FUNCTIONAL CEREBRAL ASYMMETRY: A TEST OF THE SELECTIVE ACTIVATION MODEL

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(ABSTRACT)

Two experiments were designed to selectively prime each cerebral hemisphere to evaluate Kinsbourne's selective activation model. The left hemisphere priming manipulation for both experiments was subvocal rehearsal of neutral words, whereas right hemisphere primes consisted of imagery (Experiment 1) and subvocal rehearsal of affective words (Experiment 2). Reaction time performance in the visual field contralateral to the activated hemisphere was hypothesized to improve. No evidence supporting this hypothesis was found in these experiments, though experimental tasks had significant interference effects. In Experiment 1, non-specific interference effects were found across visual fields for both experimental tasks, suggesting the hemispheres were not preferentially recruited. Right visual field interference was observed in Experiment 2 for subvocal rehearsal, particularly of affective words, implicating selective left hemisphere activation. This finding indicates an overloading of the left hemisphere's affective perceptual capabilities. Significantly, no equivalent right hemisphere effects were observed, suggesting different functional space characteristics for affect perception across the hemispheres. These findings appear to substantiate a structural rather than activational model of functional cerebral asymmetries, but interference effects do unequivocally support either model. Furthermore, in Experiment 2, neutral faces were perceived as angry equally often in both visual fields, though neutral faces in the control and affective rehearsal conditions were more frequently perceived as angry relative to the neutral rehearsal condition. Methodological issues are presented to account for these findings.

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Functional Cerebral Asymmetry: A Test of the Selective Activation Model

The organization of the visual system permits the selective presentation of stimuli to each cerebral hemisphere. Information from each visual field is projected to the contralateral occipital lobe; visual stimuli in the left visual field are projected to the right occipital lobe, whereas stimuli in the right visual field travel to the left occipital lobe. Through use of tachistoscopic apparati and techniques, researchers are confident that information from each visual field is projected to the contralateral hemisphere (Moscovitch, 1986). Standard experimental techniques include subject fixation on a central point, stimulus presentation a few degrees from this point and brief stimulus exposure to prevent eye movements. Evaluation of the speed and accuracy with which the hemispheres perceive various stimuli allows inferences regarding hemispheric processing style, capacity and specialization.

A consistent finding in tachistoscope research is the functional cerebral asymmetry of the hemispheres. In other words, hemispheric processing advantages exist for different types of stimuli. For example, considerable evidence indicates a left hemisphere specialization for the perception and recognition of alphanumeric stimuli (see

Beaumont, 1982). Kimura's (1966) early finding have been substantiated by more recent experiments demonstrating superior left hemisphere verbal/linguistic processing (McKeever, 1986; Strauss, 1983). In a representative study, Strauss (1983) required subjects to judge whether tachistoscopically presented strings of letters were real or non-sense English words. Compared to right hemisphere presentation, stimuli presented to the left hemisphere were judged significantly more quickly and accurately. This tachistoscope research is consistent with clinical findings (Kolb & Whishaw, 1990, pp. 569-574), carotid sodium amytal injections (Rasmussen & Miller, 1977) and dichotic listening experimentation (Bryden, 1982) which also demonstrate preferential left hemisphere involvement during verbal/linguistic processing.

Compared with left hemisphere research, tachistoscopic experimentation assessing right hemisphere functioning has been equivocal. Gross (1972) presented two 16 cell matrices with three blackened cells in each matrix and required subjects to indicate whether the blackened cells were located identically within the two matrices. Correct decisions were made significantly faster when presented to the right hemisphere. Tkacz (1981) was unable to replicate this experiment. Kimura (1969) presented a single dot within a bordered square; a right hemisphere superiority was found when subjects indicated the dot's position on a card with the same border. This study has also proved difficult to replicate (Bryden, 1973). Though the above findings are equivocal a number of tachistoscopic manipulations have yielded consistent right hemisphere advantages: dot enumeration (Kimura, 1966); line orientation judgment (Umilita et al., 1974); and clockface reading (Berlucchi, Rizzolara, Varzi, Rizzolatti & Umilita, 1979). Conclusions based on this early research and more recent inquiries into facial perception, to be discussed below, suggest a right hemisphere superiority for processing visuospatial stimuli (see Davidoff, 1982).

The structural or direct access model was initially postulated to account for these visual asymmetric findings (Kimura, 1966). Two fundamental assumptions were made; (a.) the hemispheres specialize in processing different material, the left verbal and the right visuospatial, and (b.) direct projections from each visual field to the contralateral cerebral area enjoy a processing advantage over ipsilateral and less direct projections. As such, verbal/linguistic material presented to the right visual field is processed more efficiently as information is directly projected to the left hemisphere, whereas verbal stimuli in the left visual field require transcallosal transmission, thereby decreasing processing speed and accuracy. Similarly, visuospatial stimuli are better processed in the left visual field due to direct right hemisphere projections. Moscovitch (1986) considers this an afferent model of laterality in which perceptual asymmetries are determined via projection routes from the receptor organ to specialized cerebral areas.

Underlying this model of functional asymmetry is the notion that the hemispheres are differently organized and structured. Morphological differences are thought to reflect the particular mental specialization of each hemisphere. Geschwind (1987) notes that the two main structural differences between the hemispheres are a larger left temporal operculum and a more severe left Sylvian fissure slope. This organization provides an average of 22% more cortex in the left than the right frontal operculum (Falzi, Perrone & Vignolo, 1982). These structural differences are often considered to translate into functional differences, i.e. language production. Other structural differences include a slightly heavier and larger right hemisphere and longer right occipital horns of the lateral ventricles (Kolb & Whishaw, 1990, pp. 348-351).

Kinsbourne (1980) argues such morphological differences are minor and do not account for the consistent and often gross functional differences between the hemispheres. The structural model also poorly accounts for the plasticity of the human brain, especially the ability of one hemisphere to subsume the cognitive role of a damaged hemisphere in childhood (Goldman & Whitaker, 1985). This model is even more problematic when applied to tachistoscope research. First, it suggests the hemispheres are static processors of hemisphere-specific material. If this is so, the hypothesis poorly explains the contradictory right hemisphere visuospatial research; a phenomenon based on a structural characteristic of the brain should be stable (Cohen, 1982; Kinsbourne, 1973). More importantly, functional cerebral asymmetries can be altered and in some instances reversed. Research has demonstrated that via priming visuospatial processing by the left hemisphere may improve and even surpass that of the right hemisphere (Hellige, Cox & Litvac, 1979; Kinsbourne & Bruce, 1987). These and related studies suggest projection patterns and hemispheric specialization are not the sole factors determining functional asymmetries.

An alternative explanation for functional cerebral asymmetries minimizes morphological differences and suggests the hemispheres are differentially activated or primed. Depending on the behavior required, a brain area may be selectively activated prior to actual behavioral initiation. Kinsbourne's (1980) selective activation model suggests that the left hemisphere, among right-handers, adopts a verbal set and is selectively activated when verbal activity is required. This left-lateralized cerebral activation or priming occurs via the brainstem, particularly thalamic projections to the left hemisphere. Hence the left hemisphere does not control verbal responding because of its unique neuronal configuration, but because it is selectively activated under conditions that demand such responding. A similar mechanism activates the right hemisphere under circumstances that require visuospatial responding. Moscovitch (1986) considers this an efferent model of laterality in which perceptual asymmetries are secondary to the effect hemispheric activation has on attention or other resources that influence hemispheric processing. Rather than a distinct alternative, this more dynamic model represents an extension or amplification of the structural model (Cohen, 1982).

The selective activation model typically assesses activation in terms of attention. Attention is commonly operationalized as eye movements resulting from activation spilling over to the frontal eye fields or Broadman's area eight (Kinsbourne, 1973). When hemispheric activity or activation is in exact balance, attention is centered in the median plane. During hemispheric activation, however, attention deviates contralaterally; left hemisphere activation biases attention towards the right hemifield, right hemisphere activation to the left hemifield. Following hemispheric activation, less processing capacity is required for material presented to the contralateral hemifield, thereby improving performance. Significantly, visual attention is biased toward contralateral space not for purposes of specialized information retrieval, but secondary to asymmetric cortical activation (Kinsbourne, 1973).

The selective activation model nicely accounts for much of the tachistoscope research. Depending on the nature of the manipulation, (a) a hemisphere is preferentially primed, (b) the balance of activation between the hemispheres is altered and (c) processing improves for material presented to the contralateral hemifield. Stimulus type or characteristics are not paramount for hemispheric processing, as the structural model suggests, but functional asymmetries are determined by how the stimuli are processed. For example, subjects may verbally process visuospatial stimuli and label them "square" or "Z-shaped" (McKeever, 1985). Such labelling would prime the left hemisphere and obscure the putative right hemisphere advantage. Therefore, the processing of stimuli in a specific manner with subsequent hemispheric activation is thought to determine functional asymmetries, not the type of stimulus nor its projection path.

To imply that verbal labelling prevents emergence of a right hemisphere visuospatial superiority is admittedly a post hoc explanation. Yet visuospatial research is cognizant of potential verbal interference and typically uses stimuli not readily susceptible to verbal coding. Frequently utilized stimuli include complex forms with 12 points of line inflexion with a corresponding low verbal association value (Fontenot, 1973). Hannay, Dee, Burns, Masek (1981) directly addressed this verbal labelling issue and illustrated how verbal processing may interfere with visuospatial performance. A right hemisphere advantage was initially found on a recognition task using the 12 point complex figures mentioned above. Subjects were then required to learn an arbitrary label for each form, e.g. dog, and to subsequently use that label when identifying the form. A right to left hemisphere superiority reversal was found when such verbal processing was required. This asymmetric shift was interpreted as resulting from an activated left hemisphere.

Activation

The selective activation model predicts that hemispheric activation will increase responding and orienting in the contralateral hemifield. A common test of this hypothesis assesses lateral eye movements following verbal or spatial questions. Kinsbourne (1972) found that right-handers tend to look to the left when asked a spatial question and to the right when asked a verbal question.

Other researchers have reported similar right lateral eye movements following left-hemisphere primes such as spelling (Weiten & Etaugh, 1974), word definition (Ehrlichman, Weiner & Baker, 1974) and completion of logical problems (Galin & Ornstein, 1974). Left lateral eye movements following right hemisphere primes have resulted from visualization (Schwartz et al., 1975), figuring spatial relations (Ehrlichman et al., 1974) and identification of melodies (Weiten & Etaugh, 1974). In a clinical study, Harrison, Alden, Lanter and Zicafoose (1990) found that the number of syllables emitted (propositional speech) corresponded to right directed orienting in a demented patient. The intensity of affective vocalizations was related to the amount of time spent orienting within the left visual field. While Erlichman and Weinberger (1978) note the methodological and empirical difficulties in studying this phenomena, the paradigm remains useful in conceptualizing hemispheric activation.

Research has also examined hemispheric activation by approaching the traditional lateral eye movement paradigm from the opposite direction. Lempert and Kinsbourne (1982) found that subjects who verbally rehearsed sentences with their head and eyes turned toward right had superior recall than subjects who oriented toward the left. The direction of turning did not affect recall for subjects instructed to imagine the sentences. Walker, Wade and Waldman (1982) measured response latencies to verbal and spatial questions when subjects fixated to the left, center or right. Response latencies were significantly longer for verbal questions when subjects fixated to the left or center, but longer latencies for spatial questions were found during right fixation. This research indicates that lateral orienting can activate the contralateral hemisphere and affect subsequent performance.

Left Hemisphere Priming

While lateral eye movements implicate hemispheric activation, more complex experimental techniques have evaluated the priming effect of this activation on subsequent performance. Kinsbourne (1970) required subjects to detect the presence of gaps in squares displayed in two conditions. The verbal load condition required rehearsal of six one-syllable words during the gap detection task, whereas no rehearsal was performed in the standard condition. The hemispheres were equally accurate in gap recognition without verbal load, but right visual field recognition was superior in the verbal condition. Kinsbourne concluded this improved right visual field performance was due to an activated left hemisphere. More recently, Van Strien and Bouma (1990) have substantiated these findings and demonstrated the efficacy of verbal material in priming the left hemisphere.

The principle of functional cerebral distance (FCD) was introduced to address the important conceptual issue of how verbal material affects visual processing (Kinsbourne & Hicks, 1978). The FCD principle submits that the degree to which two concurrent activities affect one another varies with the functional distance between the cerebral regions in which the respective processes are represented. If the neural substrate of activity A is more connected to that of B than C, the activation of A will influence B more than C. This principle conceptualizes the brain as a highly interconnected set of neural networks which control behavior via neural activation (Kinsbourne & Hiscock, 1983). Activation spreads from one cerebral area to another; during verbal processing, activation of the left hemisphere is not confined to areas specialized for language. Other left hemisphere regions including those responsible for sensory (Mazziotta, Phelps, Carson & Kuhl, 1982) and motor processing (Harrison, 1991) may become activated. Spreading activation secondary to verbal processing may therefore prime or activate neuronal regions associated with visual processing.

Kinsbourne's original study has proved difficult to replicate. Boles (1979) found subvocalization of six words to interfer with performance on a form recognition task (Experiment 1). Though when the number of words was reduced to two, no right visual field interference effects were observed. Gardner and Branski (1976) were also unsuccessful in improving right visual field form recognition during subvocalization. This was consistent for six-word lists which interfered with the task (Experiment 1) and three-word lists which showed no directional effect (Experiment 2).

More recently, Kinsbourne (1985) refined the selective activation model and distinguished priming from interference. With light demands the secondary task (e.g. subvocalization) spreads activation, biases attention and facilitates processing in the contralateral hemifield. More demanding tasks, however, may overload a hemisphere and decrease processing capacity for other tasks. This is apparent when two concurrent tasks, e.g. speaking and right hand motor performance, compete for similar or adjacent cerebral areas within the same hemisphere. Thus performance on one task will preempt the other becasue its neural activity overrides that of the other or performance on both tasks will be deficent due to mutual interference (Kinsbourne & Hiscock, 1983).

Dual-task paradigms illustrate how competition for similar cerebral areas may result in interference (see Hannay, 1986). In their classic study, Kinsbourne and Cook (1971) found speaking affected concurrent right and left-hand performance differently. When right-handed subjects balanced a dowel rod on their index finger, concurrent sentence recitation impaired only right hand performance. Harrison (1991) found that reading interfered more with right than left hand and elbow tapping. Additionally, Ashton and McFarland (1991) recorded dot-making during 10 second intervals when subjects either said nothing, recited a tongue twister or said "la-la". Right-handers made significantly fewer dots in the recitation than the control condition, but a decrement was also noted in the "la-la" condition. The strong language component of the recitation task interfered with right hand performance while the "la-la" condition, which has the motoric aspects of speech with minimal verbal components, only marginally affected right hand performance. These experiments indicate that tasks which compete for similar cerebral areas may interfere with performance if either or the sum of the tasks proves too demanding. The distinction between interference and priming is determined by the effort or processing requirements of the tasks; facilitating at light and interfering at heavy loads (Kinsbourne & Byrd, 1985).

A number of experiments provide empirical support for the refined attentional model and account for both priming and interference effects (Bouma, 1987; Hellige & Cox, 1976; Hellige, Cox & Litvac, 1979; Kinsbourne & Byrd, 1985).

Kinsbourne and Byrd (1985) required subjects to rehearse words while performing a visual recognition task. Subjects rehearsed either zero, two, four or six nouns subvocally during the recognition task. Following presentation of a geometric shape, subjects identified that shape from five similar shapes and recalled the words they were rehearsing. A significant quadratic trend for recognition accuracy was found for shapes presented in the right visual field. In other words, recognition was poorer when subjects memorized zero or six words, but significantly improved when subjects memorized two or four words. Kinsbourne concluded the left hemisphere was primed in the two and four word conditions, but overloaded in the six word condition. Interestingly, shapes were recognized more accurately when presented to the right hemisphere without verbal load, but this asymmetry was reversed in the two and four word conditions.

In a similar paradigm, Hellige and Cox (1976) also found a quadratic effect with verbal loads of either zero, two, four or six words on shape recognition (Experiment 1). Ninety-seven percent and 87% of the words were remembered in the two and four word verbal load conditions, respectively. Recall dropped to 60% in the six word condition, indicating interference on both this and the recognition task. In Experiment 2, interference effects were obsevered across all verbal load conditions in a verbal recognition task, suggesting the verbal nature of both tasks overloaded the left hemisphere and obviated any priming effects of verbal rehearsal. Furthermore, both Hellige, Cox and Litvac (1979) and Bouma (1987) found right visual field priming and interference to vary with rehearsal loads in a shape identification and a letter recognition task, respectively.

Right Hemisphere Priming

Comparatively little research has examined the effects of right hemisphere priming on subsequent performance. Right hemisphere priming with visuospatial or nonverbal primes is hypothesized to improve left visual field performance. Early research used musical humming and subvocalization of musical notes as priming tasks, but these manipulations were discontinued due to inconclusive findings (Gardner & Branski, 1976; Gordon, 1970). More recent research has examined the priming effects imagery and affect have on right hemisphere performance.

Imagery

Visual imagery is perhaps the most consistently regarded right hemisphere task. Electroencephalographic (EEG) research has demonstrated right hemisphere activation, measured as a decrease in "relaxed state" brain waves or alpha waves over the right occipital lobe, during visual imagery (Ehrlichman & Wiener, 1980). Ehrlichman and Wiener (1980) required subjects to engage in a variety of covert and self-generated cognitive activities. Right hemisphere activation was found in the following tasks; visual-kinesthetic imagery or imagery of a bodily action and long-term visual memory or imagery of an object from the past. The previously discussed lateral eye movement research also implicates right hemisphere involvement in imagery (Schwartz et al., 1975).

A few tachistoscope studies illustrate the potential priming effect of visual imagery. Seamon and Gazzaniga (1973) centrally presented a pair of words followed by a picture in the left or right visual field. The picture was either a representation of one of the words or unrelated to either word. Subjects subvocally rehearsed the words prior to picture presentation in the rehearsal condition and constructed an image of the words in the imagery condition. Faster same-different judgments were made in the right visual field during rehearsal and left visual field judgments were made more quickly during imagery. Metzger and Antes (1976) used similar priming techniques and found no visual field differences when the probe following the words was verbal, but also found asymmetries when picture probes were used. This pair of experiments suggests imagery can preferentially prime the right hemisphere and asymmetrically impact performance.

Affect

Considerable research has recently investigated the right hemisphere's role in affective expression and perception (see Tucker, 1981). Research has shown the right hemisphere to be superior in perceiving emotion (Harrison, Gorelczenko & Cook, 1990), to have greater EEG activation during emotional states, particularly negative states (Davidson, Ekman, Saron, Senulis & Friesen, 1990), and to express facial affect more intensely (i.e. left-side of face) (Dopson, Beckwith, Tucker & Bullard-Bates, 1984). Right hemisphere damaged patients have been found to be affectively flat (Gianotti, 1972) and to have difficulty perceiving and expressing emotion (Borod, Koff & Lorch, 1985). Further, a number of tachistoscope studies suggest a right hemisphere bias for processing negative affect (Alden, Billings & Harrison, 1991; Harrison & Gorelczenko, 1990; Natale, Gur & Gur, 1983; Suberi & McKeever, 1977). For example, Harrison and Gorelczenko (1990) found high-hostile subjects, using the Cook-Medley Hostility Inventory, more frequently identified neutral faces as angry when presented to the right hemisphere. High and low hostile groups were equivalent on this affective bias measure when faces were presented to the left hemisphere. This group was concluded to be affectively "primed" based on questionnaire date. Natale et al. (1983) found that affective faces, except happy faces, were judged as significantly more sad when presented to the right hemisphere.

A number of experiments indicate that affective stimuli may preferentially prime the right hemisphere. Brody, Goodman, Holm, Krinzman & Sebrechts (1987) used affective words and faces as primes and found significant reaction time (Experiment 1 and 2) and accuracy (Experiment 3 and 4) improvements for affective target stimuli presented to the right hemisphere. Primes were presented for 50 msec immediately prior to target stimulus. Interestingly, affective primes interfered with left hemisphere processing of affective target stimuli. McKeever and Dixon (1981) required subjects to memorize neutral target faces using either negative affective imagery or neutral imagery. Women in the affective imagery condition showed a reaction time advantage for faces presented to the right hemisphere. No effect for neutral imagery was found for either men or women, suggesting affect selectively and independently primed the right hemisphere.

A pair of studies by Bryden and Ley (1980, 1983) also indicate the potential priming effect of verbal affective material. Subjects memorized lists of words varying in imagery and affect for five minutes after they had been tested on a laterality task, either tachistoscopically presented faces or dichotic word listening. When retested, accuracy increased for faces presented in the left visual field and for words presented to the left ear, but only when subjects memorized affective words and not neutral words. High-imagery words independently produced a similar right hemisphere performance improvement. Ley and Bryden (1982) concluded that high-imagery and affective words can independently prime the right hemisphere.

Results of the preceding experiments are inconsistent with the hypothesis that verbal activity primes the left hemisphere. Rather, under certain conditions it appears verbal material may prime the right hemisphere. This interpretation does not necessarily imply that words have affective or imagic components, but that rehearsal of a set of similar words may activate some general "affective" or "imagery" concept (Bryden & Ley, 1983). While imagery and affect perception are considered to be primarily right hemisphere mediated, the capacity of high imagery or affective verbal material to activate the right hemisphere remains unclear. Though Graves, Landis & Goodglass (1981) have demonstrated a right hemisphere superiority for the perception of emotional words. Nevertheless, the putative priming effect of affective verbal material remains an interesting area for future research.

The proposed experiments are based on the selective activation model and utilize concurrent processing tasks designed to selectively prime each hemisphere. These priming tasks are hypothesized to alter functional cerebral asymmetries in an established paradigm sensitive to hemispheric processing differences (Harrison & Gorelczenko, 1990). The paradigm requires subjects to identify the affect, happy or angry, of tachistoscopically presented faces. Consistent with other research (Hugdahl, Iversen, Ness & Flaten, 1991), a robust right hemisphere superiority is found for men in this affect recognition task.

Experiment 1

Rationale

This experiment will change functional cerebral asymmetries via tasks designed to selectively prime each hemisphere. Two priming tasks will be used; subvocal rehearsal of neutral words and imagery of high imagery words. Baseline performance will be assessed via a control condition. Two predictions will be tested: 1. Relative to the control condition, rehearsal of neutral words will prime the left hemisphere and improve right visual field performance. 2. Relative to the control condition, imagery of high-imagery words will prime the right hemisphere and improve left visual field performance.

Methods

Subjects. Twenty-eight right-handed men from the Introductory Psychology Pool participated. Handedness was determined via a behaviorally validated 13-item questionnaire which assesses four types of lateral preference (hand, foot, eye and ear) (Coran, Porac, & Duncan, 1979). Average concordance between this self-report instrument and behavioral measures is .90. Self-report items are scored as +1 for right, -1 for left and 0 for both hand dominance. Criterion for right-hand dominance and inclusion in the experiment was a score of +7 or above (max = +13). Mean handedness score was 10.9 (SD = 1.9). Subjects with known neurological or visual problems were excluded.

Tachistoscopic apparati and materials.

Twenty-four emotional faces (12 happy and 12 angry) were randomly selected from Ekman and Friesen's (1978) pictures of facial affect. Slides of these pictures were created with the stimulus face appearing in either the right (RVF) or left visual field (LVF). Stimuli were mounted with the inside edge of the picture 3 degrees from the center and the outside edge 12 degrees from the center (see Sergent, 1982). A total of 48 slides (12 RVF happy, 12 LVF happy, 12 RVF angry and 12 LVF angry) were used.

The experimental chamber was sound-attenuated with the automated programming equipment and experimenter located in a separate room. Subjects were monitored through a one-way observation window and prompted with an intercom. A constant illumination tachistoscope (Lafayette Model 42011) presented the stimuli onto a screen 2.67 meters in front of the subject. The center of the screen was marked with a black dot positioned 1.47 meters above the floor. Luminance level was 2.5 candelas per m throughout the experiment measured at subjects' eye level. Tachistoscopic trial onset was signaled by a 2000 Hz, 55dB (A-scale) tone located behind the subject. The manipulanda consisted of two "soft touch" trip switches flush mounted midline on a right-handed student desk 58.5 cm from the back of the chair. Response keys, separately labeled "Happy" and "Angry", were counterbalanced across subjects to eliminate position effects.

Priming tasks and materials.

Two priming conditions were used; subvocal rehearsal of neutral words and imagery of high-imagery words. Baseline performance in each visual field was assessed via a control condition without rehearsal or imagery. These three conditions constituted an experimental trial; the experiment was composed of four trials, each separated by a one minute rest period. Conditions were counter-balanced within the experimental trials.

Subvocal rehearsal of three neutral words concurrent with tachistoscope performance was required in the subvocal rehearsal condition. Tape-recorded instructions informed subjects to neither imagine nor picture the words. Words were presented five seconds prior to the tachistoscope presentations, after which a tone signalled subjects to recall the words. Recall percentage was computed to ensure compliance with experimental procedures. Words presented in this condition were limited to one or two syllable words. These words were among the most frequently used (Thorndike & Lorge, 1944) and were rated as difficult to image (Paivio et al., 1968). Each list of three words had an equal number of syllables (Appendix D).

In the imagery condition, three one or two syllable high imagery words were presented. These words were reported to be significantly easier to image than the neutral words (Paivio et al., 1968). Subjects developed a visual image of each word and generated a single imaginative scene containing all three images. This image was mentally held during tachistoscope performance after which subjects reported the ease in developing the image and the vividness of the image (Appendix F). Recall was not be computed in this condition.

Tachistoscope trials.

Eight slides, two of each happy and angry slides in each visual field, were tachistoscopically presented during each experimental condition. The slides were pseudorandomized into six orders with the provision that no more than two consecutive slides have the same affect or visual field. Each order was presented twice during the experiment. As three conditions constituted an experimental trial, 24 slides were presented in each trial. A total of 96 slides were presented across the four trials of the experiment, allowing 48 slides in each visual field, 24 per affect. This granted eight slide presentations per permutation of condition by visual field by affect.

Procedure.

Subjects signed informed-consent forms and completed the handedness questionnaire. After tape-recorded presentation of tachistoscope instructions (Appendix A), subjects completed a practice trial consisting of 10 happy and 10 angry slides. A one second tone signalled the slide presentation, three seconds following the tone the stimulus slide was shown for 200 ms. Subjects identified the affective valence of the face using the two-choice reaction time paradigm mentioned above. Intertrial interval was approximately 10 seconds. The second set of tape-recorded instructions was then presented (Appendix B) and each priming task practiced. Correct identification of eight consecutive slides within the three practice trials was necessary for inclusion in the study. A one-minute interval separated practice trials from the experiment.

In each priming condition the experimenter read three words to the subject via an intercom. The command rehearsal or imagery followed each list of words and indicated the type of priming required. In the rehearsal condition subjects subvocally rehearsed the words for five seconds when a tone signalled the beginning of the tachistoscope trials. Following completion of the condition, a tone notified subjects to verbally recall the presented words. In the imagery condition, subjects developed an image of the words and notified the experimenter when an image was achieved by raising their hand. A tone then signalled the beginning of the tachistoscope trials. Following presentation of the complete condition, subjects rated the ease in developing the image and the vividness of that image (Appendix F). No words were presented in the control condition and subjects sat quietly for five seconds prior to the tachistoscope trials. Twenty seconds separated the experimental conditions after which three new words were presented. Subjects were also reminded to focus on the fixation point after each trial to improve integrity of the stimulus presentation within the visual fields.

Errors. Misidentification of the slide affect and reaction times greater than two seconds were considered errors. This time limitation was used sparingly (six times across the experiment), but imposed to control for extraneous factors such as poor subject concentration or attentiveness. For each error, mean reaction time for the other presentations of that permutation were calculated and substituted for the incorrect response.

Results

Data were analyzed with a three factor fully repeated measures analysis of variance (ANOVA) with factors of visual field (2), slide affect (2: Happy and Angry) and condition (3: Control, Subvocal Rehearsal and Imagery). Reaction time was the dependent measure for all analyses. Due to the statistical power of repeated measures designs, degrees of freedom were reduced with the Greenhouse-Geisser correction factor (Greenhouse & Geisser, 1959; Hays, 1988, pp. 520-525). Significance levels of all main effects and interactions were computed with the conservative and adjusted degrees of freedom. Posthoc comparisons were performed with Tukey's Honestly Significant Difference Procedure (HSD)(alpha=.05).

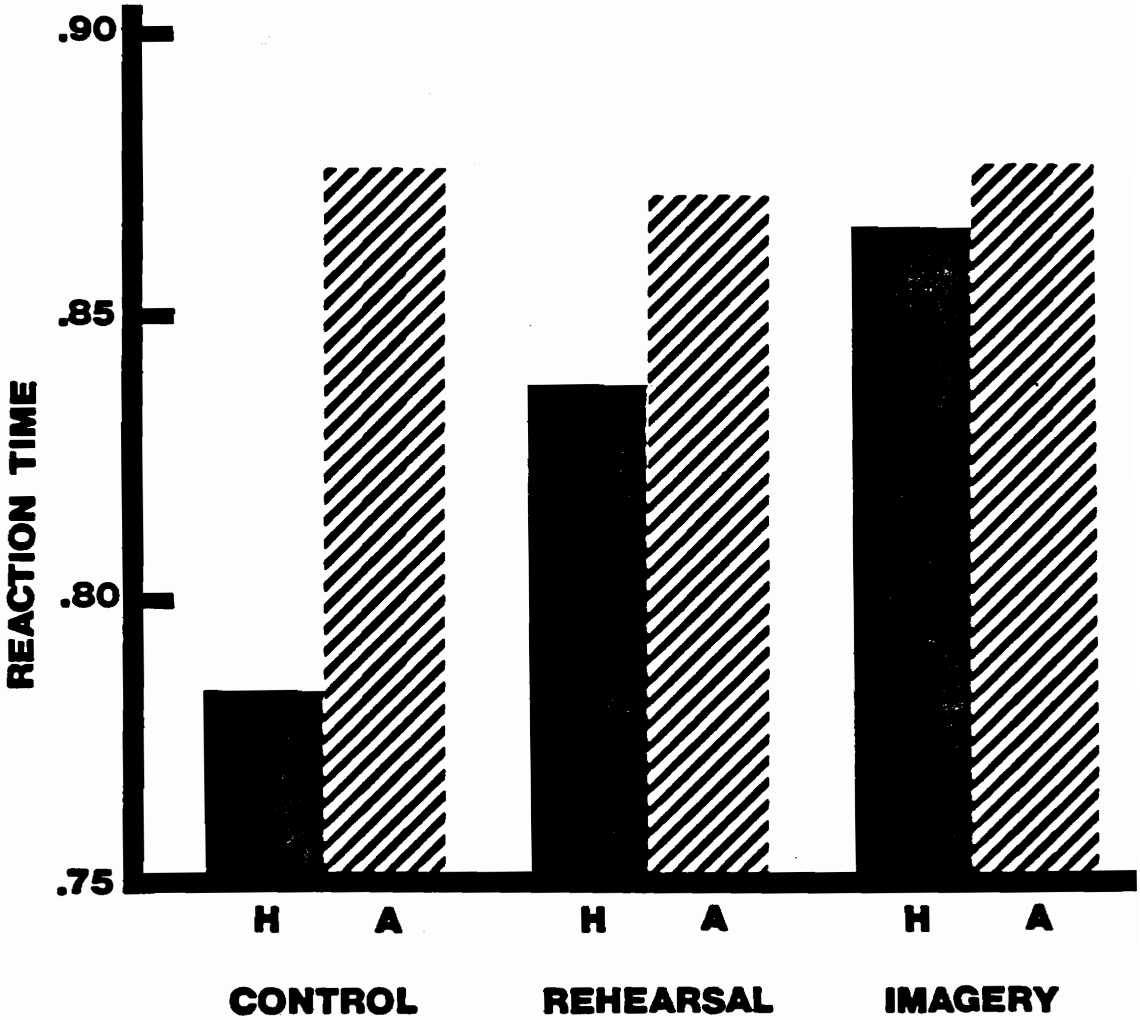
Manipulation checks revealed the ease of the priming tasks. Word recall following the rehearsal conditions was 99.4%. In the imagery condition, subjects reported ease in generating the images (M = 6.23, SD = .80) and that the ensuing images were vivid (M = 5.57, SD = 1.16). Subjects made an average of 3.25 (SD = 1.9) slide misidentification errors across the experiment. Four subjects were excluded due to error rates greater than 10% (M = 11.25, SD = 1.5). Summed across subjects, errors were roughly divided among the control (25), imagery (31) and rehearsal (35) conditions. A greater number of errors were made for angry (55) than for happy (36) slides.

Reaction-time analysis revealed that the Condition X Visual Field interaction and the Visual Field main effect were not significant. The Condition x Affect interaction, however, was significant $F\ (1,27) = 9.08$, $p<.006$, (see Figure 1). Posthoc comparisons indicated reliable differences between the control condition and both the subvocal rehearsal and imagery conditions for happy faces. No significant differences were found between conditions for angry faces. Surprisingly, the experimental conditions interfered with and retarded reaction time for the perception of happy, but not angry faces. Overall, the main effect of affect was significant, $F\ (1,27) = 13.25$ $p<.002$, with reduced reaction times for happy faces. This finding is consistent with previous research from the same laboratory (Harrison & Gorelczenko, 1990).

Though no interaction with Visual Field was observed, the main effect of condition was significant, $F\ (1,27) = 7.80$, $p<.01$. Posthoc comparisons confined significantly slower reaction times to the imagery versus control condition. Subvocal rehearsal reaction times were also

Figure Caption

Figure 1. Reaction time in seconds as a function of condition and affect.



.90
.85
.80
.75
REACTION TIME
H
A
H
A
H
A
CONTROL
REHEARSAL
IMAGERY

slower than the control condition, but this difference was not statistically significant. These results indicate that both experimental conditions affected reaction time via a non-specific interference effect apparent across visual fields. As such, each experimental manipulation appeared to equally recruit the performance of both cerebral hemispheres.

Discussion

The hypothesized selective priming effect of experimental condition on affect recognition was not supported. The main effect of condition, however, indicates that the experimental manipulations resulted in interference effects across both visual fields. Thus the experimental conditions did not appear to selectively improve the performance of either hemisphere.

Surprisingly, happy faces were more susceptible to interference than angry faces in the experimental conditions. That a dual task paradigm with non-specific interference effects across visual fields should more detrimentally impede perception of an easy (happy) versus a difficult (angry) stimulus (i.e. happy faces were perceived more quickly) is counterintuitive. Two explanations may account for this finding. A floor effect, indicated by slower reaction times, may exist for angry faces and immune them from further interference. Reaction times may, in fact, already be at their slowest level for these faces in the control condition. Alternatively, non-specific interference effects imply recruitment of both cerebrums by the experimental conditions. Previous research has demonstrated that, relative to angry faces, the perception of happy faces has greater bilateral representation (Harrison & Gorelczenko, 1990). Happy faces may thus be more sensitive to tasks which have bihemispheric, global effects. Though not observed in this experiment, considerable research has noted a right hemisphere perceptual advantage for angry faces (Harrison & Gorelczenko, 1990; Hughdahl et al., 1990; McKeever, 1986). This localized representation may result in the relative immunity of angry faces from tasks which have general interference effects but do not specifically recruit right hemisphere performance.

Experiment 2

Rationale

Concurrent tasks designed to selectively prime each hemisphere are hypothesized to change functional cerebral asymmetries. Two priming tasks will be used; subvocal rehearsal of neutral words and subvocal rehearsal of affective words. Baseline performance will be assessed via a control condition. Different than Experiment 1, this experiment will also include neutral faces to assess affective bias secondary to priming. Since only two response alternatives exist, happy and angry, the consistent choice of either affect for neutral faces will indicate an affective bias. Three predictions will be tested:

1. Relative to the control condition, rehearsal of neutral words will prime the left hemisphere and improve right visual field performance; 2. Relative to the control condition, rehearsal of affective words will prime the right hemisphere and improve left visual field performance; 3. Relative to the other conditions, faces presented in the subvocal affective condition will be more frequently judged as angry, particularly in the left visual field.

Methods

Subjects.

The same criterion used in Experiment 1 were applied. Subjects (N = 30) average handedness score was 11.83 (SD = 1.61).

Tachistoscopic apparati and materials.

Twenty-seven emotional faces, nine happy, nine angry and nine neutral, were selected from Ekman and Friesen's pictures of facial affect. Slides of these pictures were prepared with the stimulus face appearing in either the right (RVF) or left visual field (LVF). A total of 54 slides (9 RVF happy, 9 LVF happy, 9 RVF angry, 9 LVF angry, 9 LVF neutral and 9 RVF neutral) were used.

Priming tasks and materials.

Two priming conditions were used; subvocal rehearsal of neutral words and subvocal rehearsal of affective words. Baseline performance in each visual field was assessed via a control condition requiring no subvocalization. Three conditions constituted an experimental trial; a total of four trials were presented.

The same procedures used in Experiment 1 were also used in the neutral word rehearsal condition. Subjects rehearsed three neutral words concurrent with tachistoscope performance. Similar procedures were employed in the affective word rehearsal condition, but three affective words were used (Appendix E). These were one or two-syllable words which were to be neither imagined nor pictured. Each list of words was matched on the number of syllables.

Tachistoscope trials.

Different than Experiment 1, nine slides were tachistoscopically presented in each experimental condition. This allowed three slides of each affect, angry, happy and neutral, to be presented in each condition. Six pseudorandomized orders of slide presentation were designed with the provision that no more than two consecutive slides have the same affect or visual field. Each order was presented twice during the experiment. As three conditions constituted an experimental trial, 27 slides were presented in each trial. A total of 108 slides were presented across the four trials of the experiment; allowing 54 slides in each visual field, 18 per affect. This granted six slide presentations per permutation of condition by visual field by affect.

Procedure.

Subjects signed informed-consent forms and completed the handedness questionnaire. After tape-recorded instructions were presented (Appendix A), subjects completed practice trials consisting of 10 angry and 10 happy slides. No neutral slides were included in the practice trials. Slide presentation procedures and inclusion requirements were the same as those used in Experiment 1. The second set of tape-recorded instructions was then presented (Appendix C) and each priming task practiced. Correct identification of 8 consecutive slides in the practice conditions was necessary for inclusion in the experiment. A two minute interval separated the practice trials from the experiment.

Different than Experiment 1, neutral slides were included to assess a possible affective response bias as a function of priming. Subjects were not aware that neutral faces had been included nor was a separate response alternative available. The practice procedures remained the same, using only happy and angry faces, but neutral faces were included in the experiment proper.

In each priming condition the experimenter read three words to the subject via an intercom. Following each list of words, whether affective or neutral, the command rehearsal notified subjects to begin rehearsal. Subjects subvocally rehearsed the words for five seconds when a tone signalled the beginning of the tachistoscope trial. Following completion of the condition, a tone signalled subjects to verbally recall the presented words; recall percentage was be computed to assure compliance. No words were presented in the control condition and subjects sat quietly for five seconds prior to the tachistoscope trials. Twenty seconds separated the experimental trials after which three new words were presented.

Errors. Errors were calculated in the same fashion as Experiment 1. A total of twelve responses were greater than the two second time limititation and consequently considered errors.

Results

Data were analyzed with a three factor fully repeated measures analysis of variance (ANOVA) with factors of visual field (2), slide affect (2: Happy and Angry) and condition (3: Control, Subvocal Neutral Rehearsal and Subvocal Affective Rehearsal). Neutral faces were analyzed separately. Significance levels of main effects and interactions were computed with conservative degrees of freedom (Greenhouse & Geisser, 1959; Hays, 1988). The adjusted degrees of freedom are reported for each analysis. Posthoc comparisons were performed with Tukey's HSD procedure (alpha = .05).

Manipulation checks revealed the ease of the priming tasks. Accuracy of word recall following the neutral and affective word rehearsal conditions was 100% and 99.7%, respectively. The average error rate for happy and angry slides was 3.8 (SD = 2.84). One subject was excluded due to an error rate (n=14) greater than 10%. Summed across subjects, errors were roughly divided among the affective rehearsal (39), neutral rehearsal (43) and control (44) conditions. Similar to Experiment 1, more errors were made for angry (79) than for happy (47) faces.

The only significant reaction time comparison, including main effects was the Condition X Visual Field interaction, F (1,29) = 4.17, p<.05 (see Figure 2). Posthoc comparisons revealed slower reaction times for the affective rehearsal versus the control condition in the right visual field. A non-significant reaction time decrement was also apparent in the neutral rehearsal versus control condition. No reaction time differences were observed between conditions in the left visual field. Affective subvocal

Figure Caption

<u>Figure 2</u>. Reaction time in seconds as a function of condition and visual field.

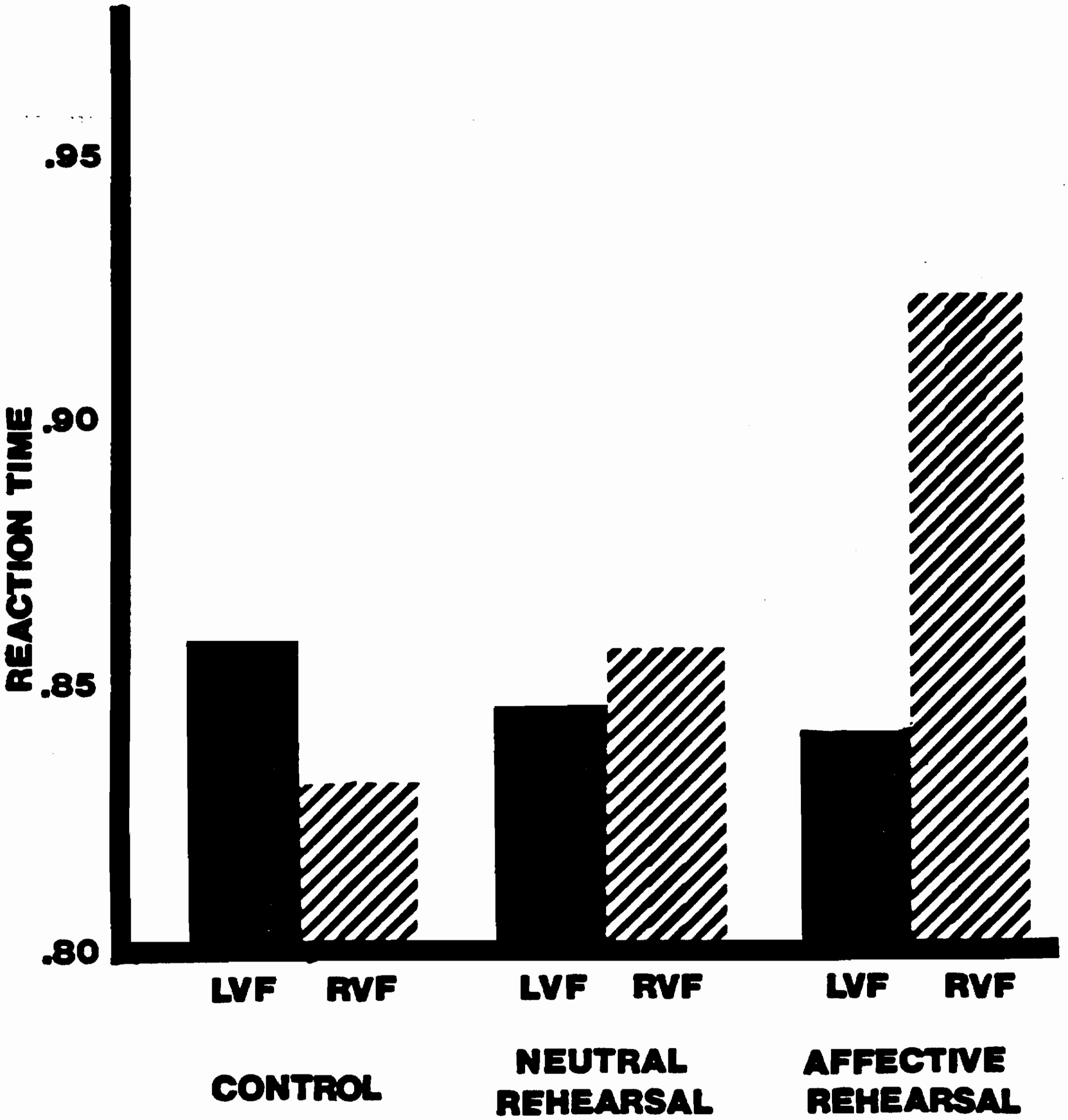
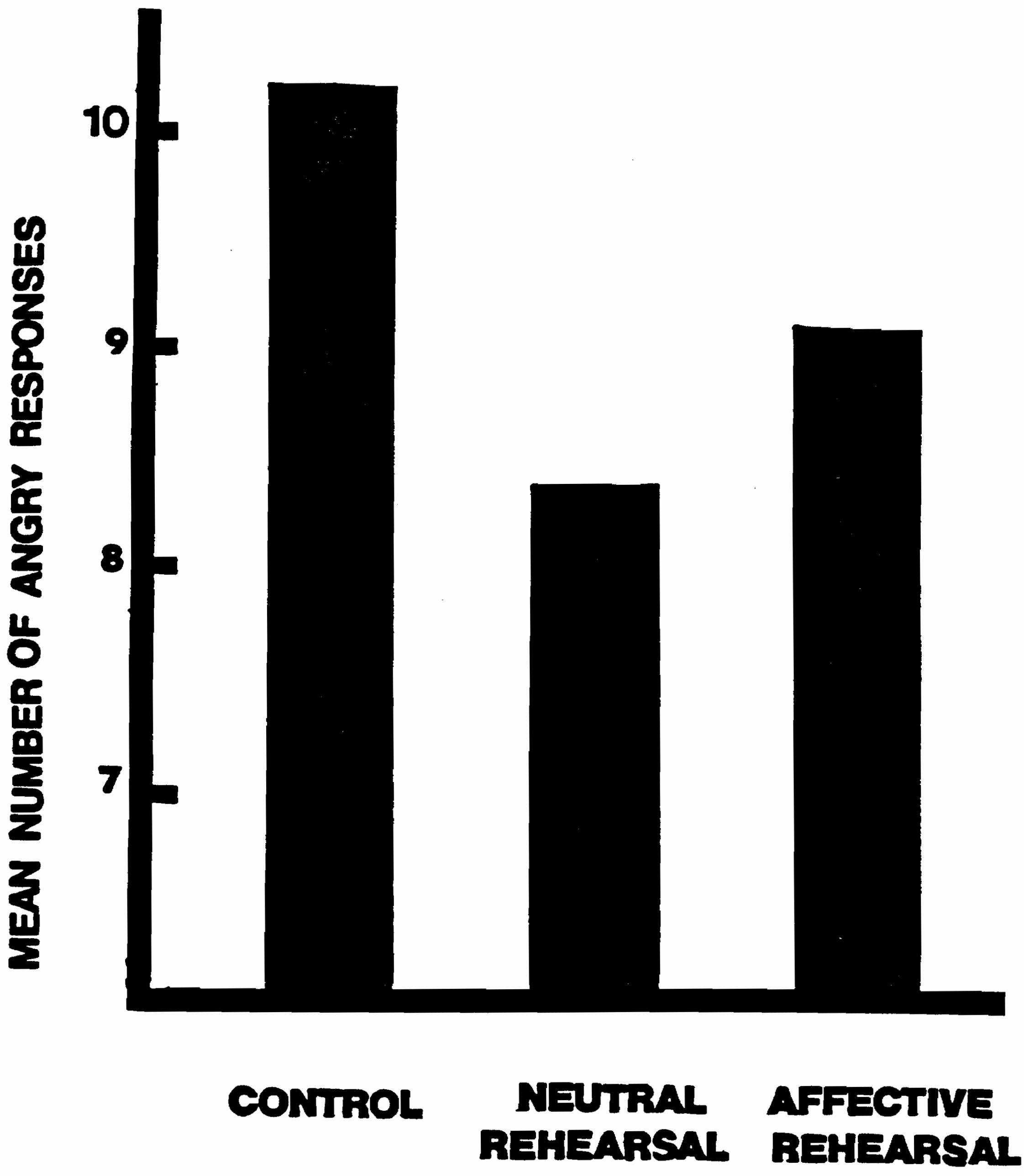

.95
.90
.85
.80
REACTION TIME
LVF
RVF
LVF
RVF
LVF
RVF
CONTROL
NEUTRAL
REHEARSAL
AFFECTIVE
REHEARSAL

Figure Caption

Figure 3. Average number of angry responses (Range: 0 - 12) for neutral faces as a function of condition.


MEAN NUMBER OF ANGRY RESPONSES
10
9
8
7
CONTROL
NEUTRAL REHEARSAL
AFFECTIVE REHEARSAL

performance was significantly slower in the right versus left visual field; reaction times across visual fields were equivalent in the other conditions. These findings indicate a selective interference effect of rehearsal, particularly affective rehearsal, on right visual field performance.

A separate ANOVA with repeated factors of condition and visual field was used in the analysis of the reported-affect data for neutral faces. The dependent measure was the number of times neutral faces were reported as angry in this forced-choice paradigm. Twelve neutral slides were presented in each condition and scores could range from 0 (no angry selections) to 12 (all angry selections).

No affective bias was attributable to the Visual Field main effect or the Visual Field X Condition interaction. However, the Condition main effect was significant $\underline{F}$ (1,29) = 19.44, $\underline{p}<.0001$. Figure 3 presents the mean number of angry responses to neutral faces for each condition and indicates a general bias toward reporting the faces as angry. Linear contrasts revealed that neutral faces in the control condition were more frequently reported as angry than those in the subvocal neutral, $\underline{F}$ (1,29) = 41.56, $\underline{p}<.0001$, and the subvocal affective conditions, $\underline{F}$ (1,29) = 13.49 $\underline{p}<.001$. This counterintuitive finding suggests affective bias comparisons with the control group may not be valid; the appropriateness of control group comparisons will be detailed below. The comparison between the rehearsal conditions was significant, F (1,29) = 4.65, p<.04, indicating greater negative affective bias in the affective rehearsal condition. This result indicates a tendency for affective rehearsal to "prime" subjects to perceive the neutral faces as angry, relative to neutral rehearsal condition in this experiment.

Discussion

No priming effects were evident in this dual-task paradigm, though right visual field interference effects were obtained in the rehearsal conditions, particularly affective word rehearsal. These findings are consistent with the view that verbal material, including affectively laden words, are subsumed via left hemisphere processing. Why the rehearsal of affective words impacted right visual field performance more than neutral word rehearsal is puzzling, but may reflect word processing differences. Affective words were more salient than the neutral words, perhaps generating more frequent word rehearsal and increased left hemisphere activation. Such an explanation must remain speculative with the present data and methodology.

The affective bias data implicate a general tendency to perceive the neutral faces as angry, especially those in the control condition. This inclination may reflect a greater similarity between neutral and angry faces than between neutral and happy faces. In fact, mean reaction times for each affective valence across the experiment implicate this; neutral (1.046), angry (.880) and happy (.843). Furthermore, the tendency to view neutral faces as angry more frequently in the control condition may be due to (a.) an artifact of the response alternatives and (b.) the effort requirements of the experimental conditions. With response alternatives of only happy or angry, subjects may have attempted to achieve consistency in their responses. An initial response choice of angry, perhaps due to the greater similarity of neutral and angry faces, might have been followed with similar responses for the sake of consistency. Yet the increased processing requirements of the experimental conditions may have interfered with this tendency, thereby resulting in fewer angry judgments of neutral faces. As such, decreased affective bias is observed in the rehearsal conditions.

General Discussion

The following are the findings of these experiments: 1. No evidence of priming was obtained for any of the experimental conditions relative to the control condition. 2. Imagery and subvocal rehearsal had nonspecific interference effects, i.e. slowed reaction times across visual fields, in Experiment 1. 3. The experimental conditions in Experiment 1 impeded happy more than angry affect perception. 4. Subvocal rehearsal, particularly of affective words, selectively slowed right visual field reaction time in Experiment 2. 5. No affective bias was found across visual fields in Experiment 2, but neutral faces were more frequently judged as angry in the control and affective rehearsal conditions.

Despite a modest overlap in results, the replication of findings across experiments is relatively poor. These findings are not diminished, however, as the experiments differed on a number of key methodological points. For instance, only Experiment 2 evaluated the potential affective bias of the priming conditions by inclusion of neutral faces. This increased the number of slide presentations per condition to nine versus the eight in Experiment 1; a total of 96 and 108 presentations were made in Experiments 1 and 2, respectively. Such differences make direct comparisons problematic. The right hemisphere tasks also differed across experiments; one employed imagery and the other subvocal rehearsal of affective words. Though the results suggest that neither manipulation primed the right hemisphere, direct comparison solely because of their putative right hemisphere status would be gratuitous.

Taken together, the manipulations used in these experiments had a tendency to interfer with rather than prime performance on an affect recognition task. These findings are inconsistent with recent dual-task research which has activated the relevant cerebral space with similar simple and non-effortful tasks (Kinsbourne & Byrd, 1985; Van Strien & Bouma, 1990). Target task performance was subsequently facilitated relative to non-primed conditions during verbal rehearsal. The interference effects obtained here were not hypothesized given these simple priming tasks; manipulation checks confirmed that they were indeed simple and non-effortful. Yet these checks of word recall and imagery rating may not have been sensitive enough to evaluate the effort requirements of the tasks. Specifically, though word recall was accurate, word rehearsal may have been more demanding as subjects repeated the words during eight consecutive slide presentations. By comparison, Van Strien and Bouma (1990) found priming effects when subjects subvocally rehearsed verbal material during only one slide presentation.

Though initially conceptualized to explain priming effects, the selective activation model was refined to also account for interference. Interference results when two tasks compete for similar cerebral areas or functional space within the same hemisphere under heavy load conditions (Kinsbourne, 1980). Selective interference effects were apparent with the right visual field reaction time decrement for affective subvocalization in Experiment 2. This finding implicates an overloading of the affective perceptual capabilities of the left hemisphere by the linguistic requirements of the word rehearsal. If the left hemisphere is assumed to be inferior for affect perception, its corresponding functional cerebral space for such processing would be more limited than the right hemisphere's. This functional space is more easily overloaded, thereby compromising right visual field performance. The lack of specific left visual field interference suggests the right hemisphere tasks were either not as effective in recruitment of their respective cerebral areas or that the right hemisphere's functional cerebral space for affect perception is greater and hence less sensitive to interference.

Imagery and subvocalization of affective words constituted the right hemisphere experimental tasks and only the latter had specific interference effects. The imagery task in Experiment 1 had a nonspecific interference effect and slowed reaction times in both visual fields. No evidence of preferential right hemisphere recruitment was found. Two reasons may account for this; (a) target words were presented verbally, potentially engaging the left hemisphere prior to image generation, and (b) subjects may have used verbal strategies or processing while developing and maintaining the image. These issues remain problematic for the preponderance of imagery research as it is typically more difficult to engage the right than the left hemisphere. In Experiment 2, the proposed right hemisphere task had a greater impact on stimuli presented to the left hemisphere. The verbal nature of the words apparently overrode their strong affective component which had been hypothesized to be subsumed by the right hemisphere. This experiment fails to support previous research which had demonstrated the capacity of verbal affective material to prime the right hemisphere (Brody et al., 1987).

More broadly, functional space characteristics, particularly size, and their place in dual-task paradigms is not explicitly discussed by Kinsbourne. Rather, Kinsbourne suggests space is relevant only to the degree that it is activated; activation primes performance on subsequent tasks at light loads, but interferes at heavy loads. This position is consistent with an activational model which suggests spreading activation, particularly to similar or adjacent cerebral areas, is the mechanism by which other tasks are affected. A structural model, however, would submit that space characteristics vary in size and that this variation may be expressed in terms of varying cortical mass. The greater cortical mass devoted to a task, the more difficult it is to interfere with performance of that task. Hence the size of these spaces, rather than their activation, would be integral in explanation of functional cerebral asymmetries.

As no priming effects were observed in these experiments, the specific left hemisphere interference effects in Experiment 2 do not clearly substantiate either model. Though results appear to support a structural model with the clear overloading of the left hemisphere's cerebral space devoted to affect perception. A structural model would suggest that given the same load requirements, the left hemisphere's cerebral space would be more easily overloaded as it is smaller than the right hemisphere's. Despite the fact that right and left hemisphere primes may have been differently effective in recruitment of their relevant cerebral area, no selective right hemisphere interference effects were noted throughout these experiments. This suggests that the space devoted to affect perception in the right hemisphere may be larger than that in the left hemisphere and subsequently less sensitive to interference. Nevertheless, these arguments must remain tentative without the hypothesized priming effects, as interference effects do not unequivocally support either activational or structural models.

Finally, use of a control condition without concurrent task performance may be problematic for dual-task paradigms. Though frequently used, single and dual task manipulations have different load requirements, potentially altering processing strategies or response tendencies independent of hypothesized laterality effects. Therefore, a more appropriate control condition might require a non-lateralized task with equivalent effort requirements to those used in the experimental conditions. Presumably, any priming or interference effects observed in such a condition would be evident across visual fields. This would provide a preferable comparison group from which to evaluate the lateralized effects apparent in the experimental conditions.

Future research examining the potential priming effect of experimental manipulations should employ control conditions with equivalent load requirements. Also, briefer trials than the 8 (Experiment 1) or 9 (Experiment 2) slide presentations in each condition would decrease the load requirements of the manipulation and allow potential priming effects to emerge. The constant word rehearsal required in these experiments appeared to have made the manipulation an interference rather than a priming task. Furthermore, left hemisphere manipulations appear to have more of an impact on subsequent affect recognition performance, suggesting the left hemisphere's functional space for these tasks is more easily compromised than the right hemisphere's. A greater sensitivity to the interaction of functional space characteristics and priming effects is thus required.

Obtained functional cerebral asymmetries may result more from the former than from activational mechanisms, as is predicted by the selective activation model.

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Appendix A

General Instructions

In this experimental condition you will make decisions concerning some faces. Presentation of the faces will be brief and either to the left or right of the black dot. Each face will be preceded by a tone (the tone is sounded). Upon hearing the tone we ask that you focus on the black dot because the face will be presented about 3 seconds after the tone. We also ask that you use your right index finger to choose whether the face is happy or angry. Please keep your index finger raised above and between the two switches labelled "Happy" and "Angry." Respond as quickly and as accurately as possible. Practice trials will be provided to familiarize you with the experimental procedures and we will inform you when the practice trials end and the study begins. During the study this condition will be known as the control condition. There is an intercom located behind you if you need to contact us. We remind you to fixate on the black dot during the testing. Any questions?

Appendix B

Experiment 1: Priming Instructions

Now we want you to make decisions concerning some faces while memorizing a list of words. These words will be presented to you through an intercom prior to the faces. Before each list of words a command of either "Rehearsal" or "Imagery" will be given. Separate instructions and practice trials for the imagery and rehearsal conditions will now be provided. In the rehearsal condition just hold the words in your memory by rehearsing them to yourself. Continue saying these words to yourself while you are making decisions about the faces. Do not say these words out loud and do not develop an image or picture of them. Following your decisions about the faces we will ask you to repeat the words you had been rehearsing. To get you used to this procedure a practice trial will now be provided.

In the imagery condition we ask that you develop an image of the words. You may put the images of the words together into a single scene or put the images next to one another. For example, if the words "bear" and "book" are presented you may imagine a book with a picture of a bear on it, a bear reading a book or some other image. Once you have developed an image raise your hand to notify the experimenter. A tone will then signal you that the faces will be presented. While making decisions about the faces hold the image in your memory and concentrate on it. Just picture the image, do not use words to describe or explain it. Following your decisions about the faces we will ask you to relax, stop the imagery task and to rate how easy it was to generate the image and how vivid that image was. We will not ask you to recall the words. A practice trial will now be provided.

The practice trials have now ended and the study will begin. Remember, if the command "Control" is given, just make judgments about the faces as you did initially without the imagery or rehearsal. Also, in the rehearsal conditions remember to say the words to yourself while making decisions about the faces. In the imagery condition remember to concentrate on the image while making your decisions. Any questions?

Appendix C

Experiment 2: Priming Instructions

Now we want you to make some decisions concerning some faces while memorizing a list of words. These words will be presented to you through an intercom prior to the faces. Following each list of words you will hear the command "rehearsal". When you hear this command just hold the words in your memory by rehearsing them to yourself. Continue saying these words to yourself while you are making decisions about the faces. Do not say these words out loud and do not develop an image or picture of them. Following your decisions about the faces another tone will signal you to repeat the words. If no words are given before the faces just make judgments about the faces as you have done on previous trials. Practice trials will be provided and we will inform you when the practice trials end and the study begins. These is an intercom located behind you if you need to contact us. We remind you to fixate on the black dot during the testing. Any questions?

Appendix D

Experiment 1: Neutral Priming Words

		Imagery Rating	Standard Deviation
1.	amount	2.73	1.58
2.	answer	2.77	1.70
3.	chance	2.50	1.52
4.	duty	3.17	1.74
5.	event	2.90	1.77
6.	hope	3.83	1.90
7.	idea	2.20	1.15
8.	law	3.73	1.93
9.	method	2.63	1.64
10.	moment	2.50	1.62
11.	theory	2.57	1.60
12.	virtue	3.33	1.96

Note 1: Imagery rating, based on a seven-point Likert scale, is the reported ease in obtaining a mental picture or image of each word (Paivio et al., 1968).

Note 2: Frequency of occurrence for each word is either AA (at least 100 occurrences per million) or A (at 50 occurrences per million) (Thorndike & Lorge, 1944).

Appendix D-1

Experiment 1: Imagery Priming Words

		Imagery Rating	Standard Deviation
1.	bird	6.67	.73
2.	ocean	6.77	.42
3.	water	6.60	.30
4.	arm	6.53	.79
5.	boy	6.57	.83
6.	doctor	6.40	1.06
7.	forest	6.63	.69
8.	horse	6.80	.47
9.	storm	6.43	.83
10.	cabin	6.47	.97
11.	star	6.70	.77
12.	winter	6.53	1.04

Note 1. These words were judged as significantly easier to image than the neutral words $t(22)=10.14$, $p<.0001$.

Note 2. Words were matched with the neutral words on occurrence frequency.

Appendix E

Experiment 2: Neutral Priming Words

		Imagery Rating	Standard Deviation
1.	belief	2.73	1.81
2.	concept	1.93	1.32
3.	cost	3.57	2.86
4.	duty	3.17	1.74
5.	fact	2.20	1.63
6.	fate	2.37	1.55
7.	hint	2.57	.75
8.	hope	3.83	1.90
9.	hour	3.60	2.26
10.	idea	2.20	1.15
11.	item	3.67	1.96
12.	pact	3.57	1.79

Note 1: Some of these words were used in Experiment 1, but additional words were chosen to match the lower frequency of the affective words.

Appendix E-1

<u>Experiment 2: Affective Priming Words</u>

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1. dead
2. fear
3. greed
4. hate
5. kill
6. malice
7. pain
8. rage
9. rape
10. slap
11. stab
12. weep

<u>Note 1</u>. These and similar words have been effectively used as right hemisphere primes (Bryden & Ley, 1983; Brody et al., 1981).

Appendix F

Imagery Rating Questionnaire

Subjects completed the following questions for each image:

1. How easy was it to develop an image of these words?

1	2	3	4	5	6	7
very difficult	difficult	somewhat difficult	average	somewhat easy	easy	very easy

2. How vivid was the image you developed?

1	2	3	4	5	6	7
very vague	vague	somewhat vague	average	somewhat vivid	vivid	very vivid

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REFEREED ABSTRACTS:

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1992. Master's Thesis. Recruited subjects, ran subjects with tachistoscopic apparati, collected and analyzed data and supervised undergraduates.

1989-1990. Research Assistant, DePaul School Transition Project. Research responsibilities included data coding and analysis, conducting parent interviews and administering academic and sociometric measures.

Supervisor: Leonard Jason, Ph.D.

1989. Program Coordinator, Essential Hypertension Study. Recruited subjects, conducted psychodiagnostic interviews, administered psychological inventories and prepared blood samples to be analyzed.

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1991. Externship, 500 hours, at Hines V. A. Hospital, Hines, IL. Primarily neuropsychological assessment and evaluation, functioning as consult liaison to medical/psychiatric services. Responsibilities included neuropsychological testing, writing consultations and debriefing medical residents/interns. Weekly attendance at brain cuttings and neurological presentations.

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