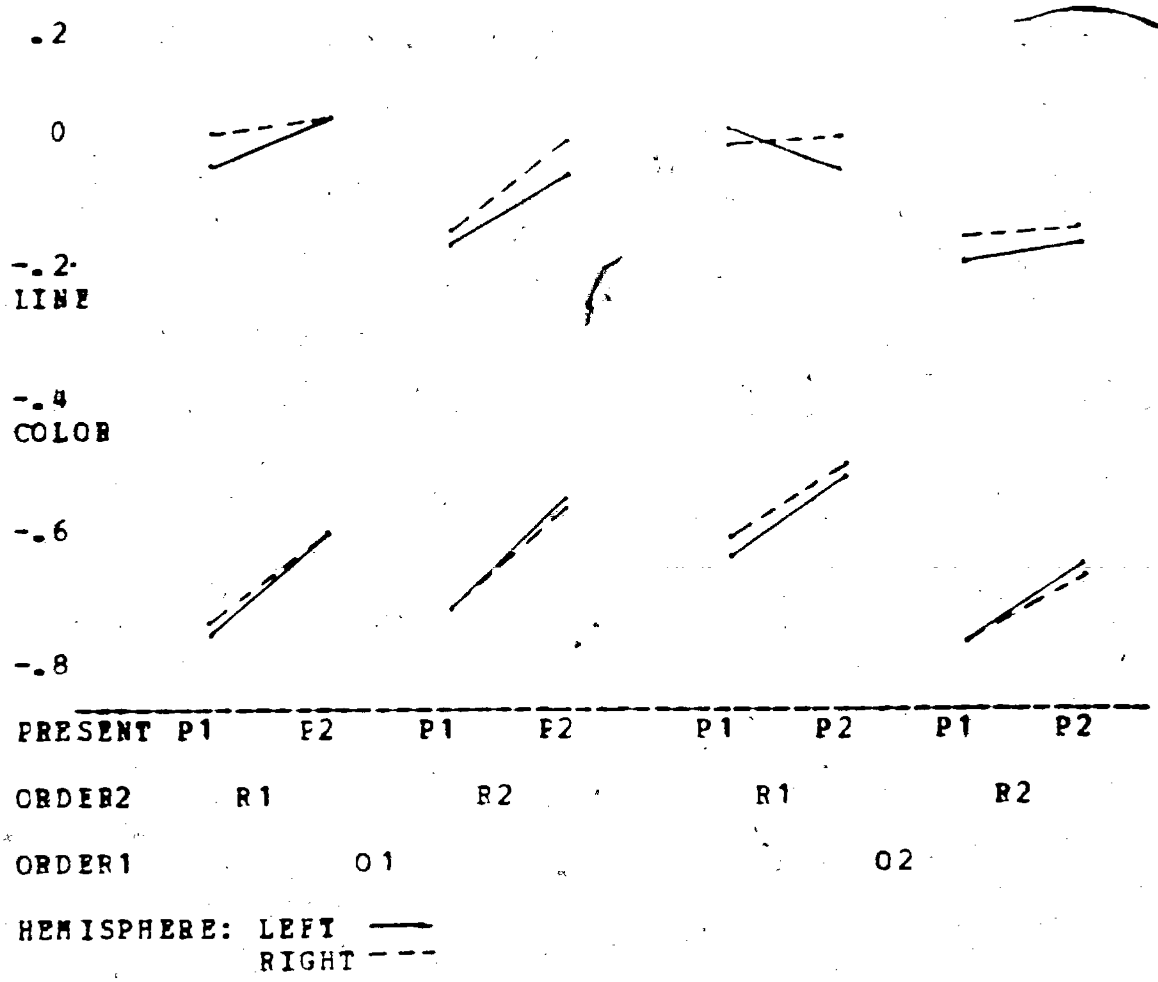


FIGURE 2

GROUP X TYPE X HEMISPHERE INTERACTION

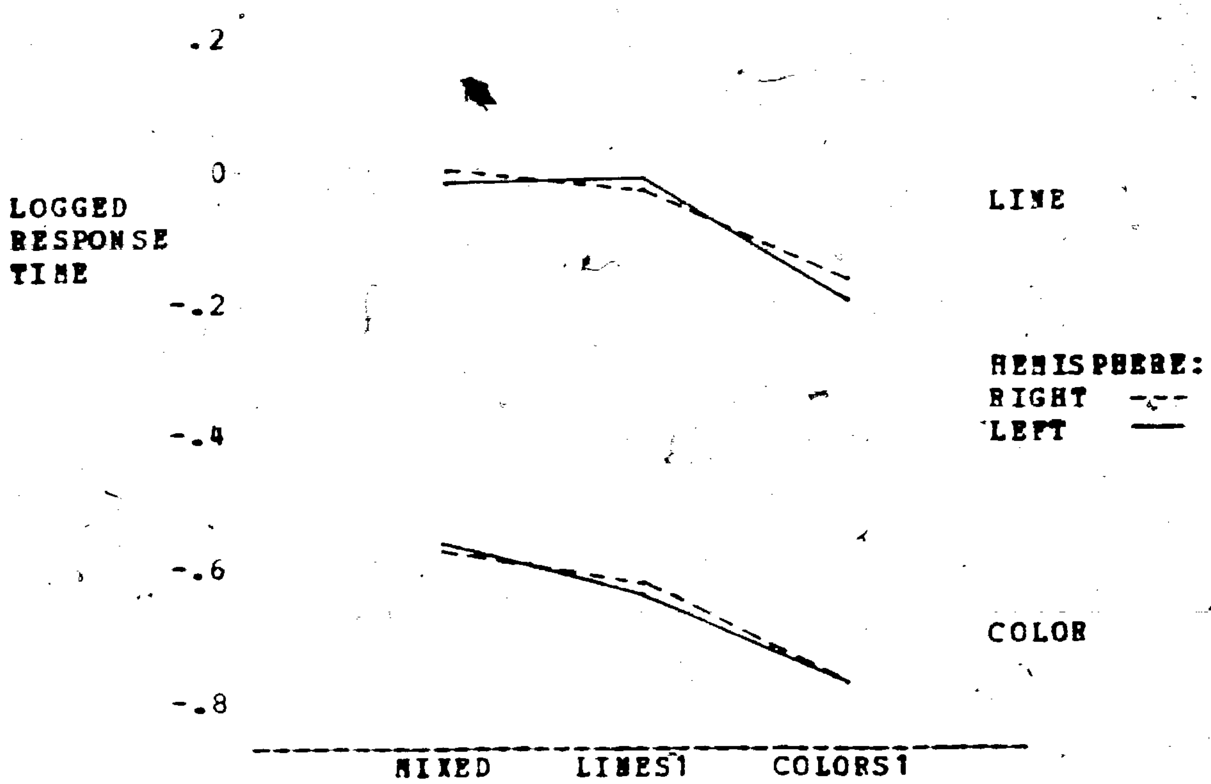


FIGURE 3

STIMULUS X TYPE X HEMISPHERE INTERACTION

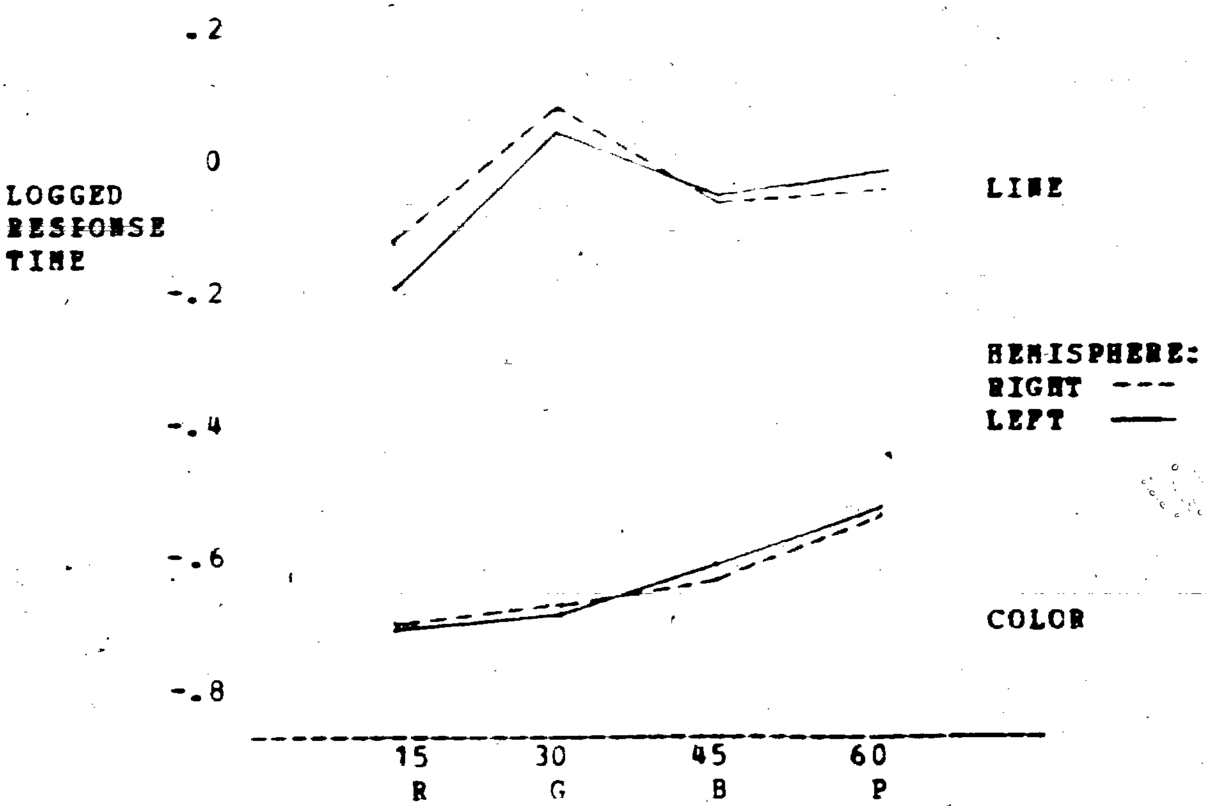


FIGURE 4

MAIN EFFECTS DUE TO STRATEGY GROUPS

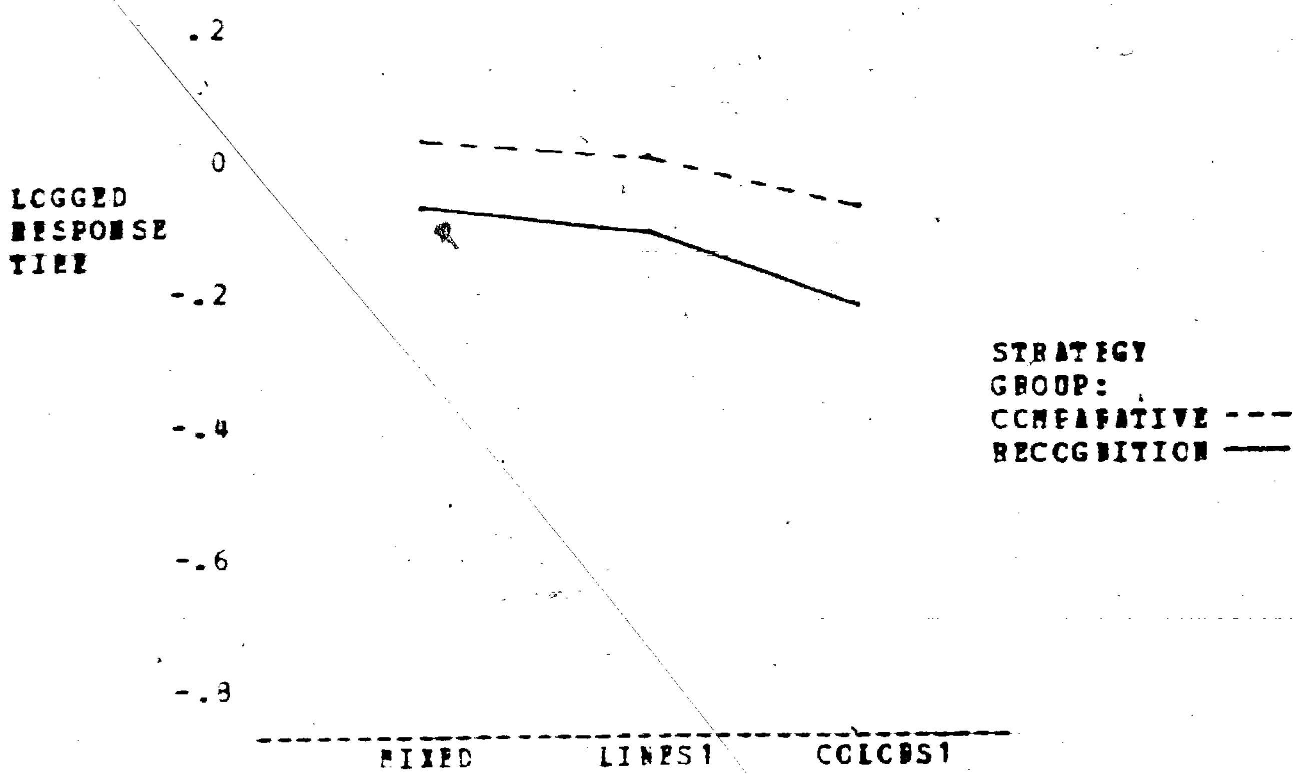
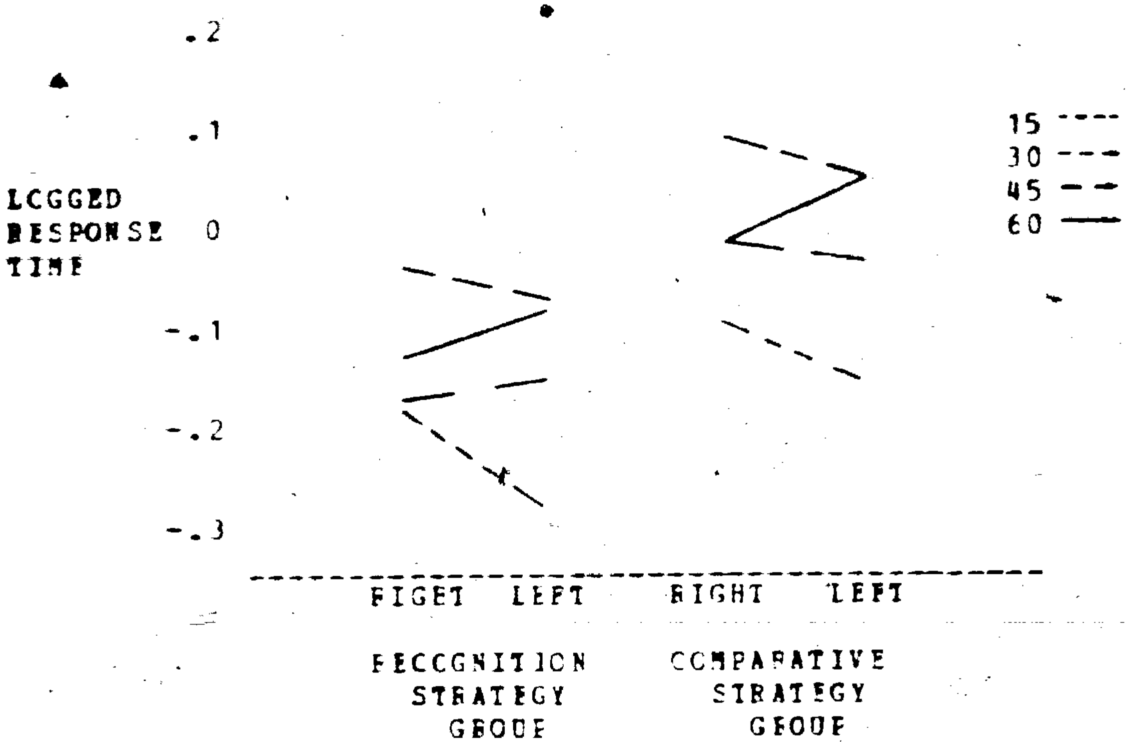


FIGURE 5

STRATEGY GROUPS X HEMISPHERE X LINE INTERACTION



APPENDIX A - TABLES OF DATA ANALYSES

TABLE 1

DESCRIPTIVE STATISTICS - AGE, NUMBER OF TRAINING TRIALS, AND NUMBER OF ERRORS

VARIABLE NAME	MEAN	S.D.	SMALLEST VALUE	LARGEST VALUE	RANGE
TRIALS	4.925	1.110	4	7	3
AGE	28.218	7.864	18	60	42
LP15	.325	.616	0	3	3
LP30	.500	.987	0	4	4
LP45	.575	.884	0	3	3
LP60	.950	1.339	0	4	4
RP15	.550	.904	0	4	4
RP30	.375	.586	0	2	2
RP45	.400	.744	0	3	3
RP60	.900	1.614	0	6	6
LM15	.575	.903	0	3	3
LM30	.525	.816	0	3	3
LM45	.800	1.181	0	6	6
LM60	1.125	1.556	0	5	5
RM15	1.125	1.636	0	5	5
RM30	.500	.961	0	4	4
RM45	.550	.714	0	2	2
RM60	.725	1.132	0	4	4

TABLE 2

ANALYSIS OF VARIANCE - TOTAL DATA

SOURCE	ERROR TERM	D.F.	MEAN SQUARE	F	PROB.
ORDER1	U (OR)	1	.1706	.42	.521
RDER2	U (OR)	1	1.7136	4.22	.473
PRESENT	UP (OR)	1	.9724	32.94	.000**
~~HEMISPHERE~~	~~UH (OR)~~	~~1~~	~~.4333~~	~~5.22~~	~~.028*~~
TYPE	UT (OR)	1	55.9330	492.60	.000**
STIMULI (T)	US (ORT)	6	.4650	15.82	.000**
OR	U (OR)	1	.3635	.90	.350
OP	UP (OR)	1	.2622	8.88	.005**
RP	UP (OR)	1	.0471	1.60	.215
OH	UH (OR)	1	.0082	.98	.328
RH	UH (OR)	1	.0011	.13	.720
PH	UPH (OR)	1	.0004	.08	.780
OT	UT (OR)	1	.0269	2.36	.133
RT	UT (OR)	1	.6592	5.81	.021*
~~PT~~	~~UPT (OR)~~	~~1~~	~~.0842~~	~~5.96~~	~~.020*~~
HT	UHT (OR)	1	.0292	4.12	.050*
U (OR)		36	.4061		
OS (T)	US (ORT)	6	.0255	.87	.520
RS (T)	US (ORT)	6	.0528	1.80	.101
PS (T)	UPS (ORT)	6	.0329	5.12	.000**
HS (T)	UHS (ORT)	6	.0513	5.64	.000**
ORP	UP (OR)	1	.0402	1.36	.251
ORH	UH (OR)	1	.0000	.00	.990
OPB	UPH (OR)	1	.0019	.35	.560
OPH	UPH (OR)	1	.0000	.00	.973
ORT	UT (OR)	1	.0901	.79	.379
OPT	UPT (OR)	1	.0849	6.00	.019*
RPT	UPT (OR)	1	.0644	4.55	.040*
OHT	UHT (OR)	1	.0061	.85	.362
~~RHT~~	~~UHT (OR)~~	~~1~~	~~.0128~~	~~1.80~~	~~.188~~
PHT	UPHT (OR)	1	.0069	1.83	.184
~~UP (OR)~~		~~36~~	~~.0295~~		
UH (OR)		36	.0083		
UT (OR)		36	.1136		
ORS (T)	US (ORT)	6	.0116	.40	.882
OPS (T)	UPS (ORT)	6	.0156	2.43	.027*

RPS(T)	UPS(ORT)	6	.0028	.43	.857
OHS(T)	UHS(ORT)	6	.0111	1.23	.294
RHS(T)	UHS(ORT)	6	.0138	1.51	.174
PHS(T)	UPHS(ORT)	6	.0036	.47	.833
ORPH	UPH(OR)	1	.0283	5.21	.029*
ORPT	UPT(OR)	1	.0020	.14	.710
ORHT	UHT(OR)	1	.0006	.08	.779
OPHT	UPHT(OR)	1	.0014	.38	.539
RPHT	UPHT(OR)	1	.0002	.05	.821
US(ORT)		216	.0294		
UPH(OR)		36	.0054		
UPT(OR)		36	.0141		
UHT(OR)		36	.0071		
ORPS(T)	UPS(ORT)	6	.0032	.50	.810
ORHS(T)	UHS(ORT)	6	.0046	.50	.807
OPHS(T)	UPHS(ORT)	6	.0038	.49	.814
RPHS(T)	UPHS(ORT)	6	.0044	.57	.757
ORPHT	UPHT(OR)	1	.0308	8.20	.007**
UPS(ORT)		216	.0064		
UHS(ORT)		216	.0091		
UPHT(OR)		36	.0038		
ORPHS(T)	UPHS(ORT)	6	.0016	.21	.974
UPHS(ORT)		216	.0078		

TABLE 3

ANALYSIS OF VARIANCE - TOTAL LOGGED DATA

SOURCE	ERROR TERM	D.F.	MEAN SQUARE	F	PROB.
ORDER1	U(OR)	1	.0888	.11	.743
RDER2	U(OR)	1	2.8498	3.49	.070
PRESENT	UP(OR)	1	2.6342	55.50	.000**
HEMISPHERE	UH(OR)	1	.0541	5.38	.026*
TYPE	UT(OR)	1	104.1900	545.46	.000**
STIMULI(T)	US(ORT)	6	.7378	20.41	.000**
OR	U(OR)	1	1.0550	1.29	.263
OP	UP(OR)	1	.4431	9.34	.004**
RP	UP(OR)	1	.0556	1.17	.286
OH	UH(OR)	1	.0052	.52	.476
RH	UH(OR)	1	.0000	.00	.978
PH	UPH(OR)	1	.0017	.24	.624
OT	UT(OR)	1	.2939	1.54	.223
RT	UT(OR)	1	.3403	1.78	.190
PT	UPT(OR)	1	.6894	39.59	.000**
HT	UHT(OR)	1	.0266	3.61	.066
U(OR)		36	.8161		
OS(T)	US(ORT)	6	.0290	.80	.569
RS(T)	US(ORT)	6	.0362	1.00	.425
PS(T)	UPS(ORT	6	.0407	5.64	.000**
HS(T)	UHS(ORT)	6	.0646	7.04	.000**
ORP	UP(OR)	1	.0505	1.06	.309
ORH	UH(OR)	1	.0002	.02	.897
OPH	UPH(OR)	1	.0072	1.04	.314
RPH	UPH(OR)	1	.0000	.00	.966
ORT	UT(OR)	1	.4201	2.20	.147
OPT	UPT(OR)	1	.0326	1.87	.180
RPT	UPT(OR)	1	.0779	4.48	.041*
OHT	UHT(OR)	1	.0021	.28	.599
RHT	UHT(OR)	1	.0218	2.96	.094
PHT	UPHT(OR)	1	.0114	2.64	.113
UP(OR)		36	.0475		
UH(OR)		36	.0100		
UT(OR)		36	.1910		
ORS(T)	US(ORT)	6	.0070	.19	.979
OPS(T)	UPS(ORT)	6	.0117	1.63	.141

RPS(T)	UPS(ORT)	6	.0045	.62	.714
OHS(T)	UHS(ORT)	6	.0104	1.11	.360
RHS(T)	UHS(ORT)	6	.0113	1.23	.293
PHS(T)	UPHS(ORT)	6	.0065	.80	.575
ORPH	UPH(OR)	1	.0302	4.38	.044*
ORPT	UPT(OR)	1	.0005	.03	.863
ORHT	UHT(OR)	1	.0000	.00	.967
OPHT	UPHT(OR)	1	.0015	.34	.561
RPHT	UPHT(OR)	1	.0009	.21	.647
US(ORT)		216	.0362		
UPH(OR)		36	.0069		
UPT(OR)		36	.0174		
UHT(OR)		36	.0074		
ORPS(T)	UPS(ORT)	6	.0022	.31	.934
ORHS(T)	UHS(ORT)	6	.0037	.40	.876
OPHS(T)	UPHS(ORT)	6	.0072	.88	.513
RPHS(T)	UPHS(ORT)	6	.0031	.38	.889
ORPHT	UPHT(OR)	1	.0290	6.70	.014*
UPS(ORT)		216	.0072		
UHS(ORT)		216	.0092		
UPHT(OR)		36	.0043		
ORPHS(T)	UPHS(ORT)	6	.0043	.52	.791
UPHS(ORT)		216	.0081		

TABLE 4

ANALYSIS OF VARIANCE - PARTIAL DATA

SOURCE	D.F.	MEAN SQUARE	F	PROB.
GROUP	2	.4630	5.10	.011*
ERROR	37	.0907		
HEMISPHERE	1	.0021	1.09	.303
HO	2	.0011	.59	.562
ERROR	37	.0020		
TYPE	1	12.3653	500.41	.000**
TO	2	.0063	.26	.775
ERROR	37	.0247		
HT	1	.0006	.47	.495
HTO	2	.0053	4.13	.024
ERROR	37	.0013		

TABLE 5

MEANS AND VARIANCES OF LEFT-RIGHT DIFFERENCES

	LINES	COLORS	DIFFERENCES LINES-COLORS
MIXED	-.025	.005	-.031
COLORS1	-.035	.001	-.036
LINES1	.025	-.017	.042
VARIANCES	.005114	.001359	.005151

TABLE 6

T TESTS ON LEFT-RIGHT DIFFERENCES

COMPARISONS: THE DIFFERENCE OF ANY MEAN FROM ZERO USING THE POOLED LINES AND COLORS VARIANCE AND A SIGNIFICANT T VALUE(37) P=.002 OF 3.30

		T VALUE
MIXED	LINES	1.97
	COLORS	.39
	DIFFERENCES	2.43
LINES1	LINES	1.39
	COLORS	.95
	DIFFERENCES	2.33
COLORS1	LINES	1.95
	COLORS	.06
	DIFFERENCES	2.00

COMPARISONS: THE DIFFERENCES BETWEEN GROUPS ON LINES AND COLORS

MIXED-LINES1	1.47	.65
MIXED-COLORS1	.29	.46
LINES1-COLORS1	1.53	.12

TABLE 7

ANALYSIS OF VARIANCE - PARTIAL DATA, STIMULI PRESENT AS NESTED FACTORS

SOURCE	ERROR TERM	D.F.	MEAN SQUARE	F	PROB.
GROUP	U(G)	1	1.2379	3.32	.030*
HEMISPHERE	UH(G)	1	.0109	1.40	.245
TYPE	UT(G)	1	53.9549	564.44	.000**
U(G)		36	.3726		
STIMULI(T)	US(GT)	6	.4453	18.56	.000**
GH	UH(G)	3	.0053	.69	.566
GT	UT(G)	3	.0889	.93	.436
HT	UHT(G)	1	.0078	1.64	.209
UH(G)		36	.0078		
UT(G)		36	.0956		
GS(T)	US(GT)	18	.0232	.97	.497
HS(T)	UHS(GT)	6	.0243	2.60	.019*
GHT	UHT(G)	3	.0209	4.42	.010**
US(GT)		216	.0240		
UHT(G)		36	.0047		
GHS(T)	UHS(GT)	18	.0061	.65	.855
UHS(GT)		216	.0093		

TABLE 8

STRATEGY GROUP ASSIGNMENT

ASSIGNMENT ON PURE	ASSIGNMENT ON MIXED	STRATEGY GROUP NAME	#s IN GROUP
COMPARATIVE	COMPARATIVE	COMPARATIVE	18
COMPARATIVE	RECOGNITION	COMPARATIVE CHANGE	5
RECOGNITION	RECOGNITION	RECOGNITION	14
RECOGNITION	COMPARATIVE	RECOGNITION CHANGE	3

TABLE 9

ANALYSIS OF VARIANCE - PARTIAL DATA WITH STRATEGY GROUPS

SOURCE	D.F.	MEAN SQUARE	F	PROB.
GROUP	2	.3465	3.81	.032*
STRATEGY GROUP	1	.1757	1.93	.173
GS	2	.0389	.39	.677
ERROR	34	.0909		
HEMISPHERE	1	.0014	.65	.425
HG	2	.0013	.63	.541
HS	1	.0000	.00	.974
HGS	2	.0006	.28	.761
ERROR	34	.0021		
TYPE	1	9.3918	386.87	.000**
TG	2	.0044	.18	.834
TS	1	.0656	2.70	.110
TGS	2	.0041	.17	.846
ERROR	34	.0243		
HT	1	.0009	.66	.423
HTG	2	.0041	3.13	.057
HTS	1	.0000	.08	.777
HTGS	2	.0014	1.04	.363
ERROR	34	.0013		

TABLE 10

ANALYSIS OF VARIANCE - LINE DATA WITH STRATEGY GROUPS

SOURCE	D.F.	MEAN SQUARE	F	PROB.
GROUP	2	.8217	3.75	.034*
STRATEGY GROUP	1	.9117	6.25	.017*
GS	2	.0321	.22	.804
ERROR	34	.1460		
HEMISPHERE	1	.0088	.82	.372
HG	2	.0200	1.86	.171
HS	1	.0003	.03	.872
HGS	2	.0063	.58	.564
ERROR	34	.0108		
LINE	3	.3581	11.03	.000**
LG	6	.0332	1.02	.414
LS	3	.0017	.05	.984
LGS	6	.0372	1.15	.342
ERROR	102	.0325		
HL	3	.0372	2.58	.058
HLG	6	.0094	.65	.691
HLS	3	.0054	.37	.774
HLGS	6	.0123	.85	.533
ERROR	102	.0145		

APPENDIX B - HANDEDNESS QUESTIONNAIRE

NAME: ______________________________

STUDENT#: __________________________

TELEPHONE#: ________________________

Is anyone in your family of birth, brother, sister or parent, left handed? yes_____ no_____

Instructions: For each of the activites listed below, indicate with a "+" which hand you normally use to perform the activity. If you would only use the other hand when forced to, mark a "++". If you would use both hands equally often, place a "a" in each column.

	left	right
Writing a message		
Drawing a picture		
Using a toothbrush		
Throwing a ball		
Using a pair of scissors		

APPENDIX C - COLOR STIMULI

Munsell Color Chips

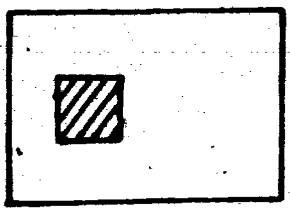
initial

	hue	value	chroma
red	5	4	8
green	5	4	8
blue	5	4	8
purple	5	4	8

final

	hue	value	chroma
red	5	4	8
green	2.5	5	12
blue	5	4	8
purple	5	4	8

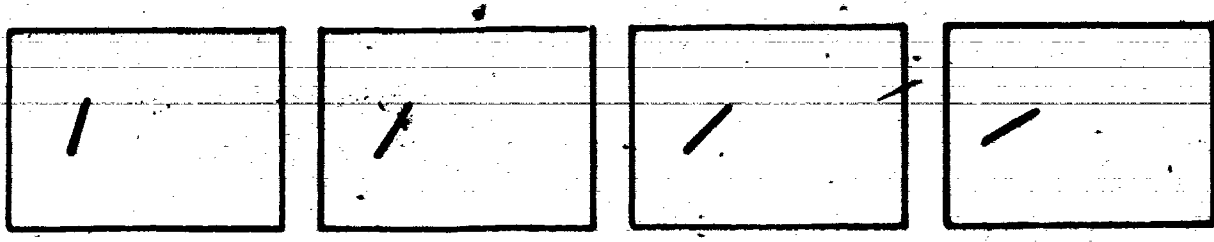
actual size of color square on slide



APPENDIX D - LINE STIMULI

Lines shown to the left visual field
actual size of slide

15 30 45 60



Lines shown to the right visual field

60 45 30 15