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INDIVIDUAL DIFFERENCES IN
LATERALIZATION OF COGNITIVE PROCESSES:
TYPE I AND TYPE II PROCESSORS

Walter Berry Branch



Georgia Southern College

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LATERALIZATION OF COGNITIVE PROCESSES:
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submitted by

Walter Berry Branch

A Thesis Submitted to the Graduate Faculty of
Georgia Southern College in Partial
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MASTER OF ARTS

Statesboro, Georgia

1985

Individual Differences in
Lateralization of Cognitive Processes:
Type I and Type II Processors

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Walter Berry Branch

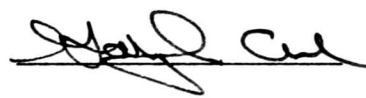
A Thesis Submitted to the Faculty of
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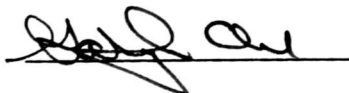
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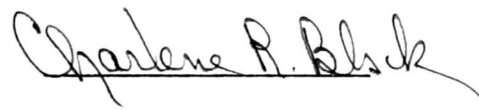
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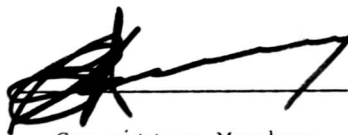
Department Head



Committee Member



Dean, Graduate School



Committee Member

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Abstract

Recent research indicates that the two hemispheres of the human brain serve different functions when processing visual information.

Specifically the left hemisphere, for most individuals, is specialized for an analytic or sequential type of processing and the right hemisphere is specialized for a holistic or gestalt type of processing. However this dichotomy is not always found, and it is hypothesized that individual subject differences may partially account for the somewhat inconsistent results in the research literature. The present study attempts to examine the effect of one individual difference dimension upon process lateralization.

Subjects were classified into two types, Type I and Type II, based on previously established criteria. Type I individuals are characterized as having only a holistic processing capability, while Type II individuals have both holistic and analytic processing capabilities. This individual difference variable is hypothesized to have an effect upon the analytic/holistic lateralization dichotomy within the two hemispheres of the brain. The subjects in the present study were divided into Type I and Type II subject groups. However the low incidence of Type I subjects observed precludes any meaningful comparison between the Type I and Type II groups. The data from subgroups of subjects that were observed were examined for analytic/holistic lateralization effects. It was hypothesized that process lateralization would occur in the Type II subjects, since

these individuals have been described as having dual-processing capabilities. Functional analytic/holistic differences between the two hemispheres were not found. Future research is suggested to clarify the role of individual differences along the Type I/Type II and analytic/holistic dichotomies within the hemispheric specialization research literature.

Individual Differences in
Lateralization of Cognitive Processes:
Type I and Type II Processors

A commonly used method for investigating ways in which the human brain processes visual information is a same-different comparison task. Using this procedure, a trial consists of two simultaneously or successively presented stimuli that are either the same or vary along some experimenter-manipulated dimension, and the subject is asked to judge whether the stimuli are the same or different. Typically, studies have found that the more dissimilar the two stimuli are, the faster is the reaction time (RT) to make a response of "different". In addition, "same" responses have been found to be much faster than the average "different" response (Bamber, 1969; Bindra, Donderi, and Nishisato, 1968; Egeth, 1966; Hawkins, 1969; Nickerson, 1972). This is known as the "fast-same" phenomenon.

There has been little agreement among researchers as to the methodological procedures or cognitive mechanisms that account for these observations. Felfoldy (1974), Krueger (1973), and Williams (1972) have suggested that the same-different phenomena may be due to biased stimulus sampling. In the typical same-different experiment, the total number of possible "same" trials is less than the total number of possible "different" trials. This follows from the fact that there are only \underline{n} ways to achieve all possible stimulus combinations for "same" trials (where \underline{n} = the total number of

stimuli), but the total number of possible "different" trials is $n(n-1)$ (Nickerson, 1973; Silverman & Goldberg, 1975). This is because the "same" trials utilize stimuli that are indeed, exactly the same, hence the individual stimuli that compose "same" trials are used more often than the individual "different" stimuli in order to achieve a .50 probability that a given trial will actually be "same" or "different". In other words, since "same" and "different" pairs occur with equal frequency, the possibility that any given pair of stimuli are repeated is greater for the "same" trials. Williams (1972) and Krueger (1973) suggest that RTs to "different" stimuli would tend to be slower than RTs to "same" stimuli because each "different" combination is novel. Since each "same" pair eventually involves repetition, they are more likely to produce faster RTs. Williams (1972) and Kreuger (1973) systematically varied the frequency of occurrence of specific stimuli, including "same" pairs, and found a significant effect of stimulus frequency on RT; the more frequently appearing stimuli had shorter RTs.

As a test of this proposition, Silverman (1973) used a same-different paradigm in which no specific stimulus pair was repeated. Silverman found that RT to "same" pairs of five-digit numbers was still significantly faster than RT to "different" pairs. Nickerson (1973), in addition to pointing out several possible methodological and empirical flaws in Williams' (1972) study, varied the frequency of occurrence of specific stimuli and found that repetition effects alone could not account for the "fast-same"

phenomena. Also, the results of Kreuger's (1973) experiment are equivocal since the difference between "same" and "different" RT was also significant when stimulus frequency differences were controlled. Thus it appears that sheer frequency of "same" pairs can not account for the "fast-same" phenomenon.

Several models of visual stimulus processing have been postulated to account for the "fast-same" phenomenon. Most common among the various models are those that assume the operation of a single-process type comparison. Some researchers have proposed various stimulus "priming" models (e.g., Beller, 1971; Grill, 1971; Proctor, 1981). According to these models, during successive presentations of stimuli, the first stimulus acts as a prime for the second. If the second stimulus is the same as the first, a fast "same" response can be made since encoding the second stimulus is facilitated by the priming effects of the first stimulus. When the second stimulus is different, there is no facilitation effect, but rather an inhibition effect occurs which results in increased RT. Evidence for the facilitation of priming effects can also be found in the verbal learning hierarchies and linguistic conceptual organizations research literature (Collins & Quillian, 1969; Meyer & Schvaneveldt, 1971).

While priming models appear to account for "same" responses being much faster than "different" responses, they suffer from a lack of generalizability. Priming, by definition, can occur only with successive stimulus presentations, that is, some degree of temporal

separation between stimuli is required (Bagnara, Boles, Simion, & Umilta, 1982). This is assuming, of course, that simultaneously presented stimuli are indeed processed simultaneously, an assumption which has apparently gone unchallenged. Although Proctor (1981) argues that the same-different results occur only with successive stimulus presentations, studies have indicated that the "fast-same" phenomenon can be found using simultaneous stimulus presentations, when priming effects can not operate (Bagnara, Boles, Simion, & Umilta, 1982; Nickerson, 1973). Clearly, stimulus priming models are inadequate in trying to understand all "fast-same" data since priming effects can occur only with successive stimulus presentations.

Other researchers have emphasized the comparison process itself, and a single-process, self-terminating type comparison model has been proposed to account for some same-different comparison task results (Egeth, 1966; Hawkins, 1969). This single-process model states that features of the two stimuli are compared and as soon as a difference is detected, a "different" response is made. The comparison process is analytical in nature, in that stimulus features are analyzed sequentially. This model can explain the decrease in RT as the two stimuli become increasingly dissimilar since the more disparate features there are, the sooner a disparate feature will be detected and a "different" response made. The single-process model also has an advantage over stimulus "priming" models in that comparisons can be made with either simultaneous or successive presentations. Difficulty arises however, with regard to the frequent observation

that "same" responses are faster than the average "different" response. Under a single-process, feature comparison model, "same" responses should be slower than the average "different" response since a "same" response can be emitted only after all possible feature comparisons have been made. It would appear that another comparison process is responsible for "same" responses being faster than the average "different" response. Accordingly, several researchers have proposed a two-process model to explain some same-different comparison task results. "Different" responses are thought to originate from an analytic-type, feature comparison process, much the same as the single-process type model described above, and "same" responses are thought to be determined by a gestalt or holistic comparison process, with both processes operating simultaneously in the same person (Bamber, 1969; Hock, 1973; Keuss, 1977; Nickerson, 1972; Silverman and Goldberg, 1975; Taylor, 1976a, 1976b). An analytic processor would necessarily compare each stimulus feature until a difference was found, hence the more dissimilar the second (probe stimulus) is to the first (criterion stimulus) the quicker a difference can be detected and a "different" response made. A gestalt or holistic type processor could detect sameness faster than an analytic type of processor because the holistic processor would not waste time comparing each stimulus feature, but instead would compare the stimuli as wholes. A two-process model seems to represent more closely the existing data on visual comparisons. Thus Silverman and Goldberg (1975) state:

"There seems to be no way of explaining the present results (of their study) within any single-process system, and therefore some dual-process system seems the only workable theoretical framework that accommodates the 'same'-'different' data" (p. 193).

It should be noted that many of the early studies of visual stimulus processing, while employing considerable variability in design, were concerned with how the brain as a whole processes visual information. Typically, these studies utilized stimuli that were presented in the subject's center visual field (CVF). This procedure assured that the visual images of the stimuli would be equally accessible at the same point in time across all neuronal tracts of a subject's visual system, including those within the two hemispheres of the brain. However, delineation of specific parameters of a phenomenon are often achieved by varying one or more aspect of an experimental situation and comparing the results of this new situation with that of the old. This principle is especially true of the information processing literature. By manipulating visual field of stimulus presentation (among other variables), researchers are able to examine hemispheric differences in visual stimuli processing.

In recent years much attention in cognitive and physiological psychology has been devoted to hemispheric specialization of function within the human brain. The initial impetus for hemispheric specialization research was provided by Sperry and Gazzaniga (Gazzaniga, Bogon, & Sperry, 1955; Sperry, 1964, 1968, 1974). Part of Sperry's technique involves surgically separating the two cerebral

hemispheres by severing the connecting tissue, a procedure called a commissurotomy. Originally designed to alleviate the behavioral effects of severe epilepsy, this procedure allows for exquisite experimental control over many variables. However, it is beyond the capability of the average researcher. Fortunately, simply varying visual field of stimulus presentation circumvents the obvious ethical and procedural problems associated with commissurotomy. The underlying optical and neuro-anatomical mechanisms that allow such non-invasive investigations are deceptively simple.

The retina of each eye can be divided into two equal areas. The retinal tissue that extends from the fovea (the approximate center of the eye) towards the nose is called the nasal retina. That part extending from the fovea towards the ear is called the temporal retina. When a subject is fixated on a point directly ahead, all stimuli in the subject's right-visual-field (RVF) are projected to the temporal retina of the left eye and the nasal retina of the right eye. Similarly, all stimuli in the subject's left-visual-field (LVF) are projected to the temporal retina of the right eye and the nasal retina of the left eye. This process is called lateralizing the optical input of a visual stimulus, or simply, lateralization of a stimulus to the right or left visual field. Furthermore, the bundles of nerve fibers forming the optical tracts that extend from the temporal retina of each eye project to the ipsilateral or same-side cerebral hemisphere, where further processing of the visual image takes place. However, those nerve fibers that extend from the nasal

retina of each eye cross over at the optic chiasm and project to the contralateral or opposite-side cerebral hemisphere. In effect, any stimulus appearing in a subject's RVF has direct access to the left hemisphere (LH) and any stimulus in the LVF has direct access to the right hemisphere (RH). Naturally information transfer from one hemisphere to the other is achieved through the corpus callosum and other minor commissural tissue, but this transfer takes a finite amount of measurable time. It can be readily seen that, using a same-different comparison task, RT differences to stimuli lateralized to the LVF and RVF can be attributed to processing differences between the two hemispheres.

Using this procedure (and others), it has been postulated that the two cerebral hemispheres differ with respect to the type of stimulus, and the type of stimulus processing, each is specialized for. This supposition is aptly stated by Dimond and Beaumont (1974):

Another proposition about the two hemispheres is that although each may proceed towards its solution of a task or problem, each may do so in a rather different way, thereby increasing the chance of a satisfactory solution but also distributing the load between the cerebral hemispheres by the introduction of special modes of function. (p. 49)

One system involving specialization of cerebral function is the verbal/visuospatial dichotomy. It has generally been recognized that the LH is superior to the RH in processing verbal stimuli, while the RH is superior in processing visuospatial stimuli. There is

certainly no dearth of research literature supporting this dichotomy (see Dimond & Beaumont, 1974, and Bradshaw & Nettleton, 1981 for extensive reviews).

From studies involving lateralized tachistoscopic presentation of faces (Geffen, Bradshaw, and Wallace, 1971, exps. I and II; Patterson & Bradshaw, 1975), digits (Geffen et al., 1971, exps. III, IV, and V), and letters (Cohen, 1973; Martin, 1979) it has also been suggested that the left hemisphere (LH) acts as an analytic or serial type processor while the right hemisphere (RH) acts as a gestalt or holistic type processor. This analytic/holistic dichotomy at first glance appears to be another rather simple, parsimonious functional differentiation between the two hemispheres, but not all studies in the literature are in complete agreement with it (Sergent, 1982), while others find little or no evidence whatsoever to support it.

For example, in a study by Simion, Bagnara, Bisiacchi, Ronsato, and Umiltà (1980) subjects were required to make same-different comparisons on three types of visually presented stimuli. The stimuli were normal letters, letters on which a mental transformation (rotation) had to be performed, and geometric shapes. Part of the researchers' interest was to determine if there would be a significant visual field X type of stimulus interaction, or if there would be a significant visual field X match (same/different, or type of process) interaction. Simion et al. found the former interaction significant but not the latter. It is suggested that, at least in this experiment, the type of stimuli (verbal/visuospatial) were more

fundamental than the process (analytic/gestalt) in determining functional hemispheric asymmetries.

Alternatively, in a comparatively simple study by Egeth and Epstein (1972) subjects were presented with two letters, all capitals, one above the other, and the field of presentation was varied. Subjects were required to make same-different comparisons on the letters. Egeth and Epstein found a left visual field-right hemisphere (LVF-RH) advantage for "different" judgements and a right visual field-left hemisphere (RVF-LH) advantage for "same" judgements. Of course, these results are just the opposite of what one would expect if the LH were an analytic processor and the RH a holistic processor.

Bagnara, et al. (1982), in a direct test of the analytic/holistic dichotomy, used a paradigm developed by Taylor (1976a) to require subjects to make same-different comparisons on simultaneously and successively presented letter pairs. Visual field of presentation was varied to assess possible laterality effects. The letters were composed from a fixed set of line segments and the similarity of the letters was systematically varied by having the probe letters differ on one, two, or three line segments from the criterion letters. On "same" trials the two letters were simply repeated. While Bagnara et al. found that "same" responses were faster than "different" responses, and RT to "different" responses decreased with increasing dissimilarity between the two letters, they did not find a significant visual field X match (process)

interaction. It is difficult to explain the lack of an analytic/holistic lateralization effect when, if analytic and holistic processing modes are indeed lateralized to the LH and RH respectively, one should have been apparent.

It is even more difficult to compare the results of the Bagnara et al. (1982) study with other studies because hemispheric function experiments differ on so many variables such as response mode, inter-stimulus-interval, type of stimuli, method of presentation, and subject characteristics. Comparisons among experiments are tenuous at best. In fact the state of the existing lateralization of cognitive function research may have been described best by Friedman and Polson (1981):

. . . the most frequent findings to emerge in well over 100 years of research are (a) the apparent capriciousness of the phenomena, that is, the ease with which relatively superficial changes of stimuli, instructions or other task parameters can switch performance advantage from one hemisphere to the other; (b) the large amount of data that defy replication across laboratories and paradigms; (c) the wide range of individual performance differences observed on tasks that are supposed to be lateralized one way or the other, even among populations suspected to be relatively homogeneous in their degree of lateralization of function, such as right-handed males; (d) the lack of consistency within individuals in the degree of lateralization they show across time and tasks; and finally,

(e) the absence of a global theory that can adequately explain the factors underlying even the existing regularities that have been observed. (pp. 1031-1032)

Friedman and Polson (1981) propose a multiple-resource approach to functional hemispheric lateralization. The basic idea underlying their multiple resource theory is that the available cognitive resources necessary to successfully perform a given task are many, each existing in different degrees, and at least some possibly differentially represented within the two hemispheres.

To use an example from Friedman and Polson (1981), suppose subjects are required to learn a list of visually presented nouns that are orthographically and phonemically dissimilar. The subjects may choose to use a phonemic or semantic style of learning, or they may choose to focus on the global shapes of the words, or even some combination of the above, yet the task performance level may be the same for all the subjects. Thus people may use different strategies to obtain the same results. The types of resources used by a subject are a function of such subject-task parameters as task difficulty, response complexity, visual field, exposure duration, stimulus type and quality, practice, visual acuity, sex of subject, handedness, and so forth, and the particular resources or subset of resources required for stimulus processing. The subset of resources required by a particular task is called the resource composition.

In addition, successful task performance may require the resource composition of only the LH, the RH, or some combination of both, working together, via information transfer through the corpus callosum. Thus the resource composition of one hemisphere may be qualitatively and quantitatively different from the resource composition of the other hemisphere, hence task performance level during lateralized stimulus presentations may not necessarily be equal for all subjects for any given subject-task parameter or combination of parameters.

The implications of such a multiple-resource model are enormous because such a model, if operationally developed, can potentially explain many of the disparate and inconsistent findings of many laterality studies. Friedman and Polson maintain that manipulating such subject-task parameters as visual field, exposure duration, handedness, type of stimuli, and so forth, will change the hemispheric resource composition needed to perform a given task and thus may affect differential hemispheric processing level.

If a task can be performed using several different resource compositions and if subjects differ in which resources are available to them, then we would expect somewhat inconsistent results if relevant subject-task parameters are not controlled for. Thus Friedman and Polson (1981) state that:

. . . in addition to the fact that tasks vary in the extent to which they demand resources from one or the other hemisphere, we assume that subjects vary in the extent to which the

resources of either hemisphere can be efficiently applied to performance. . . we recognize that individual differences in the factors above are important parameters of information processing, so that it is probably most appropriate to speak in terms of degrees of lateralization for a given person under a particular set of circumstances. (pp. 1053-1054)

While Friedman and Polson do not explicitly indicate some possible cognitive resources (we can assume analytic and holistic processors to be two) and their nature and degree of lateralization, if any, the approach taken by Friedman and Polson is unique in that it attempts to unify the sometimes widely different findings in the hemispheric specialization literature through a model that discriminates between traditional experimenter-manipulated variables and the individual differences in cognitive resources that a person brings to a task situation. Friedman and Polson (1981) conclude that ". . . efforts to delineate what the hemispheres are specialized for may yield conclusions that depend as much upon the particular people chosen for the study as they do upon whatever experimental environment those individuals have encountered" (p. 1054).

Some attempt has been made to identify certain groups of individuals for whom lateralization of cognitive processes may not be as pronounced as for other groups. In particular, evidence suggests that females, as a population, may not be as completely lateralized in hemispheric specialization as males (Kimura, 1969). Evidence also

suggests that left-handed individuals are more diffuse in terms of lateralization of cognitive function (Hecan & Sauguet, 1971; Beaumont, 1974).

The hemispheric specialization differences between males vs. females or left-handed vs. right-handed individuals are certainly noteworthy, and many of the more recent studies control for these differences to more adequately insure subject homogeneity. Obviously this eliminates a possible source of confounding. However, individual differences of these kinds are not entirely the types to which Friedman and Polson (1981) are referring. These variables are merely superficial classificatory variables and as such, it is difficult to infer a cause-and-effect relationship between an individual's class and his or her degree of lateralization. Exposition of these variables should not elevate them to the status of explanation. They offer little by way of explaining hemispheric performance differences between classes of subjects.

Furthermore, it is commonly assumed that these classificatory variables represent the only relevant subject dimensions involved in lateralization effects. However, the cognitive abilities to which Friedman and Polson are referring may interact with male/female and left-handed/right-handed classifications, and may be more fundamental than these classifications.

Interestingly, there have been very few attempts in the literature to identify other individual differences in visual stimulus processing (Cooper, 1976; Cooper & Podgorney, 1976; Hock,

1973; Hock, Gordon, & Marcus, 1974; Levy, 1983; Simmons, 1982).

However, as Friedman and Polson (1981) point out, subjects may bring individual cognitive differences to a particular experimental task that may confound the results of the experiment if the data are pooled, as is usually done.

In an attempt to identify other types of individual differences using non-lateralized stimulus presentations, Cooper (1976) identified two subgroups of individuals who apparently used two quite different cognitive processes in a same-different comparison task. Subjects were exposed to five "standard" nonsense shapes, each different in the number of angles that composed the shape. Each standard had seven "distractors". One distractor was a mirror image of its standard and the other six were random perturbations of the standard which varied systematically in their similarity to the standard. Each standard-distractor pair was presented successively, and the subjects were required to judge whether the stimuli were the same or different. On half of the trials the stimuli were the same and on the other half they were different.

Reaction time data were analyzed for each subject and two distinct patterns were noted. For some subjects "same" responses were faster than "different" responses, "different" responses were unaffected by the similarity of the test stimulus to the criterion, and RTs and error rates were unrelated. Cooper called these subjects "Type I". For the other subjects "same" responses were slower than the average "different" response, but "same" responses were faster

than "different" responses when the stimuli were highly similar. Also, RT decreased with increasing dissimilarity between the stimuli, and there was a positive correlation between RT and error rates. These subjects were labelled "Type II".

Cooper (1976) explains the performance of the Type I subjects in terms of their using a rapid, single process, holistic type of comparison. If the outcome of this comparison produces a positive match, the "same" response is executed. If the outcome is negative, the "different" response is made by default. This single-process model accounts for the rapid "same" responses and the somewhat slower "different" responses, which require additional processing time.

The performance of the Type II subjects cannot be so easily explained. Cooper (1976) interprets the performance of the Type II subjects in terms of a dual-process model in which independent but simultaneous operation of a holistic and analytic processor is assumed. The "same" processor compares the two stimuli holistically, as do the Type I subjects, but the decrease in RT as the stimuli become increasingly dissimilar also indicates the operation of an analytic type processor. This analytic processor compares features of the two stimuli, checking for differences. The more differences there are, or the more dissimilar the two stimuli, the quicker a difference can be detected and a "different" response made.

Similarly, Hock, Gordon, and Marcus (1974) used embedded and intact figures in a same-different comparison task to find evidence for individual differences in visual stimuli processing. One group

of subjects, identified by Hock et al. as being "structural", were affected by the rotation of intact figures. They were also less able to detect embedded figures. Another group of subjects, termed "analytic", were not affected by stimulus rotation and they were better able to detect embedded figures. The design utilized by Hock et al. sought to identify a procedure for classifying subjects into dichotomous categories. It's utility is questioned because as Simmons (1982) points out, classification is determined solely on the basis of the presence or absence of a rotation effect on RT and does little to address either a single-process or dual-process theory of visual stimulus processing. Cooper's (1976) study however, employed multiple criteria for determining Type I or Type II classification. These criteria are directly relevant to single-process and dual-process theories. Also, subjects in the Hock et al. study were required to give only a "same" response and ignore "different" trials which results in an unnecessary loss of seemingly pertinent data. Simmons (1982) concludes that Cooper's (1976) methodology is more appropriate for investigating individual differences in visual stimulus processing.

Clearly the individual differences identified by Cooper (1976) have implications for the multiple-resource model postulated by Friedman and Polson (1981), and hence laterality studies in general, which attempt to identify asymmetrical hemispheric processing abilities by aggregating data across all subjects. By treating a Type I or Type II processing preference as a subject-task parameter,

one could control for this variable and provide a more adequate test of lateralization effects. In addition, any subsequent lateralization of cognitive processes could possibly provide a more operationalized indication of some cognitive resources, which Friedman and Polson fail to do.

Perhaps as Friedman and Polson (1981) suggest, combining the data from subjects who differ in their cognitive resources, or at least in their processing preferences, will lead to confounding and confusing results. Thus it is hypothesized that lateralization effects along a given dimension (e.g. analytic vs. holistic processing) may be characteristic of only certain subgroups of people.

The present study was designed to test just such an hypothesis by first classifying subjects as Type I and Type II processors, then examining the data of each group for evidence of analytic and holistic process lateralization. Specifically, the study used Cooper's (1976) criteria for classifying subjects as Type I or Type II. In addition, two different classes of stimuli were used to examine the effects of stimulus type, if any, upon process lateralization. Random nonsense shapes were used to extend Cooper's (1976) procedure to lateralized stimuli presentations, and they were compared with the verbal stimuli developed by Taylor (1976a). Both types of stimuli are well suited for use in the same-different paradigm since both easily provide for differing degrees of criterion and probe dissimilarity by manipulating the physical characteristics

of the stimuli. Generally, the study sought to determine the role, if any, of the Type I/Type II dichotomy in lateralization of cognitive function. Specifically, it was hypothesized that, given the analytic/holistic dichotomy, lateralization of process type would appear only in Type II subjects, since these subjects have previously been described as possessing dual-processing capabilities (Cooper, 1976). For these subjects the LH should show an advantage for making "different" responses and the RH should show an advantage for making "same" responses. The Type I subjects however, should show no lateralization of cognitive functions, but rather RT to "same" responses should be equal for both hemispheres.

Method

Subjects

The subjects were obtained from two large introductory psychology courses taught at Georgia Southern College, during winter quarter, 1985. The subjects consisted of 30 undergraduate right-handed males, all of whom had no immediate familial history of left-handedness. Subjects were initially screened for handedness and familial history from a larger subject pool by using the questions portion of the Harris Tests of Lateral Dominance (Harris, 1974, see Appendix A), plus additional questions concerning familial left-handedness. No individual was used who indicated using his left hand for more than three items on the questions portion of the Harris

Tests, and who had a family member who was predominantly left-handed. All subjects who passed this global screening were invited to participate after they had been individually screened for appropriate visual acuity using a Snellen chart. No subject was used whose visual acuity was not at least 20/40, corrected or uncorrected. The subjects were paid for their participation in the study.

Apparatus

Following Cooper (1976), the stimuli used to classify subjects as Type I or Type II consisted of nonsense shapes generated by Attneave and Arnould (1956) Method I for the construction of random nonsense shapes. Cooper used five standard nonsense shapes and seven distractor nonsense shapes per standard. Since Cooper's classification study required several hours and experimental sessions per subject, a reduction in the number of stimuli was used in the present study to decrease the total time needed to classify a subject. The stimuli used in the present study consisted of three standard shapes and five distractor shapes per standard. They were the same ones used by Simmons (1982) to classify subjects as Type I or Type II. Each of the five perturbations per standard varied systematically in their similarity to the standard. Cooper (1976) used a reflected or mirror image of the standard as one of the distractor stimuli, but since the use of the reflected stimulus was not crucial to the subject's classification, it was not used in the present study.

Each stimulus was black on a white circular field. At a viewing distance of 921 mm, the circular field subtended 4 deg of visual angle and the stimulus itself subtended 2 deg of visual angle. The viewing distance was the same for all stimuli. Each pair of standard/distractor shapes was presented in 3 orientations of 0 deg, 120 deg, and 240 deg.

A different set of random nonsense shapes was used to examine lateralization effects. This different set also consisted of three standard shapes and five distractors per standard, but instead of using three different standard/distractor orientations, visual field was varied. The standard stimuli were generated using Attneave and Arnould (1956) Method I for the construction of random nonsense shapes. Cooper and Podgorney (1976) detail the construction of the distractor stimuli. During all stimuli presentations the standard stimulus appeared in the center visual field (CVF) and the distractor stimulus appeared in the left visual field (LVF) or the right visual field (RVF). Each stimulus was black on a white circular field. The circular field subtended a visual angle of 4 deg while the stimulus itself subtended a visual angle of 2 deg. The angle of separation between the standard stimuli and distractor was 4 deg 21 min.

A set of verbal stimuli was also used to examine possible effects of stimulus type on process lateralization. The verbal stimuli developed by Taylor (1976a) in a study of non-lateralized analytic and holistic processes (see Figure 1) were used in the present study. Taylor used the letters A, E, O, F, H, and U as

The Six Criterion Letters

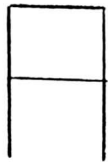


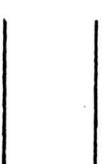
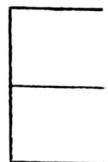
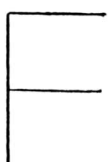
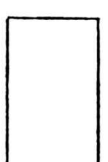
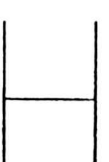
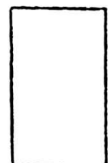
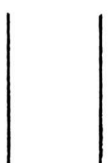
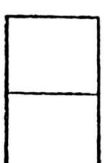
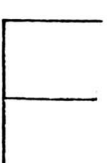
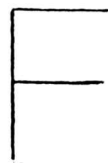
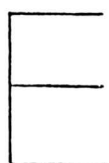
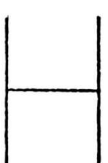
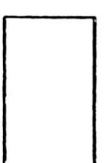
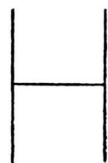
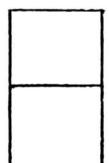
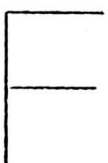

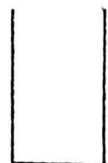
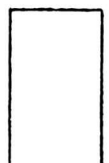
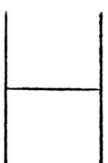
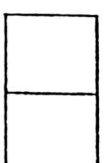
	1	2	3
			
			
			
			
			
			

Figure 1. Taylor's Verbal Stimuli.

The letters shown are twice their actual size.

(Taylor, 1976)

standard or criterion stimuli. By varying the number of line segments composing these letters, Taylor created distractor stimuli that differed from the standard stimuli on one, two, or three line segments. All the distractor stimuli for each standard were one of the other five standard stimuli.

In the present study, each of Taylor's (1976a) six standard stimuli appeared in the CVF and each of the three distractor stimuli appeared in the LVF, and the RVF. The angle of separation between the standard and distractor stimuli was 4 deg 21 min. The letters were presented in black on a white circular field. The circular field subtended a visual angle of 55.80 min and each letter was 37.20 X 22.20 min in size. The thickness of the line segments composing each letter was 6.6 min.

All the nonsense shape stimuli were constructed using ordinary black and white construction paper. The letter stimuli were drawn into the circular field using Higgins black India ink and a Speedball C-2 calligraphy pen. All stimuli were presented by means of an Iconix three-channel tachistoscope. An electronic timer, coupled to the tachistoscope, measured RT in msec and controlled presentations of the stimuli. The luminance level of all the white circular fields was kept at 68.5 cd/m^2 .

Procedure

The total experiment was divided into three sessions. The first was the same for all subjects. It was for the purpose of classifying

subjects as Type I or Type II. Subjects were greeted by the experimenter and seated in front of the tachistoscope. They were then asked to sign a letter of consent (see Appendix B) and given written instructions (see Appendix C). Any questions concerning their task, but not the explicit nature of the study, were then answered.

Using the reduced number of Cooper's (1976) nonsense shape stimuli, the subjects were first presented with a central fixation point in the CVF for 2000 msec followed by a standard stimulus in one of three orientations for 3000 msec. Immediately following the offset of the standard stimulus an inter-stimulus-interval of 100 msec began, after which a distractor stimulus was presented in the same orientation as the standard. The subjects were required to indicate whether the two stimuli were the same by saying "same" or "different" into a microphone connected to a voice activated relay which was coupled to the timer. Reaction time was measured from the onset of the distractor stimulus until a "same" or "different" response was made.

Subjects were provided with verbal feedback concerning the accuracy of their judgements. Error trials were recorded and were presented again, randomly interspersed with the remaining trials. Subjects were told that for each trial the probabilities of the distractor stimulus being the same as or different from the standard were equal. This was true of all trials in each of the three sessions. Prior to the experimental session proper each subject participated in 13 randomly selected practice trials. There were 10

comparisons per standard in each orientation, 5 same and 5 different. Thus 30 comparisons per orientation or 90 comparisons total, plus any error trials, were made per subject. The experimenter was blind as to the results of this initial classification session until after all three sessions were completed.

The second and third sessions were for the purpose of examining lateralization effects. Half of the subjects received the second set of lateralized nonsense shapes and written instructions (see Appendix D) in the second session and the verbal letter stimuli and instructions (see Appendix E) in the third session. The other half received the opposite sequence.

Presentation of the lateralized nonsense shapes was similar to that of the previously shown non-lateralized nonsense shapes. However visual field as a variable was substituted for the orientation variable, with distractor stimuli appearing in the LVF and RVF an equal number of times. The standard stimuli appeared only in the CVF. There was a 2000 msec presentation of a central fixation point. Each standard stimuli then appeared for 500 msec. Then there was a 1000 msec inter-stimulus-interval which was followed by a 100 msec presentation of a distractor stimulus. Each subject was given 13 randomly selected practice trials before the experimental session proper. There were 10 comparisons per standard in each visual field, 5 same and 5 different. Thus 30 comparisons per visual field or 60 comparisons total, plus any error trials, were made per subject.

Presentation of the lateralized, letter stimuli was the same as that of the lateralized nonsense shapes. The number of practice trials, stimulus duration, and inter-stimulus-interval was also the same. There were 18 comparisons per standard, 9 same and 9 different, and 36 comparisons per visual field, per subject. A total of 72 comparisons, plus any error trials, were made per subject.

The response mode was a manual key-press for both lateralization sessions. Since Berlucchi, Heron, Hyman, & Rizzolatti (1971) have demonstrated that responding with the hand ipsilateral to the stimulus is significantly faster than responding with the hand contralateral to the stimulus, half of the subjects responded "different" with their right index finger by tapping a key which was positioned to the right of the subject's midline, and "same" by tapping their left index finger on a key positioned to the subject's left. The other half had the opposite arrangement. This procedure should have also controlled for any response advantage that the right hand may have had due to the left or verbal hemisphere having direct access to RVF stimuli (and hence faster RT) if a verbal response were used. When not responding, subjects were asked to maintain their index fingers on two non-functioning keys located between the two responding keys.

Results

Using the data from the initial classification session, the subjects were first classified as Type I or Type II according to

Cooper's (1976) criteria. Because each overall "same" vs. overall "different" RT comparison was based on 45 data points per mean, it was felt that this comparison would be the most reliable in terms of the variance within each group of RTs. Those subjects whose overall mean "same" RT was slower than their overall mean "different" RT were tentatively classified as Type II. Those subjects whose overall mean "same" RT was faster than their overall mean "different" RT were tentatively classified as Type I. Each subject's "different" RT data was then examined to determine if there was a tendency for RT to decrease as the distractor stimuli became increasingly dissimilar to the standard. This criterion was thought to be the least reliable since only nine data points per distractor were used to compare with the 45 data points per standard, hence one would expect more variability within each distractor score. Those Type II subjects whose "different" RTs tended to decrease with increasing distractor dissimilarity remained classed as Type II. Some Type II subjects, however, failed to show decreasing RT with increasing distractor dissimilarity. These subjects were classified as Type IIA (Simmons, 1982). For those subjects tentatively classified as Type I, some demonstrated decreasing RT with increasing distractor dissimilarity. These subjects were also classed as Type IIA. The remaining subjects, those whose mean "same" RT was faster than their mean "different" RT and whose mean distractor RTs did not tend to decrease, were classed as Type I. These classification criteria resulted in 22 subjects being classed as Type II, 6 as Type IIA, and only 2 as Type I (see Figure 2 and Appendix F).

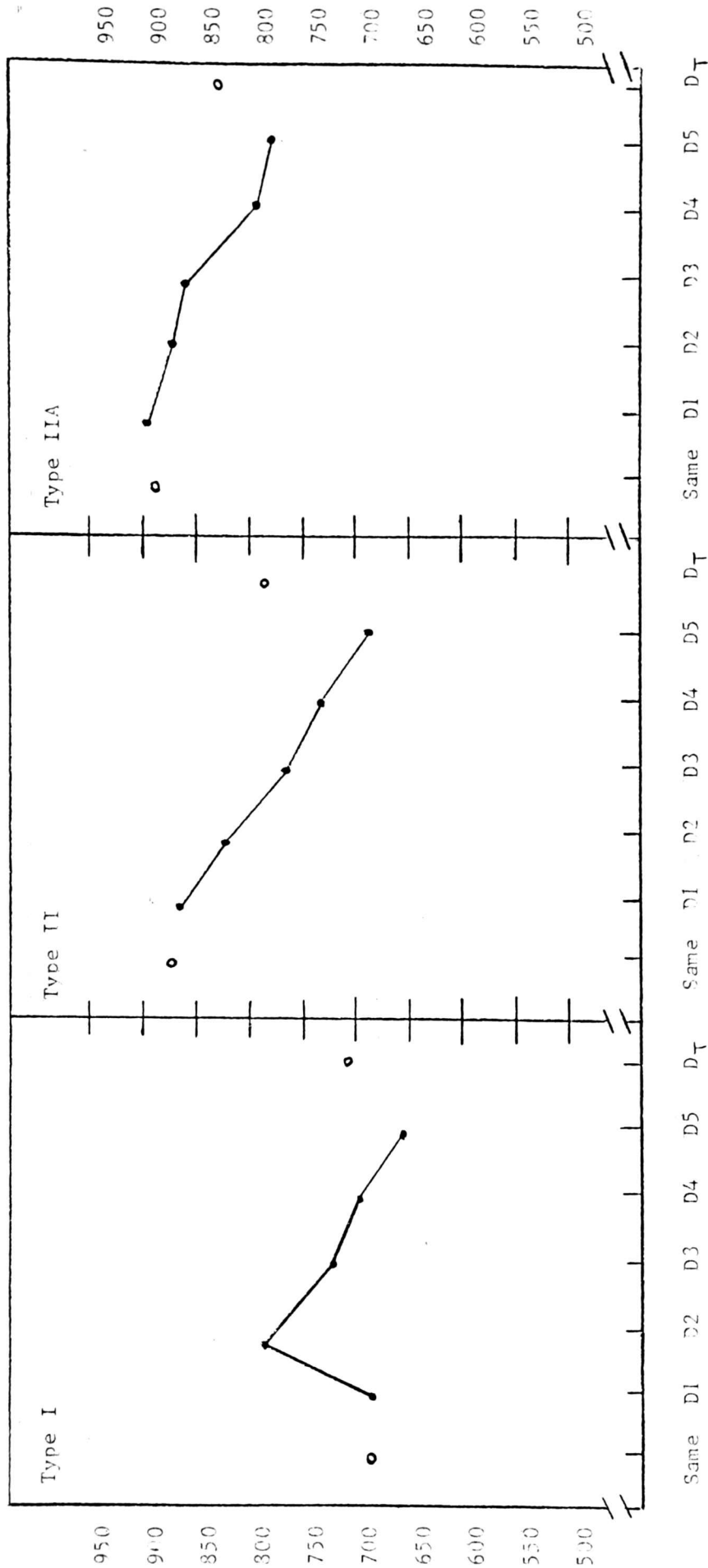


Figure 2. Mean RTs for the Type I, Type II and Type IIA subjects data from the classification session.

Originally the RT data for both the Type I subjects and the Type II subjects were to be subjected to a 2 x 2 x 2 within subjects ANOVA to examine lateralization effects. However two subjects dropped from the experiment after the initial classification session. One subject was classed as Type I and the other was Type II. This left an n of 28 for the two lateralization sessions. With only one of the two Type I subjects having lateralization data, analysis of this subject's data would be meaningless. It was decided that data analysis of the RT scores from the two lateralization sessions would consist of various combinations of the subject subgroups. Separate ANOVAs were done using, (1) the RT data for the Type I, Type II, and Type IIA groups combined, (2) the RT data of only the Type II group, and (3) the RT data of only the Type IIA group. The factors used for all the ANOVAs were stimulus type (letters vs. nonsense shapes), visual field (left vs. right), and match (same vs. different).

An ANOVA of all the subjects combined (see Table 1 and Table 2) yielded a significant main effect of Stimulus Type $F(1,27) = 6.19$, $p < .05$. The mean RT time for the letter stimuli was 666.77 msec and for the nonsense shapes it was 714.91 msec, a difference of 48.14 msec.

There were two significant interaction effects, Stimulus Type X Visual Field, $F(1,27) = 7.09$, $p < .01$, and Stimulus Type X Match, $F(1,27) = 15.87$, $p < .001$. Analysis of the simple main effects of Visual Field in the Stimulus Type X Visual Field interaction revealed that the nonsense shape stimuli were processed 22.62 msec faster when

Table 1

Source Table For The Stimulus Type X Visual Field X Match ANOVA
of the Type I, Type II, and Type IIA Subjects Combined RT Data

Source	SS	df	MS	F
Stimulus Type	129784.96	1	129784.96	6.19*
Stimulus Type X Subjects	565727.97	27	20952.89	
Visual Field	3843.66	1	3843.66	1.80
Visual Field X Subjects	57803.55	27	2140.87	
Match	3979.55	1	3979.55	1.23
Match X Subjects	87573.91	27	3243.48	
Stimulus Type X Visual Field	11506.27	1	11506.27	7.09**
Stimulus Type X Visual Field X Subjects	43833.34	27	1623.46	
Visual Field X Match	711.96	1	711.96	.37
Visual Field X Match X Subjects	51349.58	27	1901.84	
Stimulus Type X Match	43733.65	1	43733.65	15.87***
Stimulus Type X Match X Subjects	74400.93	27	2755.59	
Stimulus Type X Visual Field X Match	38.38	1	38.37	.02
Stimulus Type X Visual Field X Match X Subjects	45905.14	27	1700.19	
Total	1151898.40	196		

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

Table 2

Mean RTs for Each Term in the Stimulus Type X Visual Field X Match ANOVA
for The Type I, Type II, and Type IIA Subjects Combined

Verbal	566.77			
Non-Verbal	714.91			
LVF	686.70			
RVF	694.98			
Same	686.63			
Different	695.06			
	<u>Verbal</u>	<u>Non-Verbal</u>		
LVF	669.80	703.60		
RVF	663.75	726.22		
	<u>Verbal</u>	<u>Non-Verbal</u>		
Same	648.58	724.67		
Different	684.96	705.15		
	<u>LVF</u>	<u>RVF</u>		
Same	684.27	688.99		
Different	689.13	700.98		
	<u>LVF</u>	<u>LVF</u>	<u>RVF</u>	<u>RVF</u>
	<u>Verbal</u>	<u>Non-Verbal</u>	<u>Verbal</u>	<u>Non-Verbal</u>
Same	653.81	714.73	643.36	734.61
Different	685.79	692.47	684.13	717.83

Note. All values are in msec

they were presented in the RVF (703.60 and 726.22 msec, respectively). There was no difference in RT between visual field of presentation for the letter stimuli (669.63, and 663.75 msec for the LVF and RVF respectively), although the absolute differences were in the expected direction. Analysis of the simple main effects of Match in the Stimulus Type X Match interaction revealed that RT differences between the two stimulus types depended upon the type of response being made. Mean "same" RT to the letter stimuli was 36.38 msec faster than mean "different" RT (648.58 and 684.96 msec, respectively), $F(1,27) = 11.57$, $p < .01$. While mean "same" RT to the nonsense shapes was 19.52 msec slower than the mean "different" RT (724.67 and 705.15 msec respectively), this term approached but did not quite reach significance, $F(1,27) = 3.81$, $p = .06$.

A second ANOVA was performed using only the data from the Type II subjects (see Table 3 and Table 4). The Stimulus Type main effect approached but did not reach significance, $F(1,20) = 4.09$, $p > .056$, (668.48 and 718.92 msec for the letters and nonsense shapes, respectively). There was also a significant interaction between Stimulus Type and Match, $F(1,20) = 9.12$, $p < .01$. Mean "same" RT for the letter stimuli was 657.03 msec and mean "different" RT was 679.94. Mean "same" RT for the nonsense shapes was 730.65 msec and mean "different" RT was 707.20.

A third ANOVA was performed using the RT data from only the Type IIA subjects (see Table 5 and Table 6). The Stimulus Type X Visual Field interaction was significant, $F(1,5) = 9.85$, $p < .05$. Mean RT

Table 3

Source Table For The Stimulus TypeX Visual Field X Match ANOVA of the Type II Subjects RT Data

Source	SS	df	MS	F
Stimulus Type	106861.18	1	106861.18	4.09
Stimulus Type X Subjects	521364.48	20	26068.22	
Visual Field	3909.22	1	3909.22	2.18
Visual Field X Subjects	35835.95	20	1791.80	
Match	3.03	1	3.03	.001
Match X Subjects	58659.40	20	2932.96	
Stimulus Type X Visual Field	2724.12	1	2724.12	1.98
Stimulus Type X Visual Field X Subjects	27473.49	20	1373.67	
Visual Field X Match	969.66	1	969.66	.52
Visual Field X Match X Subjects	37216.08	20	1860.80	
Stimulus Type X Match	22555.99	1	22555.99	9.12**
Stimulus Type X Match X Subjects	49472.85	20	2473.64	
Stimulus Type X Visual Field X Match	2287.86	1	2287.86	.56
Stimulus Type X Visual Field X Match X Subjects	80475.96	20	4023.80	
Total	949809.27	147		

** $p < .01$

Table 4

Mean RTs for Each Term in the Stimulus Type

X Visual Field X Match ANOVA for the Type II Subjects

Verbal	668.48			
Non-Verbal	718.92			
LVF	688.88			
RVF	698.53			
Same	693.83			
Different	693.57			
	<u>Verbal</u>	<u>Non-Verbal</u>		
LVF	667.69	710.07		
RVF	669.28	727.77		
	<u>Verbal</u>	<u>Non-Verbal</u>		
Same	657.03	730.65		
Different	679.94	707.21		
	<u>LVF</u>	<u>RVF</u>		
Same	691.63	696.05		
Different	686.13	701.70		
	<u>LVF</u>	<u>LVF</u>	<u>RVF</u>	<u>RVF</u>
	<u>Verbal</u>	<u>Non-Verbal</u>	<u>Verbal</u>	<u>Non-Verbal</u>
Same	656.35	726.91	657.71	734.38
Different	679.02	693.24	680.85	721.16

Note. All values are in msec.

Table 5

Source Table For The Stimulus TypeX Visual Field X Match ANOVA of the Type IIA Subjects RT Data

Source	SS	df	MS	F
Stimulus Type	11994.73	1	11994.73	1.68
Stimulus Type X Subjects	35691.53	5	7138.31	
Visual Field	691.30	1	691.30	.17
Visual Field X Subjects	20687.97	5	4137.59	
Match	8395.80	1	8395.80	3.91
Match X Subjects	10724.74	5	2144.95	
Stimulus Type X Visual Field	16560.73	1	16560.73	9.85*
Stimulus Type X Visual Field X Subjects	8406.90	5	1681.37	
Visual Field X Match	82.42	1	82.42	.03
Visual Field X Match X Subjects	12914.71	5	2582.94	
Stimulus Type X Match	25344.18	1	25344.18	6.35
Stimulus Type X Match X Subjects	19955.34	5	3991.07	
Stimulus Type X Visual Field X Match	3488.43	1	3488.43	3.51
Stimulus Type X Visual Field X Match X Subjects	4969.21	5	993.84	
Total	179907.99	42		

* $p < .05$

Table 6

Mean RTs for Each Term in the Stimulus TypeX Visual Field X Match ANOVA for the Type IIA Subjects

Verbal	672.60			
Non-Verbal	704.22			
LVF	684.62			
RVF	692.21			
Same	675.19			
Different	701.64			
	<u>Verbal</u>	<u>Non-Verbal</u>		
LVF	687.38	681.85		
RVF	657.82	726.59		
	<u>Verbal</u>	<u>Non-Verbal</u>		
Same	636.40	713.97		
Different	708.81	694.47		
	<u>LVF</u>	<u>RVF</u>		
Same	670.08	680.29		
Different	699.15	704.12		
	<u>LVF</u>	<u>LVF</u>	<u>RVF</u>	<u>RVF</u>
	<u>Verbal</u>	<u>Non-Verbal</u>	<u>Verbal</u>	<u>Non-Verbal</u>
Same	658.39	681.77	614.40	746.18
Different	716.37	681.93	701.24	707.00

Note. All values are in msec.

for the letters appearing in the LVF was 687.38 while letters appearing in the RVF had a mean RT of 657.82. Mean RT for the nonsense shapes appearing in the LVF was 681.85, while shapes appearing in the RVF had a mean RT of 726.59. These simple main effects, though not significant, are in the expected direction. The Stimulus Type X Match Interaction was also significant, $F(1,5) = 6.35$, $p > .05$. Mean RT "same" and "different" for the letter stimuli was 636.40 msec and 708.81 msec. Mean RT "same" and "different" for the nonsense shapes was 713.91 msec and 694.47 msec.

Chi-square analyses were performed on the error rate data from the classification session. There were significantly more errors made on "same" trials than on "different" trials, $X^2(1, N = 351) = 7.42$, $p < .01$. The five distractor stimuli also differed significantly in their distribution of errors, $X^2(1, N = 351) = 234.99$, $p < .01$, with the number of errors increasing as the distractors increased in similarity to the standard.

Additional chi-square analyses were performed on the two types of stimuli to determine if the distribution of error rates differed with respect to visual field. There was no significant difference in error rates across both visual fields for the letters, $X^2(1, N = 67) = .37$, $p > .05$, and for the shapes, $X^2(1, N = 137) = 3.52$, $p > .05$.

Discussion

Most notable among the results of the initial, classification session is that only 2, or 7%, of the 30 subjects were classed as Type I. Both Cooper (1976; Cooper & Podgorney, 1976) and Simmons (1982) reported the proportion of Type I subjects and Type II subjects as being about .30 and .70 respectively (including the Type IIA subjects in Simmons study as Type II). A chi-square analysis of the frequency of Type I and Type II subjects in the present study, based on Cooper's and Simmons' classification data, reveals that the incidence of Type I and Type II subjects in the present study differs significantly from the expected frequency, $\chi^2 (1, N=30) = 6.635, p < .01$.

A total of six subjects in the present study could not be clearly classified as Type I or Type II. They most nearly resembled the Type II subjects so they were labeled Type IIA. Cooper (1976; Cooper & Podgorney, 1976) did not find these subjects in her experiments. Simmons (1982), using a reduced number of Cooper's stimuli reported 9 out of 30 subjects as being Type IIA.

Rather than suggesting the existence of a third class of subjects, the occurrence of the Type IIA subjects in Simmons' and the present study are probably the result of using a reduced number of standard and distractor stimuli from that used by Cooper (1976). Cooper used a total of five standard stimuli and seven distractor

stimuli per standard. This standard/distractor combination resulted in a total of 420 comparisons per subjects, significantly more than the 90 comparisons used in the present study. Specifically, each "same" mean RT score per subject in Cooper's study was based on 210 comparisons, whereas each "same" mean RT score per subject in the present study was based on only 45 comparisons. Each of the seven mean distractor RT scores in Cooper's study was based on 30 individual comparisons, whereas in the present study, only nine comparisons determined each mean distractor RT. Since so few raw data points determined each mean distractor RT in the present study, any given mean distractor RT was more readily influenced by extreme score values. Hence a random occurrence of a few extreme raw data points probably contributed in affecting the "actual" mean value for some of the distractor or standard stimuli, if indeed these subjects are actually Type II, and may have resulted in a misclassification.

It is also interesting to note that, while more errors were made in "same" responses in the present study, this finding is the exact opposite of that found by Cooper (1976). However in both studies errors tended to decrease as the distractor stimulus decreased in similarity to the standard.

The comparatively low incidence of Type I subjects in the present study may be explained as simply a sampling problem. That is, by chance only 2 of the 30 subjects in the present study may have actually been of the Type I variety.

Alternatively, some type of subject selection bias may have been operating to produce so few Type I subjects. Cooper (1976; Cooper & Podgorny, 1976) reports that, of a total of 26 subjects in 3 experiments, 11 were female and 1 male was left-handed. Simmons (1982) reports that 13 of a total of 30 right-handed subjects were female. Neither study controlled for familial handedness. Since gender, handedness, and familial-handedness have previously been identified as factors affecting cognitive performance, it is not unreasonable to assume that these variables may have interacted with the subject's available cognitive resources in both Cooper's and Simmons' studies to produce the subject classifications they observed.

The criteria for subject selection used in the present study were more stringent than those used in Cooper's and Simmons' studies. To participate in the present study an individual had to be male, right-handed, and have no immediate familial history of left-handedness. Additionally, all of the the subjects in the present study were grossly screened for visual acuity. These criteria probably insured a more homogeneous subject sample than the subject samples used in the previously cited studies. It is not unreasonable to assume that those factors influencing subject heterogeneity (i.e. including females, left-handed males or males with a familial history of left-handedness) may have been the same ones operating to produce the Type I subjects in Cooper's and Simmons' studies. At any rate, the central thesis of the present

study, examining the effects of subject type on the lateralization of cognitive processes, could not be adequately tested since so few Type I subjects were observed.

Analysis of the lateralization sessions RT data produced rather interesting results. The letter stimuli were consistently processed faster than the nonsense shapes. Bindra, Donderi, and Nishisato (1968) have suggested that quicker "same" responses are produced by easily codable stimuli. Since letters are probably the most meaningful, overlearned, and easily codable stimuli, the faster RT to the letters observed in the present study is not surprising.

Analysis of the significant Stimulus Type X Match interactions reveals that, while the letter stimuli did produce faster "same" responses than "different" responses, the nonsense shapes produced faster "different" responses than "same" responses. Assuming the most efficient processor is operative for any given combination of task demand and cognitive resource composition, the faster RTs for "different" responses for the nonsense shapes preclude the operation of an analytical, feature-by-feature comparison process. This finding is also evident from the overall "same" vs overall "different" classification data of the Type II subjects, and three of the Type IIA subjects given in Appendix F.

Also of note is the lack of a significant Match main effect in any of the analyses. Since both types of stimuli were always included in the same analysis, the consistently significant Stimulus Type X Match interaction may explain the lack of a significant Match

main effect. The faster "same" response to letter stimuli and the faster "different" response to the nonsense shapes probably offset each other to produce a negligible difference between "same" and "different" responses.

Analyses of the RT data from the two lateralization sessions only partially suggest processing differences between the two cerebral hemispheres. An examination of the data from all the subjects combined did yield a significant interaction between Stimulus Type and Visual Field, but this interaction was significant only because RT to the nonsense shapes was faster when the shapes appeared in the LVF, and hence had direct access to the right, or visuo-spatial hemisphere. This finding is in agreement with much of the hemispheric specialization literature (Bradshaw & Nettleton, 1981; Dimond & Beaumont, 1974).

However, there was no difference in RT scores between the LVF and the RVF for the letters. If the LH does have a processing advantage for verbal material, then the RT to letter stimuli appearing in the RVF should have been faster than the RT for letter stimuli in the LVF. In the Bagnara et al. (1982) study, there was a significant LVF advantage using the same letters that were used in the present study. As an explanation of their observation of opposite than expected lateralization effects, Bagnara et al. suggest that "letters yield a RVF advantage only when comparisons are based on their phonetic code"; comparisons based on the physical structure of the letters yield mixed results. Some researchers find a LVF

advantage (Cohen, 1972; Geffen, Bradshaw, and Nettleton, 1972), some find a RVF advantage (Egeth and Epstein, 1972), and still some find no visual field advantage (Simion et al., 1980, exp. 4). Since the letters used in the Bagnara et al. study and in the present study systematically varied in their degree of physical similarity (Taylor, 1976), then perhaps some of the subjects in these studies compared the letters based on their physical identity, rather than their name identity. An admixture of subjects who made letter comparisons based on name identity with subjects who made comparisons based on physical identity would introduce error variance into the Stimulus Type X Visual Field interaction. It is not unreasonable to conclude that the introduction of too many of these subjects would yield a non-significant interaction between the letter stimuli and visual field.

It was hypothesized that for the Type II subjects there would be a significant Visual Field X Match interaction having the form of RT "same" being faster in the LVF and RT "different" being faster in the RVF. To the contrary this interaction was quite non-significant in every analysis in the present study. There is no evidence that visual field had any effect upon the type of response made. It is difficult to explain the lack of evidence for the lateralization of analytic and holistic processes to the LH and RH respectively, assuming that these processing capabilities exist independently within their respective hemispheres. Certainly, the type of subjects used could not be a source of confounding. The subjects composing

the present experiment have previously been identified as being the most homogeneous with respect to hemispheric specialization. Similarly, both types of stimuli were specifically constructed for the identification of analytic and holistic processes and they have been successful at doing so with non-lateralized stimulus presentations (Cooper, 1976; Taylor, 1976).

The lack of a significant Visual Field X Match interaction is identical with the results found by Bagnara et al (1982). Bagnara et al. did find that RT decreased as the number of segments forming the distractor letter increased. In addition "same" responses were significantly faster than "different" responses. Thus, they conclude that, "if the Taylor paradigm is accepted as implicating analytic and holistic processes in visual comparison, it would appear that the hemispheres are not differentiated in that respect: both can process visual information analytically and holistically".

In sum, five observations can be gleaned from the data analysis presented above: (1) Significantly more subjects were classed as Type II (including the Type IIAs) than was expected. This may have been due to an inadvertent subject selection bias which excluded Type I subjects. (2) RT to letter stimuli was significantly faster than RT to nonsense shapes. Certainly we can presume that the letter stimuli were more meaningful and easily codable than the nonsense shapes, hence they should have been processed faster. (3) Making a "same" response to letter stimuli is faster than making a "different" response, while making a "same" response to nonsense shapes is slower

than making a "different" response. The interaction between Stimulus Type and Match supports the notion of faster "same" responses to easily codable stimuli. (4) RT to nonsense shapes was faster than RT to the letter stimuli when the shapes were presented in the LVF, while no visual field differences were observed for the letters. Possibly different hemispheric resource strategies were used by some subjects to compare the letters. (5) No evidence of analytic/holistic lateralization effects was found. This was perhaps the most significant finding, however it is not without precedent (Bagnara et al., 1982).

It is suggested that since both types of stimuli were constructed such that each distractor varied systematically from its standard, both types of stimuli could have been readily processed based on their physical identity. In other words, there would be a significant effect of the type of distractor on RT. Distractors least dissimilar to their respective standards should have longer RTs than distractors most dissimilar. This hypothesis is not readily tested from the analysis presented above, therefore another analysis was done using only the distractor data. The data were subjected to a 2 X 2 X 2 ANOVA to assess the effects of distractor type upon RT. The factors used were Type of Stimulus (verbal vs non-verbal), Visual Field (left vs right), and Type of Distractor (least dissimilar vs most dissimilar).

Results of this analysis are presented in Table 7 and Table 8. There was a significant main effect of Type of Distractor, $F(1,27) =$

Table 7

Source Table For The Stimulus Type X Visual Field X Distractor TypeANOVA of the Type I, Type II, and Type IIA Subjects RT Distractor Data

Source	SS	df	MS	F
Stimulus Type	23847.35	1	23947.35	1.17
Stimulus Type X Subjects	551432.26	27	20423.42	
Visual Field	17021.66	1	17021.66	3.47
Visual Field X Subjects	132472.56	27	4906.39	
Distractor Type	364229.54	1	364229.53	49.27***
Distractor Type X Subjects	199594.77	27	7392.03	
Stimulus Type X Visual Field	8036.55	1	8036.55	2.54
Stimulus Type X Visual Field X Subjects	85389.40	27	3162.57	
Visual Field X Distractor Type	743.94	1	743.94	.29
Visual Field X Distractor Type X Subjects	69525.82	27	2575.03	
Stimulus Type X Distractor Type	19297.35	1	19297.35	4.39*
Stimulus Type X Distractor Type X Subjects	118791.94	27	4399.70	
Stimulus Type X Visual Field X Distractor Type	8397.08	1	8387.08	1.23
Stimulus Type X Visual Field X Distractor Type X Subjects	183461.84	27	6794.88	
Total	1151898.40	196		

* $p < .05$
 *** $p < .001$

Table 8

Mean RTs of Each Term in the Stimulus Type X Visual Field X DistractorType ANOVA for the Type I, Type II, and Type IIA SubjectsCombined Distractor Data

Verbal	693.65			
Non-Verbal	714.28			
LVF	694.24			
RVF	713.54			
Least Diss.	743.07			
Most Diss.	664.68			
	<u>Verbal</u>	<u>Non-Verbal</u>		
LVF	690.12	698.44		
RVF	697.23	729.85		
	<u>Verbal</u>	<u>Non-Verbal</u>		
Least Diss.	723.18	763.68		
Most Diss.	663.59	665.77		
	<u>LVF</u>	<u>RVF</u>		
Least Diss.	734.96	751.17		
Most Diss.	653.45	675.91		
	<u>LVF</u>	<u>LVF</u>	<u>RVF</u>	<u>RVF</u>
	<u>Verbal</u>	<u>Non-Verbal</u>	<u>Verbal</u>	<u>Non-Verbal</u>
Least Diss.	726.79	743.74	719.43	782.94
Most Diss.	652.14	654.75	675.03	676.79

Note. All values are in msec.

49.27, $p < .001$. The least dissimilar distractor RTs were 78.39 msec slower than the the most dissimilar distractor RTs (743.05 and 664.68 msec respectively). There was also a significant interaction between Stimulus Type and Type of Distractor, $F(1,27) = 4.39$, $p < .05$. Analysis of the simple main effects of type of distractor reveals that there was a significant effect of stimulus type upon the least dissimilar distractor RT data. For the least dissimilar distractor RTs, the verbal stimuli were processed 40.5 msec faster than the than the shapes (723.18 and 763.68 msec respectively). This term approached but did not quite reach significance, $F(1,27) = 3.5$, $p = .07$. For the most dissimilar distractor RTs, the difference between the verbal and non-verbal stimuli were negligible (663.59 and 665.77 msec respectively). No interaction with visual field as a term was significant.

The results of this analysis indicate that standard/distractor comparisons for both types of stimuli were made on the physical characteristics of the stimuli. Reaction time decreased with increasing distractor dissimilarity, which also denotes the operation of an analytic type of processor. Also, when a difficult standard/distractor comparison is being made (as in the case of the least dissimilar distractor RTs), RT is shorter with the more readily codable letter stimuli than with the shapes. Easily made discriminations yield no such stimulus type advantage.

In general, all of the discriminative RT analyses presented above suggest that both verbal and non-verbal stimuli can be

processed with an analytic or feature-by-feature comparison based on the physical identity of the stimuli. There is no evidence that either hemisphere has an advantage along this process dimension. There is also no evidence for the notion of a holistic processor, lateralized or not, since the recognized criterion for this processor, "same" responses being significantly faster than "different" responses, failed to materialize in the present experiment.

Further research is needed along an individual difference dimension in cognitive resources in general, and specialization of hemispheric function in particular. In particular, future research is needed to explore the relationship, if any, between previously recognized factors that affect cognitive performance (i.e. handedness and gender), and the Type I/Type II classification scheme. For example, subjects could be grouped according to gender, subject handedness, and familial handedness, and the relationship between their grouping and Type I/Type II classification could be examined. Future research is also needed to determine the reliability of the Type I/Type II classification scheme. If the Type I/Type II classifications are merely transient, then the low incidence of Type I subjects in the present study becomes moot.

It is also suggested that instead of trying to identify simplistic, dichotomous entities that are presumed to reside within the two cerebral hemispheres, research is needed to identify the significant parameters that result in differential performance levels

within and between subjects on a given task. Bertelson (1982) has suggested that the analytic/holistic classification scheme in particular is inherently fraught with limitations:

The analytic/holistic distinction is however a vague one. Like most terms borrowed from everyday language, it carries a number of different meanings. This is not a reason to prohibit such importations, but the danger exists that terms of that kind be taken more seriously than they deserve, leading to unwarranted generalizations from some of their meanings to others. . . . If one tries to translate the holistic/analytic dichotomy into more operational terms, which would allow testable predictions, one finds that it is compatible with several not necessarily equivalent translations such as focal attention vs. pre-attentive segmentation of the sensory field, attention to local detail rather than overall configuration, serial classification vs. parallel testing of several features (or template matching), attention to high frequency vs. low frequency Fourier components. . . . many explanatory successes of the analytic/holistic dichotomy are actually post-hoc. Marshall (1981) took the example of the task consisting of choosing among several circles the one of which a particular arc is a part, and which work with split-brain patients has shown to be better accomplished by the isolated RH (Nebes, 1974). Bradshaw

and Nettelton (1981) describe the task as involving "the ability to form a complete Gestalt (e.g. a circle) from incomplete information (e.g. arcs of a circle)". And Marshall comments: "Had the data gone the other way, we can be sure that the task would have been described as implicating the ability to decompose circles into their constitute arcs (an analytic operation). . . ". (p. 197-198).

The disdain which is reflected by Bertelson (1982) exists in part because of a lack of consensus in operationally defining analytic and holistic processes. Although the present study does not directly address this problem (and indeed, may contribute to it), it is clear that some consistency in definition is needed if the "analytic/holistic" dichotomy is to yield further, meaningful research.

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Harris Questionnaire

In order to participate in the study you must complete this questionnaire. Please answer the questions below as best as you can. Please do not leave any questions blank. If you do not answer every question, there is a good chance that you will not participate, hence you will receive no money.

Name: _____ Landrum Box#: _____ Phone #: _____

With which hand do you. . .	Left	Right
1. Throw a Ball	----	----
2. Wind a Watch	----	----
3. Hammer a Nail	----	----
4. Brush Teeth	----	----
5. Comb Hair	----	----
6. Turn Door Knob	----	----
7. Hold Eraser	----	----
8. Use Scissors	----	----
9. Cut with Knife	----	----
10. Write	----	----

Answer the following questions Yes, No, or DNA (Does Not Apply).

1. Is your father predominantly right-handed.	Yes	No	DNA
2. Is your mother predominantly right-handed.	Yes	No	DNA
3. If you have any sisters, are all of them predominantly right-handed.	Yes	No	DNA
4. If you have any brothers, are all of them predominantly right-handed.	Yes	No	DNA

Appendix B

Consent Form

I understand that participation in this study is voluntary and that I will be exposed to no bodily or psychological stress. I will be required to make perceptual judgements on visual stimuli over a period of three sessions, and the data will be used as part of a masters thesis. The data will be held in confidentiality and will in no way affect my grade in any class, except for the addition of the extra-credit points. I may withdraw participation at any time. I further understand that if I do withdraw participation before the end of the 3rd session I will receive no money points for any prior participation.

Name: _____

Date: _____

ID#: _____

Appendix C

Instructions for First Session

This is the first of three sessions. These are the instructions for this session. On the machine in front of you, there is a place for you to look into. At first you will see a center cross. This is called the "fixation point". Look at this point; do not remove your eyes from it. Immediately following this point, you will see a geometric shape. Notice this shape; do not remove your eyes from it as it will be visible for only a short time. Immediately following this shape you will see another one. Your task at this point, is simply to make a decision as to whether the two shapes that you saw were the same or different shapes. If you think that they were the same, say "same" into the microphone below the viewer. If you think that they were different, say "different" into the microphone. Make your decisions as fast and as accurate as possible. This will constitute a "trial".

After you finish this trial the machine will be reset, and a new trial will begin with another fixation point. You will then see two new shapes, and you will decide whether these two are the same or different.

Keep the following points in mind. Always look at the direct center of the screen, in other words, on the fixation point. This is to make it easier for you to view the shapes. Also, on any given trial the probability that the two shapes are actually the same or

different is equal. There will be an equal number of same and different trials so try not to guess.

We will run through a few practice trials at first. Are there any questions?

Appendix D

Instructions for Second Session

During this session, you will again be presented with several trials of two stimuli, and you will be asked to make "same-different" judgements on these stimuli. However a few things will be different from the first session. This time, instead of saying "same" or "different" into a microphone you will respond by tapping your fingers on a mechanical key. If you think that the two stimuli were different, press the outermost left key with your left index finger. If you think that they were the same, press the outer-most right key with your right index finger. At all times when you are not responding keep your fingers positioned on the two innermost keys. This will let me know that you are ready to begin another trial.

Also, sometimes the second stimulus that you see will be either to the left or right of the first stimulus. Since the chances that the second stimulus will appear in any one of these positions are equal, keep your eyes fixated at the center. This will give you the best chance of making a fast, accurate response. We will start with a few practice trials.

Are there any questions?

Appendix E

Instructions for Third Session

This is the third and final session. This session will be exactly like the second. If you think that the two stimuli are different, then press the outermost left key with you left index finger. If you think that the two stimuli were the same, press the outermost right key with your right index finger. At all other times keep your fingers placed on the two innermost keys.

like in the second session, the second stimulus will appear randomly either to the left or to the right. Keep your eyes fixated on the center to maximize your decision making. There will be a few practice trials before we begin.

Are there any questions?

Appendix F

Subject Data from the Classification Session*

Subject	Same RT	Different RT	<u>Distractor Stimuli</u>					Overall Mean RT
			<u>Most Similar to Least Similar</u>					
			D1	D2	D3	D4	D5	
<u>Type I</u>								
JL	601.29	643.47	628.67	758.55	623.22	639.78	567.11	629.04
CD	776.51	788.73	744.00	832.66	830.88	765.55	770.55	782.62
<u>Type II</u>								
KB	873.50	795.60	865.80	861.00	780.60	754.70	715.60	834.60
RL	893.09	758.13	829.11	797.89	714.33	746.56	702.78	825.61
AG	1008.20	894.76	972.89	958.44	830.33	894.67	817.44	951.48
JB	845.09	714.91	797.56	803.56	653.00	645.00	675.44	780.00
BR	1124.80	1028.84	1109.22	1211.44	944.11	921.89	957.56	1076.82
VM	938.24	725.96	654.11	842.78	713.78	707.00	712.11	832.10
JP	980.00	939.56	1117.22	987.56	874.33	848.44	870.22	959.78
DM	623.00	562.42	572.00	581.30	541.20	566.50	551.00	592.71
BB	732.90	709.51	737.40	770.80	682.40	681.50	675.20	721.21
JM	950.13	862.42	910.89	1011.67	873.89	781.11	734.56	906.28
JA	960.42	860.47	924.67	891.22	883.00	814.11	789.33	910.44
CR	697.60	676.24	750.00	693.70	620.70	673.00	643.60	686.95
WF	744.78	725.87	827.00	753.78	704.00	672.78	671.78	735.32
KG	702.09	646.42	726.11	705.67	592.44	607.44	600.44	674.26
PC	630.20	608.67	620.70	645.00	600.20	605.60	571.60	619.40
AL	675.36	662.00	720.33	723.33	655.00	605.78	605.56	668.68
JW	1092.96	1019.71	1255.78	1078.78	945.11	927.67	891.22	1056.33
JOL	1086.78	921.29	998.78	951.89	871.89	894.33	889.56	1004.03
HD	747.93	714.64	770.44	709.44	698.67	713.33	681.33	731.29
WM	1023.71	868.96	958.89	900.67	810.33	881.44	793.44	946.33
GP	773.18	752.44	804.67	753.11	746.79	734.11	726.56	762.81
CC	875.84	797.84	872.33	807.22	903.56	744.44	761.67	836.84
<u>Type IIA</u>								
PB	788.84	737.77	730.33	776.33	716.11	740.00	726.11	763.31
DW	1111.98	943.64	971.00	935.56	966.11	901.44	944.11	1027.81
TH	678.75	701.46	758.33	720.88	722.50	644.30	661.40	690.13
AJ	924.87	937.42	1155.22	979.00	950.22	813.11	789.55	931.14
JC	741.89	774.89	904.00	812.44	700.67	713.78	739.78	758.01
DOW	1066.73	950.31	878.11	1055.11	1083.22	914.11	821.00	1008.52

* All values in msec