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The present study investigated the relationship between access to verbal processes and visual discrimination behavior. If reversal-shift behavior requires access to verbal processes, then response latencies should be shorter when sensory information has direct access to the areas concerned with these functions than when such information must travel indirectly to these areas.

In accordance with the fact that language areas are primarily found in the left hemisphere of the normal, right-handed adult, stimuli were tachistoscopically presented to the right, center, and left visual fields. It was predicted that response latencies for nonverbal tasks during the initial discrimination should not be affected by visual field of presentation; verbal stimuli would result in shorter response latencies with right field presentation. During the reversal discrimination, both verbal and nonverbal stimuli should have shorter reaction times with right field presentation.

Results indicate that during the initial discrimination, reaction times for verbal tasks were not affected by field of presentation; reaction times for nonverbal tasks were significantly higher with right field presentation. During the reversal discrimination, right field presentation resulted in significantly shorter response latencies for the size and name discriminations than did left field. Field of presentation, though a significant factor during both the initial and reversal discriminations, accounted for a small proportion of the total variance.

EFFECTS OF VISUAL FIELD OF PRESENTATION

AND STIMULUS CHARACTERISTICS

ON VISUAL DISCRIMINATION

LEARNING

by

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INTRODUCTION

Recent studies on discrimination learning have led to the formulation of a mediational model for describing the strategy used by adult subjects in solving visual discrimination problems. These studies examine the nature of the mediation mechanism and suggest a relationship between mediated responses and access to verbal processes. The present research seeks to clarify the nature of this relationship.

In studying discrimination behavior, Kendler and Kendler (1972) suggest an experimental paradigm for comparing reversal and nonreversal shift behavior. As illustrated in Figure 1, this paradigm utilizes two

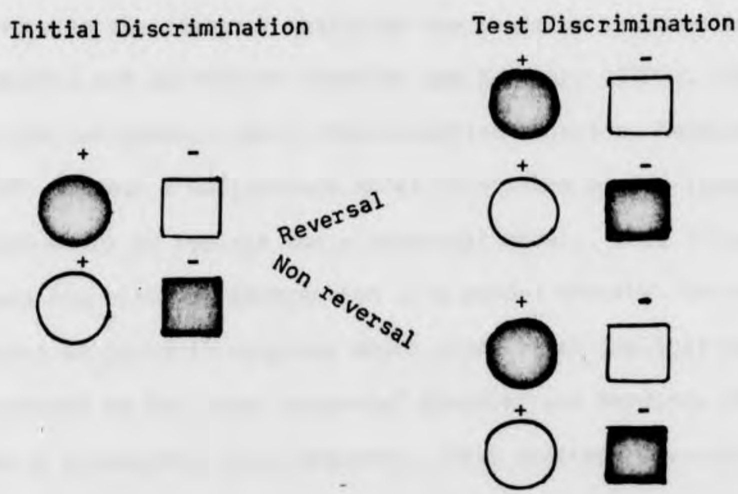

Figure 1: Illustration of possible stimuli and correct responses for reversal and nonreversal shifts.

successive discriminations. The subject learns the first discrimination which differs simultaneously on two dimensions (color and shape), only one of which is relevant. Following this initial task, the subject is presented with identical stimuli, but with a different member of the stimulus pair being correct. A reversal shift requires that the subject respond on the same dimension, but in an opposite manner (i.e., the response to the previously negative stimulus becomes reinforced). In a nonreversal shift, the previously irrelevant stimulus dimension becomes relevant; this type of shift requires a discriminative response within a new dimension.

Kendler and D'Amato (1955) found that college students perform reversal shifts faster than nonreversal shifts. This reversal behavior shown by college students is inconsistent with predictions made by a single-unit S-R theory whereby there is a direct connection between the external stimulus and the overt response. According to this single-unit model, nonreversals should be learned more easily because the irrelevant dimension has been previously associated with some reinforcement; moreover, in the reversal shift the now positive response has been consistently not reinforced (Kendler and Kendler, 1970b). To better describe and predict adult discrimination behavior, Kendler and D'Amato (1955) suggest a mediational model consisting of two integrated S-R units with which to replace the single-unit model. This integrated unit processes the stimulus information in a manner whereby "the external stimulus evokes an implicit response which produces an implicit cue which is connected to the overt response" (Kendler and Kendler, 1962, p.5). Figure 2 illustrates this sequence. This strategy operates

Overt Stimulus → Implicit Response → Implicit Cue → Overt Response

Figure 2: Representation of mediation process.

according to S-R connections, but contains a covert link in the behavioral sequence. In learning the initial discrimination, the symbolic (implicit) cue becomes available for the reversal discrimination (Kendler and D'Amato, 1955).

Other accounts of discrimination behavior have been advanced by Tighe (1965) and Zeaman and House (1962). Tighe suggests a differentiation theory to account for the improvement in reversal behavior with increasing age. According to this view, increased sensitivity to dimensions will facilitate reversal shifts in that such shifts occur along the previously relevant dimension. Experience with objects increases the perceiver's ability to extract critical features and dimensions (Gibson, 1969). This increased specificity of response will allow the subject to discriminate between objects along dimensions rather than as undifferentiated entities. Once the critical dimension is isolated, the reversal shift is easier since the same dimension remains relevant. Though Tighe may be correct in assuming that practice facilitates differentiation and discrimination, such an explanation does not provide an adequate description of the processes involved during reversal shift performance.

House and Zeaman (1962) account for the ease of performing reversal shifts in terms of an observing response. Because reversal shifts occur along the initially learned dimension, the execution of such a shift does not require the learning of new cues. That is, the relevant cue in the initial discrimination remains relevant in the shift situation; the nonreversal shift would necessitate the learning of a new cue. And, once a discrimination is learned, the probability of observing irrelevant cues decreases, thereby decreasing the probability that a nonreversal shift, which requires identification of a new dimension, will be made.

Though this explanation may account for facilitation of execution of reversal shifts, it does explain the nature of such discrimination behavior. Perceptual factors may indeed influence discrimination behavior, but they do not adequately explain it. Further, these various accounts of reversal shift behavior - differentiation, attention, and mediation - need not be contradictory; there is merely a difference in emphasis.

There is evidence that the chosen discrimination strategy will vary with the age of the subject. Kendler and Kendler (1959) found that children of kindergarten age showed no significant difference in number of trials to criterion for reversal and nonreversal tasks. Neither the mediational model nor the single-unit model predicted the behavior of kindegarten-age subjects. However, sorting the subjects into fast and slow learners on the basis of trials to criterion on the initial discrimination resulted in a significant interaction effect: fast learners performed reversal shifts more rapidly and slow learners performed the nonreversal more rapidly. Kendler, Kendler, and Wells (1960) found that nursery-school children perform nonreversal shifts faster than reversals, a strategy which is consistent with direct S-R connections. This finding in conjunction with the Kendler and Kendler (1959) research suggests a developmental trend in which younger subjects respond according to single-unit S-R relationships and older subjects respond mediationally.

The validity of this 1959 research has been questioned on the grounds of dimension dominance (Kendler and Kendler, 1970). To control for this factor and for the effects of intermittent reinforcement, Kendler and Kendler (1970b) studied shift behavior using a counter-balanced, optional-shift design. In this optional-shift design, the

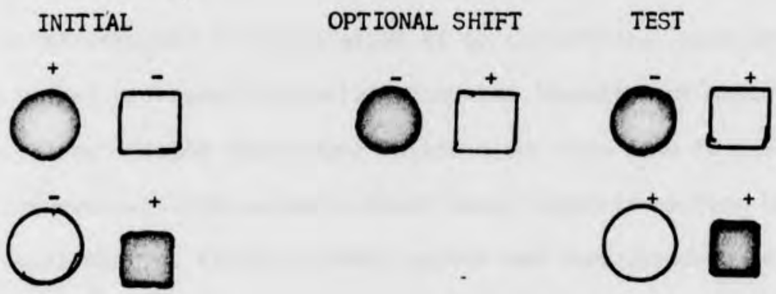

Figure 3: Illustration of Possible Stimuli and Correct Responses for Optional Shift Design

initial discrimination consists of pairs of stimuli varying along two dimensions. After learning the initial discrimination, an optional-shift discrimination is presented, and the pattern of reinforced responses is reversed. This discrimination can be learned by responding to either dimension. These stimuli, then, differ along two dimensions and both are relevant (i.e., either a response to square or white will be reinforced). Following the optional shift, the subject receives a test series consisting of both pairs of stimuli used in the original discrimination. A response to either member of the pair that has not appeared in the optional shift series is reinforced. Responses to this test pair indicate that basis of responding during the optional shift. A reversal shift would be indicated when the subject chooses the white circle; a nonreversal shift would be indicated by choice of the black square, given that the subject is continuing to respond in the same manner. Subjects from four developmental levels were tested using this design (Kendler and Kendler, 1970a). Results showed that the probability of the execution of a reversal shift increased with age of the subject.

It is primarily the acknowledgment of this developmental trend that has resulted in speculation as to the critical role of language and verbal processes in facilitating the formation of mediating responses. Noting that young children and rats tend to perform better on nonreversal shifts, while older human subjects perform better on reversal shifts, Kendler (1964) points out that language is a response system characteristic of the latter subject population, but not of the former. She hypothesizes that overt verbalization of stimulus dimensions should increase the number of optional reversals in kindergarten-age children. Verbal labels should provide the implicit cues necessary for a reversal shift. Experimental results using the optional-shift paradigm support this hypothesis (Kendler, 1964). During the discrimination task, subjects were instructed to precede their choice with a sentence that labelled the correct and incorrect dimensions of the task; control subjects were not instructed to verbalize. Comparisons between the number of reversal shifts made by each group during the test series showed that significantly more reversal shifts were performed by the experimental group. Kendler also found, however, that verbalizations following the initial discrimination were often inappropriate to the test (i.e., saying "the black is the winner" and picking the correct white stimulus). Attempts to encourage adjustment in the verbal behavior resulted in no significant changes in shift performance.

The research using younger subjects, nursery-school age, (Kendler, Kendler, and Wells, 1960) showed no significant effect of dimensional verbalization on shift performance. Kendler, et al. offer the explanation that perhaps though verbalizations are available to children at this age, such verbalizations do not mediate responses. That is, though the verbal skills are there, the child may be unable to use them to mediate between the visual stimulus and the reversal-shift response. This type of explanation is congruent with a mediation mechanism which is verbal in nature, but not yet fully developed or useable. Kendler and Kendler (1970b) suggest the existence of a developmental trend in language development, in discrimination learning, and in the relationship between the two.

Verbal labels may not only facilitate mediation, but may also facilitate observing responses as postulated by House and Zeaman (see page three). To isolate the mediational role from a possible observing response, Kendler, Kendler, and Saunders (1967) employed a sorting task with college-age subjects. This sorting task involved associating a stimulus with a motor response; after initial learning, the proper response was reversed. The stimuli were consonant trigrams or conceptually-related words. The prediction was confirmed that subjects having these conceptually-related words would reverse faster than those subjects who performed the sorting task with trigrams.

Though Kendler, et al. (1960, 1964, 1967) do present evidence implicating the role of language in the execution of mediated responses, the evidence is far from conclusive. The finding of Kendler (1964) that verbalizations need not be accurate for mediation to occur may indicate that verbalizations are not the sole determinant of mediation.

Rather, verbal reports of stimulus dimensions may only serve to direct attention to these dimensions. This explanation is congruent with the hypothesis mentioned earlier offered by House and Zeaman (1962).

Further, the study conducted by Kendler, et al.(1967) in which using words rather than trigrams increases speed of reversal performance is subject to dual interpretation. Though this 1967 research does indicate that verbal stimuli are more easily processed, this effect may be due to familiarity or pronounceability factors rather than to facilitation of a verbally mediated response.

Evidence does indicate some type of relationship between access to verbal processes and shift performance. It may be, however, that the relationship is merely a temporal correlation, with the probability of reversal performance spuriously increasing at the same rate as facility in language use. This temporal concommitance would be consistent with Tighe's (1965) differentiation theory. The ability to extract critical features during visual as well as speech perception increases with perceptual experience (Gibson, 1969).

In contrast to this, it may be that verbal cues facilitate an observing response or the direction of attention, thereby increasing the probability that responding along an already relevant dimension will continue. This type of explanation would favor a discrimination process which is identical in both the initial and reversal phases of a discrimination task. That is, learning the initial task and learning the reversal task is an identical process.

A mediation account of reversal performance would not necessarily be incongruent with facilitation by practice or orientation of attention, but it would differ from the accounts of Tighe (1967) and House and Zeaman (1962) by postulating a discrimination process that may be different during each phase of the discrimination task. That is, during the initial task, behavior can be accounted for by direct S-R connections; but, during the reversal phase, a covert mediational response is necessary to explain a relative ease of executing a reversal shift rather than a nonreversal shift. According to the mediational account, the facilitating effect of language is due to its ability to serve as the symbolic mediator between the overt stimulus and the overt response. If mediation is occurring in a manner suggested by the Kendlers, and information is being mediated rather than influenced by attentional factors, the execution of a reversal shift should require a different process from those active during acquisition of an initial discrimination.

Inquiries, then, into the nature of the mediational processes yield inconclusive evidence. The present research will investigate further the possible relationship between the verbal factor and discrimination behavior. If mediation is facilitated by accessibility to verbal processing, then information must travel to the areas of the brain concerned with this function. Whether differential access to these areas during mediational and nonmediational tasks affects performance will hopefully give information as to the nature of mediation.

There is ample evidence for localization of the speech function within the dominant hemisphere. Penfield and Roberts (1959), depending on cortical mapping data, conclude that there are three main cortical areas which are involved in language behavior: Broca's area, Wernicke's area, and the Rolandic motor strip, all of which are located in the dominant hemisphere. Only in rare cases (one out of 14 right-handed patients) did stimulation of corresponding areas of the right hemisphere affect the speech. Geschwind and Levitsky (1968), on the basis of postmortem investigation of 100 normal adult brains, found significant anatomical differences in the brain areas concerned with speech. Geschwind's (1970) study of brain organization discusses aphasia as caused by specific lesions in Wernicke's or Broca's areas. Though lesions in Broca's area result in aphasias different from those occurring after damage to Wernicke's, there is strong evidence to support a theory of localized speech function.

This evidence for language specialization is supplemented by EEG data. McAdams and Whitaker (1971) recorded EEG's preceding self-initiated speech and nonspeech activity of the vocal tract and recorded larger potentials from the left hemisphere over Broca's area than from a corresponding area in the right hemisphere in the speech condition; no difference was found during the nonspeech activity. Wood, Goff, and Day (1971) found a similar lateralization during a speech-perception task in which subjects were required to indicate which of two verbal stimuli had occurred on the basis of either name or frequency. The former task required analysis of linguistic information, while the latter only required analysis of an acoustic parameter. Their results indicated that evoked potentials were identical for both tasks in the right hemisphere; significant differences existed within the left hemisphere's activity. Similarly, Morrell and Salamy (1971) found overall mean amplitudes of evoked potentials to be greater in the left hemisphere in response to natural speech stimuli. Negative waves from the left temporoparietal region were significantly larger than those from the right. Further, for the left hemisphere, the temporoparietal activity was greater than that found in the frontal and motor areas. Such electrocortical response differences during speech production and perception seem to indicate a lateralization of speech function.

It follows, then, that the execution of tasks requiring processing by these speech areas should be performed more rapidly when the task stimuli have easy access to the areas. If mediation requires verbal skills, then such discriminations should be executed faster with direct access to the cortical areas responsible for speech and/or verbal skills. Verbal stimuli projected to the nondominant side will have to be transmitted to the dominant side before processing can occur.

Transmission between hemispheres occurs via fibers running through the corpus callosum (Gazzaniga, 1970). According to Gazzaniga (1970), this mechanism is necessary for integration of input to the separate hemispheres. Without callosal transmission, the hemispheres remain two conscious but independent spheres. Observations of subjects whose corpora callosa have been sectioned agree with findings previously cited that there is some localization of speech function within the dominant hemisphere (Filbey and Gazzaniga, 1969; Gazzaniga and Sperry, 1976; Gazzaniga, 1970). Gazzaniga and Sperry (1967) found that tactual and visual information perceived only in the minor hemisphere could not be expressed in speech or writing; verbal comprehension occurred in both hemispheres, though to a lesser degree in the minor hemisphere. In split-brain patients the right hemisphere was capable of reading letters, numbers, and short words. Further, when a drawing of a member of class of objects was presented only to the minor (right) hemisphere, the left hand could match that drawing with a different member of the same class (Gazzaniga and Sperry, 1967). It appears from these data that the right hemisphere does possess the ability to perform some verbal processes. In the matching of dissimilar objects having the same conceptual antecedents, the right hemisphere was executing an action which involved some language reference. When subjects were asked to indicate verbally what object had been flashed in the left visual field, they were unable to respond. Linguistic expression, then, is a function of the dominant hemisphere. Comprehension of language is possible, though to a lesser extent, for the minor hemisphere.

So, since major language functions are performed within areas of the dominant hemisphere, stimuli which require reference to verbal areas entering the minor hemisphere must be transmitted through the corpus callosum to the speech areas located on the dominant side. To study the time necessary for such transmission and to confirm the hypothesis of lateralization of speech function, Filbey and Gazzaniga (1969), using normal subjects measured reaction times for tasks requiring reference to verbal areas. Subjects were instructed to indicate verbally the presence or absence of a tachistoscopically flashed dot presented either one degree to the right or to the left of fixation. Everything to the right of fixation travels to the left hemisphere and everything to the left travels to the right hemisphere.

Presentation to the left visual field resulted in longer reaction times, presumably reflecting additional time necessary for callosal transmission to the dominant hemisphere. These results contrast with those obtained using a manual response to an identical task in which latencies for left and right presentation were not significantly different. Filbey and Gazzaniga conclude that for motor response, both hemispheres have equal access, while responses in the verbal mode are only accessible to the major hemisphere.

Moscovitch and Catlin (1970), in a study similar to that of Filbey and Gazzaniga (1969), provide additional evidence that information which must cross from one hemisphere to the other requires increased reaction time. Using a recognition task involving tachistoscopically presented letter stimuli, Moscovitch and Catlin measured reaction time for a verbal naming response. Results indicated that for right-handed subjects, left-visual field presentation requires 10 milliseconds longer than right-field presentation. Though these results do suggest that interhemispheric crossing time is necessary for left field presentation of verbal tasks, Moscovitch and Catlin advance another possible explanation: the dominant hemisphere is more efficient for processing such information. This alternative does not seem likely in view of Gazzaniga's (1970)finding that the left hemisphere is solely responsible for verbal expression.

Cohen (1972) conducted a study in which speed and accuracy of judgement was measured for unilaterally presented letter pairs. Using a task designed by Posner and Mitchell (1967), Cohen asked his subjects to classify letter pairs such as AA and Aa as same or different, the former match being considered physically identical (PI) and the latter match being identical in name (NI). Such a task would, according to Posner and Mitchell, and Cohen, allow differentiation of verbal versus nonverbal conditions. In this view, PI should not require verbal abilities, whereas NI comparisions should necessitate involvement of verbal skills. Posner and Mitchell found that responses to NI matches took 71 milliseconds longer than responses to PI matches. Cohen tachistoscopically presented such stimuli to the left and right of fixation. If laterality differences are present for verbal tasks (NI), then presentation directly to the dominant hemisphere for such tasks should result in superior performance. And, minor hemispheric presentation should require additional time because performing a name match requires that information be transferred to the dominant hemisphere. It should be mentioned that the task that these experimenters considered to be discrimination by name could be learned on the basis of physical characteristics. That is, when a subject was presented Aa in what is termed a name match condition, the discrimination could be learned either by a same name rule or by associating this physical configuration with a certain response.

Cohen, to avoid confounding laterality effects due to task mode with those due to response mode (verbal or manual), used a keypress response, Filbey and Gazzaniga (1969) having found that such a response mode can be mediated equally well by both hemispheres. Cohen's results confirm the hypothesis that NI matches are more accurate and faster when stimuli are presented to the right visual field; further, Cohen found the left visual field to be superior for PI matches. Again, as in the study by Moscovitch and Catlin (1970), these results reflect either specific lateralization of function or at least differential efficiency between hemispheres in performing verbal and nonverbal tasks. At the minimum, it can be concluded that there does exist a processing advantage when verbal stimuli are presented directly to the major hemisphere.

Gazzaniga (1970), in an experiment similar to that of Cohen, found a right-field superiority for NI matches, but found equal response latencies between hemispheres for the PI matches. These results indicate a hemispheric advantage for verbal tasks, but an equality of processing between hemispheres for PI tasks.

Research comparing processing time and accuracy for left and right hemispheric presentation aural stimuli is consonant with evidence indicating localization of language function. Kimura (1961), using a dichotic listening task, found "that when verbal stimuli are presented to the two ears, those stimuli which arrive at the ear opposite the dominant hemisphere are more efficiently recognized" (p. 169). The measure of efficiency used by Kimura was number of items reported. Kimura concludes that the crossed auditory pathways to the dominant hemisphere are more effective, offering a more efficient path to the dominant or speech area of the brain than the uncrossed auditory pathways. Using visual stimuli in successive presentation to either left or right visual field, Kimura (1966) found more items of a verbal nature were reported when stimuli are presented to the right visual field. No laterality effect was observed with certain nonalphabetical stimuli such as nonsense forms.

There is, therefore, localization of speech in the dominant hemisphere; and the processing of visual stimuli requiring reference to verbal processes is faster and more accurate when presented to the right visual field because such stimuli have direct access to the areas concerned with these processes.

Using this rationale, the present research was designed to investigate the relationship between access to verbal processes and discrimination behavior. Using the reversal-shift paradigm, stimuli were presented in either the left or right-visual field. If execution of reversal shifts requires reference to the speech areas of the brain, there should be performance differentials associated with fields of presentation.

METHOD

Design: The experimental task was based on a two-choice, simultaneous visual discrimination similar to that used by Kendler and Kendler (1962). The paradigm was altered to include performance only on the initial discrimination and a forced reversal shift. Since execution of reversal shifts is facilitated by mediation, this condition would be the one of major significance. Further, since college students are known to perform reversal shifts faster than nonreversals, this nonreversal condition would have added little new comparative data. The discrimination task consisted of tachistoscopic presentation of two letters, varying both in name and size. These letter stimuli were used, rather than geometric figures used by Kendler and Kendler (1962), in order to detect any effects due to using type of stimuli. The discrimination based on size corresponds to what Posner and Mitchell (1967), Gazzaniga (1970), and Cohen (1972) called a physical identity (PI), and the discrimination based on name corresponds to a name identity (NI). In these studies there were reaction-time differentials between types of stimuli, reflecting a lateralization of function. By applying the same type of stimuli to the present research it was hoped that the effect produced by type of stimuli and that due to the nature of reversal discrimination behavior could be separated.

For half the subjects, name was the relevant dimension, and for the other half, the relevant dimension was size. The shift, as indicated in Figure 3, was a reversal in which the same dimension remained relevant, but with the pattern of reinforcement reversed. Half

	Initial Discrimination			Reversal Discrimination		
I.	+A	−b	Reversal	−A	+b	(size dimension)
	+B	−a		−B	+a	
II.	+A	−b	Reversal	−A	+b	(name dimension)
	−B	+a		+B	−a	

Figure 3: Experimental design for forced reversal shift based on name or size dimension.

the group with size task had "small" as positive; half had "large" as positive. For the name group, letter name "a" or "A" was correct for half, and for half the group, letter name "b" or "B" was correct. This counterbalancing procedure resulted in four experimental groups.

Data were analyzed separately for reaction times generated during attainment of criterion and for performance after criterion was reached for each discrimination. It was thought that during acquisition, reaction-time measurements would reflect both time needed for learning the task and time needed for neural processing of information. In this sense, reaction time would decrease with the number of trials and reflect individual differences in response strategies and learning, thus involving a large error factor. During this stage the more meaningful measure would be the number of trials necessary to attain criterion. The following was predicted.

A. Performance on initial discrimination: During acquisition and after criterion is reached, no difference was expected as a function of field of presentation for PI. This prediction is based on Gazzaniga's (1970) results, although Cohen (1972) did find a left field superiority for PI tasks. The discrimination based on size should not require utilization of verbal processes and therefore no callosal transfer should be necessary, especially since the response is nonverbal. Both hemispheres should be able to perform a discrimination based on physical characteristics.

The initial NI discrimination, including acquisition and post-criterion trials, should be executed with shorter response latencies with right-field presentation than with left-field presentation. If the NI discrimination involves naming, it should be executed faster when presented to pathways with direct access to language areas.

For NI and PI center-field presentation should not be slower than both off-center presentations. In the center condition, information is simultaneously going to both hemispheres. PI should be faster than NI within the same field of presentation during acquisition and after criterion is reached on the initial discrimination. According to Posner and Mitchell (1967), PI requires a lower level of processing in that it depends primarily on analysis of physical characteristics than NI which requires a name analysis. According to Posner and Mitchell, this difference in level of processessing results in a time differential with PI requiring less time.

B. Performance on reversal discrimination: If execution of reversal shifts is facilitated by access to language processes, then performance on such tasks should reflect differences as a function of ease of access to the areas of the brain concerned with these processes. Performance on the reversal discrimination with stimuli presented in the right visual field should be superior if it is true that speech functions are primarily localized in the left hemisphere. After criterion is reached on the reversal discrimination, analysis of response latency measures should yield estimates of the time differentials involved in transfer of information from the left to right hemispheres during reversal shift behavior. There should be faster reaction times with right-field presentation than with left-field presentation for both NI and PI. If mediation is involved in the reversal learning, then for both NI and PI shifts, reaction times may be the same within the same field of presentation. However, it may be the case that some difference may exist due to the ease of processing the particular task stimuli. As Cohen (1972) and Posner and Mitchell (1967) found, size discriminations require less time than name discriminations.

Subjects: Subjects were 44 introductory psychology students from the University of North Carolina at Greensboro and 8 adults not enrolled at the University. All subjects were of comparable ages. Preliminary tests to establish right-handedness were administered. Potential subjects were asked which hand they used to throw a ball, to write, and to light a match. Additionally, they were asked if they considered themselves, their mother, and their father to be right-handed, left-handed, or ambidextrous. Subjects from this pool were asked to write their names in the presence of the experimenter to confirm their hand preference. Only subjects scoring consistently as right-handers were used. Only right-handed subjects were choosen to maximize the probability that subjects had left-hemispheric speech functions. Branch, Milner, and Rasmussen (cited in Kimura, 1967) estimate that 90% of normal, right handers have left-hemispheric speech functions. Also, Geschwind and Levitsky (1968) found that 93% of normal adults are right-handed, and 96% are left-brained for speech. Subjects were randomly assigned to one of the four experimental groups.

Stimulus Materials: Commercially prepared lettering was used to make stimulus cards. Upper case letters was approximately 3/4 inches high, and lower case leters were approximately 1/4 inches high. Letters were placed on 4 x 5 cards. Each card had one upper-case and one lower-case letter, one 1/4 inch above the other, located in one of three positions: at a central fixation point, one inch to the left of the central fixation point, and one inch to the right of the central fixation point. This distance of one inch represents a visual angle of approximately 3 1/3 degrees. Cohen (1972) used a visual angle of 3 degrees; Filbey and Gazzaniga (1969) used an angle of 1 degree.

Apparatus: The stimulus cards were presented in a two-channel Polymetric tachistoscope with a viewing distance of 17 inches. Presentation of stimuli was coincident with the starting of a Standard Electric clock, and the subject's response stopped the clock. Responses were made by flipping a switch with the right hand in the direction which corresponded spatially to the choice of stimuli. Gazzaniga and Filbey (1969) found that a manual response could be performed equally well by both hemispheres.

Procedure: Subjects were instructed to fixate on the center dot. They were told that when the stimulus pair was flashed on the screen they should decide which of the two was correct and move the switch in the direction to correspond to their choice. They were asked to respond as quickly as possible and as accurately as possible. Following the subject's response, the experimenter indicated whether the choice was correct or incorrect. Elapsed time for each response and number of errors were recorded.

There were four possible combination of letters, and three possible locations: to the right of fixation, to the left of fixation, and on-center, giving a total of twelve different stimulus cards. For each block of three trials during acquisition, a card from each location was presented. This order in which the cards appeared was randomly determined after satisfying the location requirements. During the twelve post-criterion trials, each card appeared once, the order being completely random. This treatment was intended to minimize any tendency of the subjects to shift fixation toward an anticipated direction of presentation with the result of a central retinal projection in the off-center conditions. A further check on maintenance of fixation was made by the experimenter, who looked at the subject's fixation point through an apperture in the apparatus before each stimulus presentation and presented the stimuli only when the fixation appeared to be on the center dot. Any off-center fixations were easily detected with this procedure.

The subjects practiced trials on the initial discrimination until a criterion of 4 out of 5 correct was reached. Following training, an additional 12 trials with the same discrimination task were given. Then without warning, the reversal shift was initiated. Again, criterion was 4 out of 5 correct, with 12 trials following the attainment of criterion. Data from subjects not reaching criterion within 30 trials were not used.

Each stimulus was presented for 200 milliseconds, with an intertrial interval of approximately 20 seconds between feedback and the next stimulus presentation. The 200 millisecond duration was chosen since it would be highly unlikely that the subject could shift his gaze away from fixation during that period. Approximately 180-250 milliseconds must elapse between stimulus movement and initiation of a saccadic eye movement (Haber and Hershenson, 1973). Further, pilot studies indicated that this 200 millisecond duration was sufficient to allow the subject to easily recognize the stimulus letters.

RESULTS

Analyses of variance were performed on the response latency data during acquisition and after criterion was attained for both the initial discrimination and for the reversal discrimination. Factors were Field of presentation (a repeated measure), Type of task (NI-PI), and Counterbalancing; the latter factor was nested in Task. Additionally, an analysis of variance was performed for number of trials necessary to attain criterion for the initial and reversal discriminations. Response data from three subjects were not used due to failure to attain criterion on the initial discrimination; data from one subject was not included due to the subject's being intoxicated.

Initial Discrimination

The analysis of the acquisition latency data, summarized in Appendix B, Table 5, revealed no significant effects. Table 1 reports cell means for response latencies during acquisition of the initial discrimination.

Table 1
Response Latencies during Acquisition
of Initial Discrimination

		Left	Center	Right
PI	Counter-balance 1	.80667	.93667	.67083
	Counter-balance 2	.97333	.75667	.67583
NI	Counter-balance 1	.65750	.94667	.82500
	Counter-balance 2	.62667	.86083	.64883

During acquisition, field of presentation did not significantly affect response measures; nor were there significant effects due to type of task.

The analysis of the post-criterion latency data, summarized in Appendix B, Table 6, indicated a significant main effect due to field of presentation ($F = 13.196$; $df = 2,88$; $p < .01$) and a significant effect for field of presentation and type of task ($F = 7.65$; $df = 2,88$; $p < .01$). Table 2 reports cell means for initial post-criterion

Table 2
Response Latencies for Post Criterion
Trials on Initial Discrimination

		Left	Center	Right
PI	Counter-balance 1	.48042	.51500	.60917
	Counter-balance 2	.47167	.50167	.54646
NI	Counter-balance 1	.52771	.49312	.53354
	Counter-balance 2	.47375	.48687	.49000

discrimination. Tukey tests for differences between means showed that right-field presentation reulted in significantly longer response latencies than either left or center field ($q = .03511$; $r = 3$; $df = 88$; $p < .01$). Tukey tests for the interaction indicated that for the NI task, the effect of field of presentation was not significant; for PI tasks, the right field was inferior to both left and center fields ($q = .04966$; $r = 3$; $df = 88$; $p < .01$). Further, the right-field latencies were significantly longer for the PI tasks than for center field presentation of NI tasks ($q = .04966$; $r = 3$; $df = 88$; $p < .01$). Visual field of presentation accounted for 2% of the total variability and the interaction of visual field and task accounted for 1% of the total variability (based on Utility Index, Dodd and Schultz, 1973). Calculation of the strength of association after subtracting the variance due to subjects showed that field of presentation accounted for 10% of the variability, and the interaction effect represented 5%.

Reversal Discrimination

Table 3 reports cell means for response latencies during

Table 3
Response Latencies during Acquisition
of Reversal Discrimination

		Left	Center	Right
PI	Counter-balance 1	.45417	.54917	.54583
	Counter-balance 2	.52833	.76083	.62333
NI	Counter-balance 1	.48483	.54167	.63583
	Counter-balance 2	.52333	.59750	.53167

acquisition of the reversal discrimination. The analysis of variance of acquisition data, summarized in Appendix B, Table 7, indicated that there was a significant effect due to Field of presentation ($F = 11.0339$; $df = 2,88$; $p < .01$) and a significant interaction effect due to Field of presentation and the counterbalancing procedure ($F = 4.2052$; $df = 2,88$; $p < .05$). Tukey tests for the interaction showed that latencies for center-field presentation were significantly higher than left or right field of presentation in Counterbalance Two ($q = .076801$; $r = 3$; $df = 88$; $p < .01$), while latencies for right and center presentation were significantly higher than left presentation in Counterbalance One ($q = .05780$; $r = 3$; $df = 88$; $p < .05$). Right and center field presentation were not significantly different from each other. Field of presentation during acquisition of the reversal discrimination accounted for 3% of the total variability, and the interaction accounted for 1%. Without the variance contributed by subjects, these factors represent 10% and 3% respectively.

The analysis of variance summary table for the post-criterion latency data is shown in Appendix B, Table 8. Table 4 reports cell

Table 4
Response Latencies for Post Criterion
Trials on Reversal Discrimination

		Left	Center	Right
PI	Counter-balance 1	.43375	.42917	.42625
	Counter-balance 2	.53146	.48250	.49917
NI	Counter-balance 1	.49021	.45437	.46250
	Counter-balance 2	.51667	.50146	.46667

means. The analysis of variance showed only a significant main effect due to Field of presentation. Tukey tests indicated that left-field presentation results in significantly longer latencies than either center or right presentation ($q = .02040$; $r = 3$; $df = 88$; $p < .05$). Field of presentation accounts for 7% of the total variance. Without variance due to subjects, Field of presentation accounts for 50% of the variance.

Trials to Criterion

The analysis of trials to criterion necessary for all conditions in both the initial and reversal discrimination showed that the NI-PI factor was significant ($F = 4.1800$; $df = 1,44$; $p < .05$). The data, summarized in Appendix B, Table 9, was analyzed as a function of type of task, discrimination phase, and counterbalancing; trials per field of presentation was not considered a factor in this analysis. Subjects having PI tasks took a mean of 5.937 trials to attain criterion; whereas, subjects having NI tasks required 7.604 trials to attain criterion. This factor accounted for 1% of the total variance.

DISCUSSION

Discussion of these results must consider not only the significant effects of field of presentation on response latency measures, but also the small amount of total variance accounted for by such a factor.

Analysis of reaction times during acquistion seemingly yields little valid information. During acquisition of initial discrimination no factor produced a significant effect. During acquisition of the reversal discrimination there was a significant main effect and a significant interaction effect. Interpretation of both analyses must be made with care. Not only did the significant effects account for a small proportion of total variance, but measures taken during acquisition represent an unstable pattern of responding. That is, since the number of trials necessary to attain criterion was very small ($\overline{X}$ = 6.3 for the initial discrimination; $\overline{X}$ = 7.6 for the reversal discrimination), these trials represent a multiplicity of uncontrolled factors which would effect response time. Before a stable pattern of responding was established, the experiment had progressed to the post-criterion phase. The significant interaction effect found during acquisition of the reversal discrimination accounts for only 1% of the total variance, though when variability due to subjects is removed from the total variability, this strength of association rises to 3%.

Similarly, when using trials to criterion as a response measure, the finding that NI tasks required significantly more trials than did PI tasks both in the initial and reversal discrimination accounts for only 1% of the total variance, and 2% when subject variance is removed. Though this significance seems to indicate that subjects tend to respond along a size dimension faster, it appears that many other factors are influencing the acquisition of a discrimination.

Clearly the more valuable data are obtained from measures of response latencies during post criterion trials. Post criterion trials on the initial discrimination showed a significant interaction effect due to field of presentation and Type of task. The finding that NI tasks could be performed equally well in either field of presentation differs from the findings of Cohen (1972) and Gazzaniga (1970), both of whom found a consistent right-field advantage for tasks which were termed "name identities". There are two possible explanations for the finding in the present study that performance on NI tasks did not differ as a function of field of presentation. First, it appears likely that the initial NI task could actually be performed by either hemisphere. Gazzaniga (1970) reports that the minor hemisphere can spell, comprehend, and read. It appears that the task of picking the correct letter on the basis of name may well fall within the limits of the right brain's capacity to deal with simple verbal tasks. The alternative explanation may be that this task can, in fact, be done by feature analysis and does not require reference to verbal processes. The Cohen (1972) and Gazzaniga (1970) research required that the subject merely make a judgement of <u>same</u> or <u>different</u> on the basis of physical shape or name. The present research required a judgement of which of two stimuli was correct on the basis of a learned concept. Though judgement of <u>same</u> or <u>different</u> required verbal areas for NI tasks, as in the case of Cohen and Gazzaniga, it need not be the case that choice of stimuli on a name basis requires these same areas. That is, the present task may be less verbally demanding than that used by Cohen and Gazzaniga.

For the PI task, the present research points to a significant facilitation of left-field presentation. This result is congruent with the findings of Cohen, though Gazzaniga found no field affect for PI tasks. The PI task, therefore, in which the concept is concerned with the dimension of large-small, could in the initial phase be performed faster by the right hemisphere. And, the NI task could be performed equally well by both hemispheres due either to the task being less verbally demanding or to the right hemisphere's being capable of simple verbal tasks.

During post-criterion trials on the reversal discrimination, again there was a significant field effect. Both NI and PI discriminations were performed faster with right-field presentation. This finding is consistent with the prediction that mediation requires reference to the verbal areas. This right-field advantage existed equally for both NI and PI tasks. For the reversal shift, the major effect is due to the process of mediation rather than to the type of task. Visual field of presentation accounted for 7% of the total variance, and for 50% of the variance not accounted for by subjects. This latter estimate of strength of association is of statistical value in that in the present design repeated measures was used. Such a manipulation has an inherent control for individual variance, but in calculating a utility index, this individual variance is included in the total variance. It appears that, in calculating strength of association for a repeated-measures design, the estimation of variance accounted for by a particular factor may be logically computed without considering variance due to subjects. The experimenter realizes that both estimates of strength of association give information about the predictability of a specific factor but is unable to assess their relative utility.

For the post-criterion latencies in the PI condition during the initial discrimination phase there is a clear left-visual field (right hemisphere) superiority, while in the reversal phase, this superiority is reversed, with significantly longer response latencies for left-visual field presentation for both NI and PI. These different findings seem to indicate that there are different processes involved in the performance on the initial discrimination as compared to the reversal discrimination.

The prediction that PI would be performed with shorter response latencies than NI was not comfirmed. The disagreement between the present results and the prediction, based on the work of Cohen (1972) and Posner and Mitchell (1967), may be attributed to a difference in task requirements . As previously mentioned, the present task required that the subject respond by choosing the correct letter, a task which can be done by feature analysis. It appears that both the NI and PI tasks, in the present research, were performed on the basis of feature discrimination due to the fact that no time differential between NI and PI was found. It was found that NI tasks required fewer trials to criterion than PI tasks.

The fact that many of the significant effects in the present study did not account for a large amount of total variance calls for some comment. First, it suggests that the results be interpreted with care. Secondly, it may indicate the variables themselves are not very powerful. Though this may be the case, it also seems likely that there are other explanations. To reduce subject variability, more rigorous training procedures should have been utilized to possibly increase the predictability of the major factors. Rather than having criterion established with 4 out of 5 correct trials, it would have been advantageous to set a minimum limit of perhaps 30 trials before strict latency measures were recorded. Such a minimum would have decreased variability both within and between sugjects. Further, inasmuch as the expected time differential is rather small (less than a second), with these extended training procedures, effects due to subject idiosyncrasies would be minimized, and effects due to treatments would more likely be maximized. This procedure would have allowed comparisions between the initial and reversals for specific tasks. With a criterions of 4 out of 5 trials correct, such computations were not feasible as decreases in response latencies were possibly occurring as a function of increased practice through the reversal condition.

Another possible confounding factor may lie in the use of the dominant hand for indicating responses. Though differences due to use of the dominant hand may be an unimportant factor in the present design, it is worth considering the possibility that the right-field presentation may have an advantage that is not due to superior processing by the left hemisphere but rather due to its direct connections with the right hand. Gazzaniga (1967) notes that the right hemisphere has full control of the left hand but not of the right hand. This superiority of contralateral control would result in a motor advantage when stimuli are presented to the left hemisphere for responses with right hand. Brinkman and Kuypers (1973) confirm that for visually guided movements in the rhesus monkey, this is, indeed, the case. However, Filbey and Gazzaniga (1969) find no difference for manually indicated responses as a function of field of presentation. That is, if there had been a motor advantage, right-field presentation should have been significantly faster. The differences in these various results may involve a difference in response requirement. The research conducted by Filbey and Gazzaniga involved moving a lever either to the right or to the left; Brinkman and Kuypers used a reaching task requiring visual cues. The present research used a response more similar to that of Filbey and Gazzaniga. Further, Brinkman and Kuypers report that there is contralateral control over hand and arm movements, but also there is ipsilateral control for proximal and complex movements such as precise grasping. The present research utilized a response which entailed a nonvisually-guided response which did not involve reaching, but rather a proximal, finger movement which according to Brinkman and Kuypers, can be controlled by the ipsilateral hemisphere. Though the issue of right-field superiority due to a motor advantage is not resolved, it should be pointed out that the present data did not seem to indicate that there is such an advantage for right-field presentation. The reversal of effect of visual field of presentation between the initial and reversal discriminations (i.e., left field faster than right during the initial discrimination and right field faster than left during the reversal) together with the results of Filbey and Gazzaniga (1969) and Brinkman and Kuypers (1973) make such an advantage less likely.

In conclusion, the inferences that may be drawn from these results are, to some degree, limited in their utility. But, a trend does seem apparent. There was a significant effect of field of presentation on response latencies. During the initial discrimination of the PI task, left visual field presentation resulted in shorter post-criterion latencies than either center or right field presentation. During the reversal discrimination of both PI and NI tasks, left visual field presentation resulted in longer post-criterion response latencies than either center or right field presentation. From these findings, it appears that two processes are involved in learning successive discriminations. Learning a reversal discrimination is facilitated by processes which occur in the left hemisphere. Further, a major difference between left and right hemispheres is the differential language ability, with the left being more proficient. However, before the conclusion can be drawn that mediation requires reference to verbal abilities, greater control must be gained over extraneous variables which were operative during the present research.

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APPENDIX A

Instructions

Please write your name on the back, top of this answer sheet. You are going to participate in a learning experiment in which you will be asked to decide which of two stimuli is correct. I want you to be as accurate as you can and as fast as you can; I will be recording both your errors and your reaction time.

Look into the tachistoscope and notice the dot. You are to stare at this dot and maintain this focus during each visual presentation. The presentation will be two letters, A and B, arranged in a vertical column. I am going to show you several examples of the letters now, before the experiment begins. Look into the tachistoscope, and I will flash the letters - first, they may be on the right... or on the left... or in the center. Do not try to anticipate which direction the next presentation will be from; nor should you shift your gaze in that direction when the letters flash on. This is very important. Always keep your focus on the dot.

Now notice the switch in front of you. After the letters are flashed, you will indicate your choice by moving the key up or down. If you think the top letter is correct, move the switch up; if you think the bottom is correct, move the switch down. Please hold the switch between your thumb and index finger, using your right hand, so that it is easy to move the switch in either direction. Following your response I will tell you whether your choice was correct or incorrect. After I tell you whether you were correct or incorrect, please return the switch to the center position. Please do not return the switch to the center position until I have told you whether you were correct or incorrect.

To summarize the procedure, you are to sit comfortably with your forehead against the hood and fixate the center dot. Rest your hand on the response switch. I will say ready, and the two letters will be presented, during which time you should still maintain your center fixation. As soon as you are ready to make a choice, indicate this by moving the switch in the direction to correspond to your choice. At first you will have to guess, but after a while you will be able to figure the problem out and you will be correct every time.

Again, please make your decision as quickly as possible but with as much accuracy as possible. And be sure to maintain your center fixation; this is very important.

Do you have any questions?

APPENDIX B

Data Summary from Analyses of Variance for Response Latency Data

The following factor designations will be used throughout Appendix B:

Type Task (NI-PI) is designated as Factor A
Counterbalance is designated as Factor B
Field of Presentation is designated as Factor C
Subjects is designated as Factor S
Test Phase (Reversal-Nonreversal) is designated as Factor D

Table 5

Data Summary of Response Latencies during Acquisition of Initial Discrimination

Source of Variance	df	Sum of Squares	Mean Square	F
A	1	.06502	.06502	.1837
B	1	.09100	.09100	.2572
C	2	.71381	.35690	2.0090
AB	1	.08122	.08122	.2295
AC	2	.75975	.37987	2.1383
BC	2	.26476	.13238	.7452
S(AB)	44	15.57080	.35388	
ABC	2	.16142	.08071	.4543
SC(AB)	88	15.63332	.17765	

Table 6

Data Summary of Response Latencies during Post-Criterion Trials on Initial Discrimination

Source of Variance	df	Sum of Squares	Mean Square	F
A	1	.014249	.014249	.1563
B	1	.035549	.035549	.3898
C	2	.086072	.043036	13.3196 **
AB	1	.000356	.000356	.0039
AC	2	.049434	.024717	7.6501 **
BC	2	.011265	.056327	1.7433
S(AB)	44	4.012560	.091194	
ABC	2	.007026	.003513	1.0873
SC(AB)	88	.284330	.003231	

** significant at $p < .01$

TABLE 7

Data Summary of Response Latencies during Acquisition of Reversal Discrimination

Source of Variance	df	Sum of Squares	Mean Square	F
A	1	.021266	.021266	.1321
B	1	.124255	.124255	.7716
C	2	.340982	.170491	11.0306 **
AB	1	.140001	.140001	.8693
AC	2	.068432	.034216	2.2137
BC	2	.129959	.064979	4.2041 *
S(AB)	44	7.085951	.161044	
ABC	2	.035886	.017943	1.1609
SC(AB)	88	1.360150	.015456	

* significant at $p < .05$
** significant at $p < .01$

Table 8

Data Summary of Response Latencies During Post-Criterion Trials on Reversal Discrimination

Source of Variance	df	Sum of Squares	Mean Square	F
A	1	.008023	.008023	.1191
B	1	.091000	.091000	1.3510
C	2	.024910	.012455	6.3381 **
AB	1	.021390	.021390	.3176
AC	2	.003079	.001539	.7834
BC	2	.003327	.001663	.8467
S(AB)	44	2.963687	.067356	
ABC	2	.002813	.004067	2.0699
SC(AB)	88	.172933	.001965	

** Significant at $p < .01$

Table 9

Data Summary of Trials to Criterion for Reversal and Nonreversal Shift Phases

Source of Variance	df	Sum of Squares	Mean Square	F
A	1	66.666	66.666	4.1800 *
B	1	3.375	3.375	0.2116
D	1	15.041	15.041	0.8283
AB	1	8.166	8.166	0.5121
AD	1	8.166	8.166	0.4497
BD	1	26.041	26.041	1.4339
S(AB)	44	701.746	15.948	
ABD	1	.666	.666	0.0367
SD(AB)	44	799.074	18.160	

* significant at $p < .05$