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EFFECTS OF SELF-GENERATION AND EMOTIONALITY OF MATERIAL ON VERBAL MEMORY IN UNILATERALLY BRAIN-DAMAGED AND NORMAL ADULTS

by

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Abstract

EFFECTS OF EMOTIONALITY OF MATERIAL AND
LEARNING CONDITION ON MEMORY IN
UNILATERAL BRAIN-DAMAGED ADULTS AND NORMAL CONTROLS

by

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Memory performance was studied in two patient groups, one right- and one left-brain-damaged, and in one group of normal controls. The central interest was in the effects of emotionality of words in combination with the generation of sentences from these words. Influences of these variables were examined on three measures of memory performance: free recall, recognition, and cued recall. In addition, neuropsychological test scores were obtained to form a converging search for relationships between basic subject attributes and memory performance scores. Of secondary interest in this study was the effect of stimulus valence (positive vs. negative) and effects of demographic variables, most importantly gender and intrahemispheric site of brain damage.

Processes called upon during the study phase of this experiment (perception of emotionality, verbal fluency, activation of semantic memory) were considered to be deficient in our patient groups and to differ according to laterality of lesion. Patients with right hemisphere (RH) brain damage were expected to have deficits in emotional processing based on clinical and experimental findings of RH dominance in emotion.

Therefore, it was predicted that patients with RH damage would exhibit less of a memory-enhancing effect from stimulus emotionality as compared to patients with LH damage and normal controls. Patients with LH damage were expected to have deficits in verbal fluency and memory based on clinical and experimental findings of LH dominance in verbal processing. Hence, it was predicted that patients with LH damage would not exhibit the memory-enhancing effects of sentence generation shown by patients with RH damage and normal controls.

The groups were tested for memory of single words and sentences which differed in stimulus type (positive, negative, neutral) and in learning condition (read vs. generate). In each of the three subject groups, there were significant effects of emotionality (better memory for emotional than neutral words) and sentence generation (words were better remembered when they were the basis for sentence generation than when they were presented in the sentence framework). A two-way interaction was found indicating that improvements in memory for emotional material were stronger under sentence-reading than under sentence generation conditions, and that effects of sentence generation were stronger for neutral material than for emotional material. This interaction was greater in the brain-damaged groups and is described as a suppressive phenomenon resulting from competing demands of arousal.

Since there were no group differences in the emotionality and sentence generation effects obtained, there is no confirmation of the predictions about differences in memory performance for right and left brain-damaged groups compared to controls. However, the factors of gender, frontal lobe damage, and temporal lobe damage did influence the results, and further study of these variables is warranted in future investigations of these memory-enhancing effects.

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Introduction

Goals of this Study

This study has investigated explicit memory for both emotional and nonemotional materials and for items that were the source of generation as well as items that were the product of generation. Of specific interest was the comparison between normal and brain-damaged persons in their recall, recognition and cued recall of this material. There were three primary goals of this study and three secondary interests.

The first main goal was to investigate whether expected improvements in memory for emotional, as compared to neutral, material would be found in patients who have suffered a cerebrovascular accident to the right hemisphere. According to the theory of right hemisphere dominance in emotional processing, and based on research to be presented below, we expected right brain-damaged persons to exhibit deficits in emotional processing and thereby deficits in the ability to benefit from experimental manipulations of stimulus emotionality.

Our second goal was to determine whether expected improvements in memory for words encoded in generated sentences, as compared to words encoded in read sentences, would be found in patients who have suffered a cerebrovascular accident to the left hemisphere. According to theories invoking the importance of verbal fluency and memory in the facilitative effect of self-generation, we expected left brain-damaged persons to exhibit a decreased ability to benefit from the generation procedure.

Our third goal was to explore whether the expected benefits in memory for targets and products of generation would differ according to the emotionality of the material. And, conversely, whether the expected increase in memory for emotional material would differ according to the instructions to generate or read during the encoding (study) phase of the experiment. Finally, by including a patient sample we can determine whether the interaction of these two manipulations differs depending upon presence and/or laterality of brain damage.

Since patient groups were utilized and screening measures involved the assessment of basic cognitive functions, this prompted us to address some secondary exploratory questions. First, we found that our patient groups could be subdivided according to intrahemispheric lesion site. This allowed us to investigate the effects of frontal lobe and temporal lobe damage. Second, the utilization of both males and females allowed us to investigate the effect of gender, a factor which sometimes interacts with laterality and whose significance is questionable in the areas of emotion and memory. Finally, we explored the relationship between indices of our experimental effects and several "subject variables" to search for factors to explore more fully in future investigations.

As one can infer from the primary goals we have established, and the secondary interests we hope to address, there are a number of major issues which need to be previewed in order to adequately understand the rationale for the procedures employed in this study and to provide a framework for understanding our findings. Thus, in this introduction we will discuss each of these matters in turn, and wherever possible synthesize the topics to form a coherent picture of this study.

Neuropsychological Theories of Emotion

A major impetus of this investigation was to test two competing neuropsychological theories of emotion. Thus, we begin with a discussion of these theories, both of which focus on issues of laterality. The right hemisphere hypothesis asserts right hemisphere dominance for emotional processing regardless of valence (e.g., Borod, Koff & Caron, 1983), and the valence hypothesis asserts laterality of emotional functioning based upon valence (positive vs. negative). In the latter theory, positive emotions are viewed as being processed predominantly by the left, and negative emotions by the right hemisphere (e.g., Bryden, 1982; Davidson, 1984). The main thrust of the research testing these theories has been conducted on groups of normal, brain-damaged, and depressed subjects.

Studies with normal subjects have been designed to reflect lateralization for emotional perception through the use of behavioral procedures such as tachistoscopic viewing or dichotic listening. Less frequently, EEG monitoring or functional imaging techniques (PET) have been utilized to detect hemispheric alterations during emotional and non-emotional conditions. Research with brain-damaged subjects has searched for links between laterality of brain injury and performance deficits on tasks of emotional perception. A deficit in performance suggests that the damaged brain structures are critical for the particular processing required by the experimental task (Bloom, Borod, Obler, & Gerstman, 1992). Studies with depressed subjects have generally been designed to examine performance levels on tasks associated with the functioning of the right hemisphere, in order to implicate that hemisphere in emotional disorders and emotional processing in general. Converging evidence from these different types of studies is reviewed below for each theory.

Support for the Right Hemisphere Theory of Emotional Processing

Since the mid 1970's, when the investigation of human emotional behavior began focusing on the neocortex, numerous studies in the literature have indicated that the right hemisphere is dominant for the processing of emotion.

Studies with normal subjects. For example, in dichotic listening studies with normals, findings of left ear advantages have demonstrated that the right hemisphere (RH) is more efficient than the left hemisphere (LH) in detecting non-linguistic features, such as prosody, that are related to understanding emotion in speech (Blumstein & Cooper, 1974; Carmon & Nachshon 1973; Haggard & Parkinson, 1971; King & Kimura, 1972; Ley & Bryden, 1982; Safer & Leventhal 1977). Normals have also been found to have more pronounced left lateral eye movements, indicative of greater right hemispheric activation, when answering emotional versus neutral questions (Borod, Vingiano, & Cytryn, 1988; Schwartz, Davidson, & Maer, 1975). In tachistoscopic viewing studies, many investigators have reported left visual field/RH advantages for the perception of emotional information, and this finding has held regardless of valence (e.g., Landis, Assal, & Perret, 1979; Ley & Bryden, 1979). Furthermore, numerous studies have indicated that the right hemisphere is more accurate than the left hemisphere in the interpretation of emotion in faces (Buchtel, Campari, Derisio, & Rota, 1978; Campbell, 1978; Cohen-Leehey & Cahn, 1979; Hansch & Pirozollo, 1980; Landis, Assal & Perret, 1979; Ley & Bryden, 1979; McKeever & Dixon, 1981; Safer, 1981)

In the investigation of *linguistic* emotional perception, the results are less clear. Based on the review by Borod, Bloom, and Haywood (in press), out of five tachistoscopic studies, three have found support for right hemisphere dominance of emotional verbal material, whereas two studies did not. Graves, Goodglass, and Landis (1981) reported that although there was an overall right visual field (RVF)/LH superiority for the perception of words, when words were presented to the left visual field (LVF)/RH, male subjects processed emotional words more accurately than nonemotional words. On both a dichotic listening task and on a lateralized tachistoscopic task, Bryden and Ley (1983) found that emotional words of both valence types led to increased RH, but not LH, superiority. A third tachistoscopic study (Brody, Goodman, Halm, Krinzman, & Sebrechts, 1987) found that affective primes, as compared to neutral primes, improved performance in the LVF/RH, but impaired performance in the RVF/LH. Thus, when lexical stimuli are affective in nature, these studies suggest that the usual left-hemisphere dominance for language may be overpowered by the right-hemisphere dominance for emotion.

Strauss (1983) and Eviatar & Zaidel (1991), however, were unable to replicate these findings. Both studies found that emotional words were read faster and more accurately than non-emotional words in both visual fields, and that accuracy for all words was highest in the RVF/LH condition, regardless of emotional content. Thus, these two studies support the notion that a right hemisphere dominance for emotion may be overpowered by a left-hemisphere dominance for language, when both emotional and linguistic materials are utilized. As there have been relatively few studies in this area, and the findings conflict, more work needs to be done in order to resolve the issue of hemispheric lateralization in the perception of emotional verbal material.

<u>Studies with brain-damaged subjects.</u> Numerous studies of emotional perception and expression have analyzed the behavior of right brain-damaged subjects and confirmed the importance of the right hemisphere in general affective functions. For example, right brain-damaged patients have been found to have difficulty perceiving and utilizing prosodic differences in speech to distinguish among different emotions (Borod et al., 1990; Cicero et al., 1995; Heilman, Scholes, & Watson, 1975; Tucker, Watson, & Heilman 1977). Such patients have also performed poorly on emotion labeling and emotion matching tasks compared to left brain-damaged patients and normal controls (Borod, Koff, Lorch, & Nicholas, 1986; DeKosky, Heilman, Bowers, & Valenstein, 1980).

In fact, at all levels of language comprehension (word, sentence, discourse), patients with right hemisphere lesions have demonstrated impairments with emotional material. At the single word level, Cicero et al. (1995) found that right brain-damaged subjects were significantly impaired in the identification or categorization of emotional words relative to left brain-damaged subjects and normal controls. On a task of hierarchical clustering (Semenza, Pasini, Zettin, Tonin, & Portolan, 1986), right brain-damaged subjects treated emotional words differently from normal controls, but the groups did not differ in their treatment of neutral words.

Furthermore, right brain-damaged subjects have demonstrated difficulty comprehending the affective content of stories conveyed not only by specific emotional words, but by overall meaning of propositional sentences (Gardner, Brownell, Wapner & Michelson, 1983). Patients with RH damage have also demonstrated poor judgment of whether the emotional prosody and the semantic-emotional meaning of a sentence are coherent (Tompkins & Flowers, 1985). Furthermore, in comparison to both normal control subjects and left brain-damaged patients, right brain-damaged subjects have demonstrated less appropriate word choice in their description of slides depicting different facial emotions (Borod, Koff, Lorch, & Nicholas, 1985). Right brain-damaged subjects have also exhibited impaired performance in the comprehension and appreciation of humorous material (Gardner, Ling, Flamm & Silverman, 1975; Wapner, Hamby & Gardner, 1981) and other affectively toned situations presented in written form (Cicone, Wapner, & Gardner, 1980).

In terms of emotional expression, when asked to create a story based on an array of pictures, right brain-damaged subjects were found to demonstrate a specific deficiency in the production of emotional content relative to their production of neutral/procedural and visuo-spatial content (Bloom et al., 1992), whereas the normal control subjects and left brain-damaged subjects performed similarly across conditions. In discourse, right brain-damaged patients have also been found to produce words of lower emotional intensity than normal control subjects or left brain-damaged patients (Bloom, Borod, Obler, & Koff, 1990). Furthermore, Borod, Andelman, Obler, Tweedy, and Welkowitz (1992) found that right brain-damaged subjects performed selectively more poorly than left brain-damaged subjects and normal controls in the emotional condition of three different linguistic tasks relative to their performance in the non-emotional condition of each. Since the results did not distinguish between positive and negative valence conditions in any of the subject groups, it was concluded that valence is not a major factor in the determination of level of performance in perceptual tasks, and that the right hemisphere is the primary processor for the perception of emotional linguistic stimuli.

These findings focus primarily on quantitative differences. In addition, qualitative differences have been found, demonstrating different and inappropriate reactions on the part of right brain-damaged subjects as compared to left brain-damaged subjects or normal control subjects. For example, Cicone et al. (1980) demonstrated that a sample of right brain-damaged patients were sometimes so impaired at emotional labeling that they confused polar opposites in choosing an emotional label (e.g., sad instead of happy). Even when other brain-damaged patients had difficulty with this task, they never chose the polar extreme. Gardner et al. (1975) also found that subjects with right hemisphere lesions tended to exhibit one of two extreme reactions to a cartoon series. Either they laughed at nearly every item even when their understanding was doubtful, or more commonly, they displayed little reaction to any item, even when their understanding seemed adequate. Patients with right hemisphere lesions have also been found to confabulate and embellish inappropriately when encountering emotional or bizarre elements in the recall of a short story (Wapner et al., 1981). Furthermore, the emotional elements in discourse production have been found to trigger tangential remarks in right brain-damaged subjects (Gardner et al., 1983).

There are also studies concentrating on the behavior of right brain-damaged patients, albeit many fewer in number, which have failed to find group differences in emotional conditions, or which have found the right hemisphere-based deficit to be more subtle. For example, in some studies, right brain-damaged subjects exhibited little difficulty understanding emotionality in simple propositional sentences when the targeted emotions were explicitly stated (Bowers, Coslett, Bauer, Speedie, & Heilman, 1987; Blonder, Bowers, & Heilman, 1991; Lalande, Braun, Charlebois, & Whitaker, 1992). However, they did have more difficulty with tasks requiring inferences (Wapner et al., 1981) and tasks requiring the ability to integrate verbal and non-verbal emotional information in order to verbally identify emotional expressions (Blonder et al., 1991). Furthermore, unlike Cicero et al. (1995), Lalande et al. (1992) also found that right-hemisphere damage did not impair the ability to identify which emotional category a word belonged to, but it did impair emotional identification for both positive and negative stimuli in a non-verbal condition (humming) and in the ability to identify when semantics and prosody were discordant. In the same study, Lalande and colleagues also found a highly significant relationship between the results of prosodic and emotional concordance tasks in normals, but not in a right brain-damaged group.

Additionally, Ostrove, Simpson, and Gardner (1990) failed to find specific differences in emotional comprehension in right brain-damaged subjects, but found that with both emotional and non-emotional vignettes, right brain-damaged subjects made more factual errors than normal control subjects when instructed to continue a story, implying a general deficit in the comprehension of complex linguistic information following right brain damage. Bowers et al. (1987) suggested that perhaps mental images of emotional expressions are necessary in order to comprehend emotional intent, a capacity which may be disrupted in right hemisphere damage (Seamon & Gazzaniga, 1973). However, even at the single word level, there is evidence that emotional processing can be similar in groups of right brain-damaged, left brain-damaged, and normal controls (Etcoff, 1984). Finally, Cicone et al. (1980) also demonstrated that categorization of emotional phrases was significantly impaired in *both* left and right hemisphere patients, compared to normal controls, but that for one stimulus situation (i.e., excitement), right brain-damaged patients were more impaired than left brain-damaged patients. Thus, there is some conflicting evidence regarding the extent and consistency of the emotional impairment associated with right brain damage, suggesting that the deficit may partially depend upon specific intrahemispheric sites and/or specific task or subject factors not yet uncovered.

A different source of support for the right hemisphere theory comes from studies that have analyzed the performance of individuals with left-brain damage and aphasia. Over a century ago, Hughlings-Jackson (1880) noted that affective speech can be spared in aphasic patients. More recently, a study conducted by Landis, Graves, and Goodglass (1982) found that aphasic subjects read and wrote emotional words significantly more accurately than nonemotional abstract words. Rather than simply attributing the improvement directly to a right-hemisphere advantage in the emotional processing of language, these researchers suggested that emotional words may facilitate improved performance by increasing motivation and arousal which thereby increase the activity of the nondominant right hemisphere. The relationship between arousal and emotion is an important concept and will be discussed in greater depth in later sections of this paper.

Although Landis et al. (1982) suggested a more complex avenue by which emotional material aids in performance of the left brain-damaged subjects, their findings nonetheless implicate the right hemisphere as instrumental in the obtained facilitative effect of emotional material. Similarly, Ramsberger (1986) studied left brain-damaged aphasic patients who experienced single-word repetition difficulty and found that, regardless of valence, these patients accurately repeated significantly more emotional than neutral words.

Additionally, Reuterskiold (1991) found that on an auditory single-word discrimination task, aphasics performed better with emotional than nonemotional action words and object names. Emotional material has also been shown to improve the performance of aphasic patients for auditory comprehension (Boller, Cole, Vrtunski, Patterson, & Kim, 1979), discourse production (Bloom et al., 1992; Bloom, Borod, Obler & Gerstman, 1993), and bucco-facial praxis (Borod, Lorch, Koff, & Nicholas, 1987). Thus, it appears that emotionality often serves to enhance language performance in left brain-damaged aphasic patients. If this facilitation extends to memory, then the patients with left brain damage in the current study are likely to benefit from stimulus emotionality. However, reports to the contrary (Borod, Andelman, et al., 1992; Feyereisen & Seron, 1982) are important in highlighting that stimulus emotionality does not *always* improve the language performance of left brain-damaged individuals. Again, these contradictory findings may be due to either differences in task or subject variables.

As surmised in many of these aphasia studies, it is probable that the intact right hemisphere is responsible for the improvement observed when the lexical material has an emotional component. In support of this view, Zaidel (1976) demonstrated that the right hemisphere has adequate access to the verbal lexicon. Although, even if we were certain that the right hemisphere was responsible for the improved performance of aphasics in emotional conditions, there are two ways of interpreting the RH role in processing emotional language: as compensatory or as normally functional. For example, Reuterskiold (1991) suggested that the ability of the right hemisphere to process words is accessed in patients with severe auditory comprehension deficits. In the same vein, Landis, Regard, Graves, and Goodglass (1983) proposed that the left hemisphere must be relatively damaged before the right hemisphere steps in to aid in verbal processing. These investigators have, therefore, interpreted the role of the right hemisphere as compensatory.

A different interpretation of the aphasia literature is that the findings demonstrate normally-utilized right hemisphere functions rather than unused functions that only contribute to the emotional verbal processing after left hemisphere brain damage occurs. Evidence for this interpretation comes from the many studies listed above utilizing patients with right brain damage and normal controls. If the right hemisphere does not normally have a role in emotional verbal processing, as Landis et al. (1983) seem to suggest, then patients with right hemisphere lesions should not show the deficits in emotional verbal conditions. Likewise, in studies with normal subjects, there should be no evidence of increased activation of the right hemisphere in emotional conditions, since the suggestion is that the left hemisphere controls all verbal processes in the absence of left hemisphere insult.

Studies with depressed subjects. Further support for the right hemisphere theory comes from studies of affective disorders. A number of studies measuring brain activity via EEG or blood flow techniques have found reduced right parieto-temporal activation in depressed patients (e.g., Flor-Henry, 1976; Monakhov, Perris, Botskarev, von Knorring, & Nikiforovet, 1979). Depressed patients have also been found to be selectively impaired on tasks that are sensitive to right parieto-temporal function (e.g., Bruder & Yozawitz, 1979; Brumback, Stanton, & Wilson, 1980; Jaeger, Borod, & Peselow, 1987; Taylor, Greenspan, & Abrams, 1979).

There is even support for the right hemisphere theory from normal subjects induced to feel sad (Tucker, Stenslie, Roth, & Shearer, 1981). For example, longer reaction times to lateralized visual stimuli were obtained in the left visual field/RH, as compared with the right visual field/LH, in students with depressed moods (Natale & Gur, 1981). Thus, there was a relationship between mood and processing time in the right hemisphere. More recently, Banich, Stolar, Heller, and Goldman (1992) also found a deficit in right-hemisphere performance after induction of a depressed mood. Thus, the evidence strongly suggests that, at least for depression, there is a link between variations in emotional state and variations in activity level of the right hemisphere. The strong effect of mood on cognitive functioning may be an important factor in reconciling some of the results in the studies on lateralization of emotion in normals. Thus, studies should incorporate a measure of current mood state to determine whether or not it is affecting results.

Conclusion. There is currently a vast literature from converging sources supporting the dominant role of the right hemisphere in many aspects of emotional functioning. Even in the processing of verbal material, which is normally a left hemisphere function, most studies indicate that the right hemisphere has an important contributory role when the material includes an affective component. Additional evidence for right hemisphere dominance comes from studies of emotion and memory (Borod et al., 1996; Cimino, Verfaellie, Bowers, & Heilman, 1991; Gardner et al., 1983; Wechsler, 1973), which will be described in a later section of this introduction.

In order to better understand why the right hemisphere may be a more efficient processor of emotion, Borod (1992) has delineated the many different attributes ascribed to the right hemisphere which may assist in its special affective role. These include the right hemisphere's greater capacity for multi-modal integration (Semmes, 1968), greater interlobular organization (Egelko et al., 1988), greater degree of interconnectivity among its regions (Tucker, Roth, & Blair, 1986), and greater involvement in arousal and habituation (Tucker & Williamson, 1984) than the left hemisphere. Borod (1992) also proposed the following list of the strategies and functions for which the right hemisphere is dominant in processing emotion: nonverbal functions (e.g., in the perception of prosody), visuo-spatial functions (e.g., in the perception of faces and environmental conditions), integrative functions (e.g., putting together prosody with face with discourse), and holistic functions (e.g., seeing the different aspects of the face together as one in the determination of an emotion).

Support for the Valence Theory of Emotional Processing

Despite the strong support for the right hemisphere theory, the valence theory has also gained support. To reiterate, the valence theory distinguishes between positive and negative emotions in the assignment of hemispheric involvement.

Studies with normal subjects. Using a tachistoscopic procedure, Suberi and McKeever (1977) found a greater left visual field/RH advantage in the recognition of emotional, as compared to non-emotional faces. They also found, however, that sad faces produced the greatest LVF/RH advantage, whereas happy faces were associated with the least LVF superiority. Furthermore, Davidson, Schwartz, Saron, Bennet, and Goleman (1979) recorded more left than right frontal EEG activity during positive responses to a TV show, and more right than left frontal activity during negative responses. In a different type of paradigm, heart rate changes were greater when positive film segments were presented to the left hemisphere and when negative film segments were presented to the right hemisphere (Dimond & Farrington, 1977). Another physiological study measured cerebral blood flow during the discrimination of facial emotions (Gur, Skolnick, & Gur, 1994) and found that right parietal activation was related to the discrimination between sad and neutral expressions, and left frontal activation was related to the discrimination between happy and neutral expressions.

Two studies reviewed by Silberman and Weingarten (1986) also provide support for the valence theory of emotional processing. Ahern and Schwartz (1979) found more right lateral eye movements in subjects with happy or excited responses to questions, but more left lateral eye movements when responses contained sad or fearful emotions. Reuter-Lorenz, Givis, & Moscovitch (1983) found shorter reaction times for happy faces shown to the RVF (LH) and sad faces shown to the LVF (RH).

Partial support for the valence theory has also been found. For example, although Carmon and Nachson (1973) found a left ear (RH) advantage for detecting affective tone in speech, this effect was larger with negative stimuli compared with positive stimuli. Similarly, when examining Ley and Bryden's (1979) tachistoscopic data, Davidson (1984) found that, although there was a LVF (right hemisphere) advantage across all emotions, subjects made more errors when extremely positive expressions, as compared to extremely negative expressions, were presented to the LVF. Furthermore, Davidson and Fox (1982) monitored EEG activity in 10-month-old infants and found a greater activation of the left than right frontal regions in response to happy faces. Davidson did not suggest that each hemisphere is solely responsible for certain emotions, but rather that each hemisphere is biased toward particular types of emotions or toward positive aspects of emotional stimuli. In support of this idea, other studies have found that, although differentiation of stimuli according to valence was better overall when presented to the LVF (RH) in comparison to the RVF (LH), faces were judged as more positive when shown to the RVF (LH) (Davidson, Mednick, Moss, Saron, & Schaffer, 1987; Natale, Gur & Gur, 1983).

Furthermore, as reviewed by Borod et al. (in press), five studies using emotional lexical stimuli provide additional evidence for the valence hypothesis, although most of these find the expected laterality differences for one stimulus type only (i.e., either positive or negative). Using tachistoscopic procedures, Van Strien and Morpugo (1992) and Van Strien and Heijt (1995) reported a RVF/LH enhancement for positive words presented as primes before stimulus letters, and a LVF/RH enhancement for the presentation of negative word primes. Zieher and Zenhausern (1984) also found that positive words led to a RVF/LH superiority, but that negative words yielded no hemispheric superiority. Richards, French, & Dowd (1995) found that negative words led to increased LVF/RH processing. Finally, utilizing a dichotic listening procedure, Wexler, Schwartz, Warrenburg, Servis, & Tarlatzis (1986) found that positive words yielded a larger right ear/left hemisphere advantage than neutral or negative words.

Studies with brain-damaged subjects. Several studies have found that euphoric or indifference reactions are more often associated with destructive unilateral right hemisphere lesions (e.g., strokes) and that catastrophic reactions are more often associated with destructive unilateral left hemisphere lesions (Babinski, 1914; Gainotti, 1972; Goldstein, 1942; Hecaen, Ajuriaguerra, & Massonet, 1951; Rossi & Rosadini, 1967). Destructive left-sided lesions have also been more frequently associated with pathological crying, whereas right-sided lesions have been more frequently associated with pathological laughing (Folstein, Mailberger, & Meutsch, 1977; Hall, Hall, & LaVoie, 1968; Sackeim et al., 1982).

Additionally, in a study of 14 cases of right hemispherectomy, 12 of these were judged as euphoric in mood (Sackeim et al., 1982).

There is evidence for emotional changes accompanying irritative lesions, as well. For example, patients with left temporal lobe epilepsy describe themselves as more depressed than do patients with right temporal lobe epilepsy (Bear & Fedio, 1977), and ictal outbursts of laughing are twice as likely to be associated with left-sided than right-sided seizure foci (Sackeim et al., 1982). Intracarotid amytal injection is often used with epilepsy patients to inactivate a single (contralateral) hemisphere and using this procedure some, but not all, studies have found that inactivation of the left hemisphere produces temporary depression and that inactivation of the right hemisphere produces temporary euphoria (e.g., Rossi & Rossadini, 1967; Terzian, 1964).

Studies with depressed subjects. In otherwise healthy normal adults, Tucker et al. (1981) reported more right than left frontal activity accompanying a depressed mood, as measured by EEG recordings. Depressed patients have also been found to show less activation in the left frontal regions than controls. Moreover, Baxter et al. (1985) found an inverse relationship between glucose metabolism in the left dorsolateral frontal cortex and severity of depressive symptomatology. That is, the more depressed the patient, the less left frontal glucose metabolic activity or blood flow was observed. Thus, endogenous depression may be initiated by hypoactivity in the left hemisphere and/or by hyperactivity in the right hemisphere. There is further speculation that in a neutral state there is a balance of activity between the two frontal lobes (which most likely varies across individuals) and that mood changes correspond to changes in this delicate balance of activation (Davidson et al., 1979; Heller, 1993). The association between left-anterior lesions and severe depression is therefore sometimes explained as a "release" phenomenon. The left-hemisphere anterior lesion removes inhibition from the "depressive prone" right-hemisphere anterior region, thus allowing for the symptoms or appearance of depression (Davidson et al., 1978; Heller, 1993).

Further evidence for an association between increased activity in the right hemisphere and depression comes from electroconvulsive therapy (ECT) studies. A number of these studies have indicated that right-sided ECT is clearly more effective than left-sided ECT and that bilateral ECT and right-sided ECT are equally effective (for a review, see D'Elia and Raotma, 1975). In addition, it has been found that following ECT to the right hemisphere, there is smiling, joking, or laughter, and that following ECT to the left hemisphere, there is anxiety or an intensification of preexisting melancholia (Deglin & Nikolaenko, 1975).

Conclusion. Taken together, these studies suggest that the left side of the brain is dominant in the expression and subjective feelings associated with positive emotional states and that the right side of the brain is dominant in the expression and subjective feelings associated with negative emotional states. However, almost all of the evidence involves moods and behaviors and can be summed up as expressive or experiential in nature. Therefore, in studies such as the one described herein, which are heavily perceptual in nature (i.e., concerning the comprehension and interpretation of emotion), there is more evidence for right hemisphere dominance of emotional processing.

Since one of the main foci of this study is the effect of emotionality on memory, our discussion will now turn toward the relationship between emotion and memory. More specifically, we will review the studies examining the effect of *stimulus emotionality* on memory. However, before discussing the relevant studies in this area, we will review the current existing theories of the relationship between emotion and cognition in general, to provide a framework for interpreting the findings from the varied studies of memory for emotional material.

Theories of the Cognitive-Affective Relationship

There are several questions that can be asked about the relationship between emotion and cognition. For example, how strong is the effect of emotion upon memory in normals? Do different types of emotion (e.g., positive vs. negative) affect memory equally? Do emotional components of stimuli have a similar effect on all types of memory (e.g., semantic vs. episodic; explicit vs. implicit) and across all types of retrieval tasks (e.g., recall vs. recognition)? Do encoding conditions affect this relationship? Or conversely, is the effect of different learning conditions altered by emotional factors? Finally, is the relationship between emotion and memory altered after brain damage?

Although no unified model answering these specific questions has been proposed, some of these questions are addressed by the theories reviewed below. The first step, it seems, in dealing with these issues is to substantiate *when*, in processing affective/cognitive stimuli, emotionality exerts its effect. The next step is determining *how* affective qualities exert their effects upon cognitive behavior. All of the theories deal with the first step of the equation (when) and some of the theories go into detail about how these effects are exerted.

Emotions are antecedent to cognitions: Affective primacy theories

Several investigators view the processing of emotion as automatic, effortless, and disparate from processing the cognitive aspects of one's internal and external environment.

Psychoevolutionary conceptions. A number of emotion theorists, especially those influenced by Darwin, assume that emotions are specific neuropsychological phenomena that organize and motivate adaptive responses (e.g., Izard, 1977; Plutchik, 1980). In this evolutionary-biopsychological conception of emotions as motivators, emotions are *basic* in the fundamental sense of the term (Izard, 1984). They are the basis for play, exploration, learning, and other biological and social phenomena which all serve an adaptive function for the organism (Darwin, 1965). An example of a psycho-evolutionary model is Izard's (1977) differential emotions theory. In this theory, the feeling-motivational aspect of responses is viewed as the primal component which biases the selection of cognitions and actions.

Primacy and independence of emotion and cognition. Furthermore, Zajonc (1980) and others (Posner & Snyder, 1975) have revived the long dormant theory (Wundt, 1907) that emotion can be apprehended both prior to and independently of cognitive processing. Zajonc maintained that processing the emotional component of a word, along with processing other features such as imaginability, does not depend on time-consuming cognitive analyses. In other words, the effect of emotionality is immediate and automatic.

Thus, in the current study, if emotionality effects do not differ across learning conditions or retrieval tasks, this will provide support for the idea that emotional processing is automatic and that cognitive operations do not not interfere with it.

Cognitions are antecedent to emotions: Cognitive primacy theories

There are several authors who have an opposite viewpoint of the relationship between cognitive and affective processing. These authors maintain that in any given situation, cognitive processing occurs before emotional processing. Three examples of such theories are described below.

Cognitive-relational theory of emotion. Lazarus (1990) has been the major proponent of this theory which contains two basic themes: (1) emotion is a *response* to cognitive appraisals, and (2) emotional judgments are about ongoing relationships with the environment. What is emphasized in this theory is that human emotions are understood in cognitive terms. There are several other theorists who have emphasized cognitive appraisal in their comprehension of emotion (e.g., Averill, 1982; Leventhal, 1984). For example, Rogers, Kuiper, & Kirkner (1977) have maintained that the emotional evaluation of a word occurs at a late processing stage, when the individual analyzes the content of the word and relates it to him or herself.

Associative network theory. Bower (1981), in describing human memory, used the analogy of an electrical network, in which activation spreads from one concept (node) to another by associative linkages between them. Emotional reactions are linked to cognitive stimuli that are present when the reactions take place, and similar emotions may be summoned when any of those links are activated in the future.

Utilizing the associative network theory, Bower (1981) proposed several ways to explain the notion of enhanced recall for emotional material. First, both feelings and cognitions are simplified as "nodes" in this electrical chain. Therefore, with emotional material, there are more nodes and these additional affective nodes enhance the strength of encoding. It has also been argued that cognitive processes marked with emotion ('hot' cognitions) might be more efficient than those not so marked ('cold' cognitions; Norman & Rumelhart, 1975). Thus, the "emotional tag" of an event would serve as one node, and the retrieval cue would serve as the second, which, in combination, raise the total activation of a relevant memory above a threshold of consciousness. This particular network model predicted a later analysis of emotional features of a word since nodes are activated by words only after they have been interpreted semantically.

In applying this theory to the current study, if the emotionality effect is *not* found in one of the patient samples, it may be presumed that the affective nodes (links) were damaged by the brain injury. If there is a greater concentration of affective nodes in the right hemisphere, this would explain a deficit in emotional processing associated with right hemisphere damage. If affective nodes are differentially concentrated in the hemispheres based on valence, this would explain a deficit in the processing of negative emotional material associated with right hemisphere damage and a deficit in the processing of positive material associated with left hemisphere damage.

Interacting cognitive subsystems. In 1985, Barnard presented the Interacting Cognitive Subsystems as a complex model of overall cognition and as a conceptual framework for understanding cognitive-affective relationships. The model assumes that mental activity reflects the collective action of a substantial number of specific processes which function to manipulate, store, or recover mental representations (Barnard & Teasdale, 1991).

These processes are organized into nine distinct subsystems, each specialized for dealing with and processing a specific type of information. Examples include the acoustic subsystem, the visual subsystem, the limb subsystem, and the propositional subsystem. Subsystems preserve a long-term record of the information they receive, called an *image record.* All incoming information is continually transferred into that image record. Other processes within subsystems serve the function of transforming information from one mental code into other mental codes so that it may be processed by other subsystems. Information processing activity is viewed as a dynamic yet coordinated flow of information among the nine proposed subsystems. Retrieval of information depends on the construction of a "description" in the appropriate code, summarizing the nature of the desired information.

The Interacting Cognitive Subsystems model can also be used to explain enhanced recall of emotional material. According to this model, upon hearing a word in the acoustic subsystem, the message is transferred to certain systems for the cognitive aspects of the message to be processed and to other systems for simultaneous processing of other aspects of the message. For example, a shaky voice arriving at the acoustic subsystem is transformed into a pattern of nervousness in the implicational code in order for an individual to appreciate prosody. The implicational code refers to a schematic model of experience or holistic sense of knowing and feeling. Furthermore, the images, words, and concepts conjured up when the original word is processed are also sifted through the system, each with its own implicational codes. Thus, an emotional word may be better recalled than a neutral word because it is transferred into more subsystems, each of which is then transferred into the implicational mode for recall or recognition. When information arrives from more subsystems, the effect is repetitive, forming a stronger implicational code, which is then easier to access.

I have included this model under semantic primacy theories since there are several encoding activities which must take place before a stimulus is interpreted as emotional. In our experiment, if emotionality effects differ across encoding conditions or experimental tasks, this finding will support the cognitive primacy theories since it will indicate that cognitive processing demands impinge upon the processing of stimulus emotionality.

Cognitions and Emotions are Processed Simultaneously

There are also investigators who do not stand on only one side of the fence in the emotion/cognition debate. These theorists propose that cognitive and emotional appraisal occurs simultaneously and is a continuously inter-dependent process.

The Cognitive-Affective Fugue. For example, Lewis, Sullivan, and Michaelson (1984) argue against the simplicity and linearity of the two types of popular theories summarized above. The model presented by these researchers (Lewis et al., 1984) stipulates that both cognition and emotion must be viewed as continual processes that are interwoven in highly complex ways into a single fugue. In the current experiment, two-way interactions between the effects of stimulus emotionality and learning condition would support this theory of simultaneous processing.

Emotionality and Memory

Next, some empirical studies will be reviewed that relate to the theories presented above and specifically investigate the effect of stimulus emotionality on memory. Thereafter, discussion will turn from focusing on stimulus emotionality to focusing on encoding condition, the second major focus of this study.

Establishing the emotionality effect

In 1975, Posner and Snyder put forth the idea that memory for emotional material had special characteristics that set it apart from memory for material from other categories. In support of this, Strongman and Russell (1986) studied 183 subjects and found that emotional material had a more prominent role in recall than other material. In 1986, Rubin and Friendly summarized the results of 13 experiments regarding which components of 925 nouns predicted their recall. The emotionality effect (better memory for emotional words as compared to neutral words) was robust in recall studies from different laboratories and different samples of words, and emotionality was thus defined as one of the three reliable predictors of recall. (The other two predictors were availability [associative frequency] and imagery.)

In fact, the relationship between emotionality of material and memory has been has been found in several different types of studies (e.g., Boggiano & Hertel, 1983; Dutta, 1975) and has been known for quite some time (Rapaport, 1942). The main thrust of the research that has been conducted since that time has sought to determine the parameters of this relationship, as well as the mechanism of action underlying the emotionality effect. The need for increased study in this area arises from the fact that there is no explanation for this enhancing influence of emotionality on memory or for the contrasting deleterious effects of emotionality that have been found in some studies (e.g., Keppel, 1963; Levinger & Clark, 1961; Parkin, Lewinsohn, & Folkard, 1982).

Defining the parameters of the emotionality effect

Bock and colleagues (Bock, 1986; Bock & Klinger, 1986) conducted in-depth investigations into the parameters of the emotionality effect, which yielded results supporting affective primacy theories. Bock (1986) investigated retention differences between arousing and non-arousing words in two different task conditions: a structural task and a self-referential task. In accord with the levels- of-processing theory (Craik & Tulving, 1975), the authors predicted that material that is processed on a deeper level should be recalled better than that processed on a more superficial or perceptual level. Thus, as expected, subjects in the self-referential task recalled twice as many words as subjects engaged in a structural task. Furthermore, emotional words were recalled more often than neutral words. However, there was no interaction between task and emotionality. That is, under both conditions, arousing words were recalled markedly more often than less arousing words. Hence, the authors concluded that the emotionality of a word is independent of changes in cognitive processes occurring across task conditions.

Bock and Klinger (1986) then conducted a more elaborate study of emotion/memory interactions, which replicated the findings cited above. Tasks were again adapted from level-of-processing studies, and subjects were required to rate stimulus words on a 7-point scale for six different attributes. The most important variables were the arousal potential of each word, its imaginability, and its relation to the personal concerns of the subjects.

There were several interesting findings in this study: (1) Ratings of arousing words took longer overall than ratings of less arousing words. (2) As predicted, engaging in tasks related to the structural word features led to poor retention compared with tasks involving semantic distinctions. (3) None of the six task variations, differing in the number of semantic features to be encoded, altered the retention differences between emotionally arousing and less arousing words. (4) Differences in rating time between arousing and non-arousing stimuli were not related to the effect of emotionality on memory. For example, a strongly arousing word was favored for retention even in tasks that took almost no time. (5) Emotionality effects on memory were the same whether or not the subjects had previously rated the words according to their emotional value. (6) And finally, although there were relationships between the effects of stimulus imaginability and stimulus emotionality, the two word features still operated independently. This was realized by analyses demonstrating that the differences in retention between more and less arousing words remained after controlling for imaginability as a covariate. The opposite was also true. That is, retention differences between more and less easily imagined words remained after controlling for arousal potential.

The several conclusions the authors drew from these findings: 1) The processing of emotionality of verbal stimuli is independent of the processing of structural and semantic features of the stimuli. (2) The emotional impact of a word is quite robust and cannot be suppressed even with tasks that engage subjects in time-consuming, elaborative encoding processes that seem to utilize their attentional capacities completely. (3) Therefore, the emotional effects of words operate on an automatic level and, as such, they cost no processing capacity and cannot be hindered by distractor tasks; they require no conscious attention; and they are set off by presentation of a stimulus and are not subject to an individual's control (Marcel, 1983; Schneider & Shiffrin, 1977). (4) Finally, imaginal features of a word had just as automatic an effect as arousability features.

These findings support the views of Posner and Snyder (1975) and Zajonc (1980) about the primacy and parallel processing of the emotional and imaginal features of words. Likewise, these findings refute the idea of sequential processing proposed by Rogers et al. (1977) and Bower (1981) of emotional and semantic features. Rather, the presentation of individual words led directly and automatically to simultaneous activation of emotional and imaginal processing. It is interesting to note that both of these processes are regarded as right hemisphere functions. Thus, it is possible that although the left hemisphere is dominant for the processing of words analytically, the more automatic processes which occur *before* the processing of structural or semantic features may be analyzed by the right hemisphere.

Despite these seemingly strong and clear findings by Bock and her colleagues, several variables have been found that have either altered the effect of stimulus emotionality or eliminated it altogether. For example, Rubin and Friendly (1986) found that despite its persistence across several studies, the emotionality effect was never the first predictor variable in a multiple regression analysis. This suggests that it may be suppressed by other variables.

Additionally, although the emotionality effect has been found in both intentional and incidental procedures (Amster, 1964; Heuer & Reisberg, 1990), there is preliminary evidence that the magnitude of the effect can be altered by task instruction. For example, Amster (1964) demonstrated that the emotionality effect was stronger when memory instructions were explicit. Additionally, Heuer and Reisberg (1990) found that the "narrowing of attention" that is sometimes elicited in emotional conditions (see explanation below) only remained in intentional procedures.

Another factor that has affected the strength of the emotionality effect, and is quite relevant to the current investigation, is the emotionality of the context in which stimuli are embedded. For example, Amster (1964) found that the advantage for emotional words was stronger in a mixed list design (a single list containing both neutral and emotional words) than with a comparison across lists, each being composed of only one word type (neutral, positive, or negative). In a different design, the strength of the emotionality effect was *not* altered by the emotionality of the surrounding context. Strongman and Russell (1986) found that when emotional and non-emotional words were embedded into emotional and non-emotional sentences, the emotionality effect was obtained for both sentences and target words. However, there was no interaction between these variables. That is, the strength of the emotionality effect of the target words was not affected by features of the surrounding sentence.

Retrieval procedure has also been implicated as a complicating factor in the relationship between emotionality of material and memory. For example, in 1982, Strongman reported that the effect of stimulus emotionality differed in free and cued recall procedures. Furthermore, Silberman, Weingartner, Laraia, Byrnes, and Post (1983) found a three-way interaction among task demands, emotionality of material, and subject type, such that depressed subjects benefited more than controls from high emotionality in the recognition of material, but were less benefited by emotionality components in free recall. In a test of lateralized effects of emotionality, Ali and Cimino (1996) also found that performance differed depending upon the task demands at test time. In an immediate free recall procedure, there was no lateralized effect of memory for stimuli varying in valence type. In the delayed recognition procedure, however, emotionality of material interacted with laterality. Thus, task demands have had an influence upon the strength of the emotionality effect, as well as upon intervening factors (e.g., laterality, mood) associated with the effect.

Other studies have also implicated subject variables in the interpretation of their findings. Most notable and relevant are the studies conducted with unilateral brain-damaged patients. For example, in the recollection of emotional and non-emotional experiences, right brain-damaged subjects were found to describe experiences with less emotional intensity when compared to left brain-damaged subjects (Cimino et al., 1991) and when compared to both left brain-damaged and normal control subjects (Borod, et al. 1996). Wechsler (1973) and Gardner, et al. (1983) found similar results in the recall of short stories. That is, right brain-damaged subjects displayed aberrant behavior in their recall of emotional stories, and often elicited confabulatory remarks and self-references.

Since our design will utilize both positive and negative material in order to test the valence hypothesis, it is also of interest to know if both positive and negative material elicit an effect upon memory and if the effect of emotionality differs in direction or strength depending on valence. Unfortunately, most memory studies have not differentiated between positive and negative valence of emotional stimuli. In those that have, positive stimuli were remembered better than negative stimuli (Ali & Cimino, 1996; Amster, 1964; Winnick & Archer, 1974). However, in both the Ali and Cimino (1996) study and the Amster (1964) study, neutral material was remembered better than negative material on some tasks, and the reverse was found on other tasks (or on different lists, in the case of the Amster study). This preliminary evidence suggests that emotionality effects may be more reliable for positive than negative stimuli. Thus, at present, it is unclear as to whether valence interacts with the general relationship between emotionality and memory. Valence may be a factor, like several others presented, that interacts with task requirements, subject variables, etc.

Thus far in this discussion of the parameters of the emotionality effect, we have discussed factors that alter but do not obliterate or reverse the enhancing effect of stimulus emotionality on memory. There are also cases of emotionality having an adverse affect on memory. For example, the details of a story or picture are often remembered better in neutral than emotional situations. This phenomenon has been referred to as weapon-focus (Loftus, 1979) or more often as the Easterbrook hypothesis (Easterbrook, 1959) and has been explained via the intervening concept of arousal, which will be further described below. In this instance, emotional arousal is thought to cause a narrowing of one's attention to the focus of a story or event, at the expense of attention to the periphery or details. A series of experiments (Burke, Heuer, & Reisberg, 1992; Heuer & Reisberg,1990) has delineated this effect further by demonstrating that it is the periphery and not the details, per se, that is the focus of the disadvantage. That is, details associated temporally and spatially with the central point of the event or story were remembered better in emotional as compared to neutral stories. However, details of peripheral events were recalled at lower rates in emotional stories than in neutral stories.

Also, studies with different types of material have found that retention interval has interacted with the effect of emotionality (e.g., Christianson, 1984; Kleinsmith & Kaplan, 1963, 1964; Parkin, Lewinsohn, & Folkard, 1982) such that in immediate recall procedures, the emotionality effect was dampened or reversed (i.e., memory for emotional words was *poorer* than for neutral words). After a delay, however, this pattern reversed, and retention was better for emotional material. These studies concluded that emotionality of material improves the accuracy of long-term retention but not of short- term memory. Although the many free recall studies cited above (e.g., Rubin & Friendly, 1986) contradict these findings, these latter studies indicate that in some situations, the emotionality effect may be sensitive to testing intervals.

This review has illuminated the factors which should be controlled for in a study of emotionality effects on memory. Although it may be difficult to control for all of these elements in a single study, awareness of the potential confounds can at least be beneficial in a discussion of results. Thus, test interval should be accounted for, as should the valence of the emotional material. Attention should be paid to the type (mixed vs. pure) of presentation of stimuli, as well as to other variables which constitute surrounding context. More than one retrieval task should be used and notice should be taken as to the expectations of the subject (i.e., are subjects forewarned of the tests or not).

Hypotheses regarding how emotionality affects memory

We have established that in most circumstances stimulus emotionality has an enhancing effect upon memory, although there is conflicting evidence regarding the robustness of this phenomenon. According to the well-designed studies by Bock and colleagues (e.g., Bock & Klinger, 1986) the effect of stimulus emotionality is automatic and resistant to variables such as task manipulations. Findings from several other studies, however, indicate that the effect can be dampened or reversed depending upon task and subject variables.

Next, we will address the issue of *how* emotionality may exert its effect. We speculate about three mechanisms by which the emotionality of a stimulus may exert its effect upon memory. Unfortunately, given the scope of this project, we have not yet tested these theories directly, although further analysis of the current data and future extensions of this paradigm will allow for further examination of these theories.

Emotionality effects are exerted via increased imaginability. Paivio (1965) found a relationship between the imaginability of a word and its emotional component. Thus, since the concreteness of words tends to predict performance in memory tasks (Paivio, 1971), it is possible that emotional words are easier to remember because they are easier to visualize. Since visualization is primarily a right hemisphere function, a failure for emotional material to enhance memory in right brain-damaged patients could be attributed to the inability for such subjects to visualize the emotional words as well as left brain-damaged subjects and normal control subjects. Although this theory is plausible, the findings by Bock and Klinger (1986) indicate that both imaginability and emotionality operate early on, but independently, in the processing of lexical stimuli.

However, since the words in this study were rated for concreteness, it is possible to test this theory in future analyses of the data, by determining whether or not there is a significant relationship between the concreteness and the emotionality of the words recalled. It is also possible to determine the size of the effect of concreteness on the number of words recalled. This latter analysis would tell us how much concreteness contributes to memory performance, and the former analysis would tell us if this contribution is independent of the contribution of emotionality.

Emotionality effects are exerted via increased meaningfulness. In the associative network model, Bower (1981) discusses an increased number of "nodes" in the processing of an emotional stimulus as compared to processing a neutral stimulus. Likewise, in the interacting cognitive subsystems model of affective/cognitive relationships, Barnard (1985) discusses an increased number of subsystems that are engaged when a stimulus is emotional, which, in turn, increases the strength of the implicational code for that stimulus. Both of these models describing the mechanisms by which emotional material is easier to recall, can be simplified into methods by which emotional material elicits more meaning for a subject than neutral material. It is well known that increasing the meaningfulness of verbal stimuli increases the likelihood of its being recalled (e.g., Bobrow & Bower, 1969). Thus, if emotional material does, in fact, increase the meaningfulness of stimuli, this may adequately explain why emotional material is easier to remember than non-emotional (less meaningful) material.

Evidence against this theory, however, comes again from the Bock and Klinger (1986) study where emotional processing was found to be automatic and very time-efficient. The amount of time it takes for material to be meaningful to a subject (i.e., for a subject to form a number of associates) is probably longer than the time it takes for emotionality effects to occur. However, it is possible to test this hypothesis by rating words for meaningfulness (as measured by their number of associates), and testing the relationship between the meaningfulness and emotionality ratings of words. Emotional words would have to be higher in meaningfulness than neutral words in order for this mechanistic theory to be supported.

Emotionality effects are exerted via increased arousal. Schurer-Necker (1984) and Schonpflug and Beike (1964) found that words that were defined as arousing by either subjective report or electrodermal potential were recalled better than less arousing words. Bower (1992) discussed the importance of arousal in the emotionality effect. He proposed that when stimuli are affective, arousal persists for several minutes and causes a *recycling* of whatever thoughts are salient in the cognitive system at that time (Gold, 1990; McGaugh, 1983). This, in turn, interrupts ongoing thought processes (Mandler, 1980). Bower explained this recycling as rehearsal and/or reimaging of the events leading up to the emotional reaction. This rehearsal naturally enhances the degree of storage and learning that takes place. Since there may be arousal deficits after brain damage, particularly with right hemisphere patients (Heilman, Schwartz, & Watson, 1978; Morrow, Vrtunski, Kim, & Boller, 1981; Myslobodsky & Horesh, 1978; Valenstein & Heilman, 1984), some aspect of this process may be disturbed, which in turn would lead to a deficit in processing emotional stimuli. Thus, if emotional material does not play a facilitative role in brain-damaged subjects, it may be a worthwhile endeavor to explore whether such patients also have arousal deficits, and whether deficits in arousal are related to the inability to utilize the stimulus feature of emotionality to improve memory for verbal material.

This concept of recycling and interruption has been supported by learning experiments. For example, in a study of free recall of names and pictures of unrelated common objects (Ellis, Detterman, Runcie, McCarver, & Craig, 1971), the middle (eighth) item was an emotionally-surprising photo of a human nude. The seven items prior to and the seven items subsequent to the nude photo were neutral objects. The nude photo was recalled at a higher rate than the rest, and the photos immediately prior and subsequent were recalled at a lower rate than the rest. The results demonstrated that the affective reaction aroused by the nude photo gave it priority in a "rehearsal buffer" so the critical event: a) prematurely terminated rehearsal in working memory of the last few items preceding the emotional item; b) exaggerated rehearsal of that critical item; and c) caused subsequent items to receive less than normal processing (Bower, 1992).

Hemispheric Lateralization and The Emotion/Memory Relationship

Thus far we have established that emotional processing is often impaired after damage to the right side of the brain. We have also established that increasing stimulus emotionality often increases memory, although the mechanism by which this occurs has not yet been settled. The next logical question, which this dissertation addresses, is whether the effect of emotionality is a lateralized phenomenon. More specifically, does the right hemisphere contribute more to this effect than the left? If so, then patients with right hemisphere damage should fail to show an increase in memory for emotional over neutral material, or the effect should be substantially dampened. There is evidence of this in the literature. However, as we will point out, the methodology needs to be more precise to clearly implicate the right hemisphere in emotional memory.

Although not specifically stated in this manner, these studies assume that lateralized emotional processes interact with lateralized memory processes when a task entails both functions. Thus, it is not contested that verbal memory is primarily a left hemisphere function. Damage to the right hemisphere, however, is assumed to affect verbal recall if the task additionally involves functions that normally engage the right hemisphere. Studies addressing other emotional/verbal functions, unrelated to memory, such as interpretation of emotional discourse (Bloom et al.,1992), have demonstrated such an effect.

Specifically addressing the issue of emotional/verbal memory is a frequently cited study by Wechsler (1973) which found that for normals recall was similar for an emotional and a neutral story but that both left and right brain-damaged subjects performed more poorly in the "emotional" condition. Furthermore, the left brain-damaged subjects performed more poorly quantitatively, whereas the right brain-damaged subjects displayed more qualitative errors. This study (Wechsler, 1973), however, had several methodological shortcomings, including poor choice of story material (the "neutral" story contained affective content); mixture of etiologies in group selection (source, extent, and type of damage differed within and across groups); poor control over the amount of time that had elapsed since brain injury (these data were not reported and presumably not collected and therefore one group may have included many more acute patients than the other); no distinction between positive and negative affective material (both of which were present in both stories); no control over prosody or concreteness/imaginability (which would place the right hemisphere group at a disadvantage); and no distinction between storage and retrieval deficits (no recognition or delay procedure; as pointed out by Heilman, Watson, & Bowers, 1983). The study concluded that the right hemisphere has greater control over memory for emotional lexical material. Our current study aims to provide additional, more firmly based support for this conclusion.

Other studies have since improved upon methodology and obtained the same general results. That is, subjects with right brain damage have been found to be qualitatively different in their memory for emotional material (Borod, et al., 1996; Gardner et al., 1975; Wapner et al., 1981). However, these studies all involved memory for discourse and thus could not bypass the confounds of such a paradigm. That is, memory for discourse (passages longer than a single sentence) inherently requires adequate comprehension of complex verbal material as well as the ability to express such material. These studies have dealt with this difficulty by also employing a neutral passage to be recalled. However, control for other variables, such as familiarity, concreteness, and syntax were not reported, and presumably not employed. The difficulty required in matching passages of discourse on each of these variables, as well as on the presence and intensity of emotional components, may be an insurmountable task. However, the importance of controlling for these variables is clear. If an emotional passage is also less concrete than a neutral passage, then poor recall performance by right brain-damaged subjects may not be based on the differences in emotionality between the two passages, but rather on the differences in concreteness. Furthermore, right brain-damaged subjects are often impaired in the pragmatics of language (Foldi, Cicone, & Gardner, 1983; Joanette et al., 1986), and the demand for pragmatic competence may be increased in the recall of an emotional story. Thus, inferences regarding a verbal emotional deficit could only be made if the factors of concreteness and pragmatics were somehow removed. In an effort to control such factors, the current study utilizes very constrained stimuli. These discrete bits of verbal stimuli (words) have not only been rated for their emotionality, but their syntactic category, concreteness, familiarity, and length are also controlled. In this way we can dissociate a discrete emotional memory deficit for individual words from a larger deficit in memory for emotional material that is more verbally complex.

Learning Condition

Thus far we have concentrated on stimulus emotionality and its effect on memory. However, using different words based on their level of emotionality was only one of the two ways in which conditions differed at encoding. The other, equally important, variation was method of presenting the words during the study phase. That is, following initial presentation of each word, there was a sentence which served as a frame of semantic context for the target word. In one learning condition, the subject read a sentence provided by the examiner. In the other learning condition, the subject generated a sentence. These two conditions were assumed to differ in the processing demands they made upon the subject.

We utilized these different learning conditions for two reasons. First, it was of interest to determine whether generating a sentence, as compared to reading a sentence, would have the same beneficial effect on memory in brain-damaged individuals (especially those with language and memory impairments), as it is expected to have in healthy individuals. Second, it was of interest to determine whether or not the emotionality of the stimulus material would impinge upon the proposed facilitative effect of sentence generation on memory performance.

Most studies looking at the effects of generation have utilized procedures where words are either generated or read in response to a stimulus cue. Such studies have demonstrated that in most conditions there is a memory enhancing effect for words generated by the subject, as compared to experimenter-provided words read by the subject (e.g., Abra, 1968; Davies, Milne & Glennie, 1973; Dosher & Russo, 1976; Gardiner, Craik & Bleasdale, 1973; Johnson, Taylor, & Raye, 1977; Russo & Wisher, 1976; Slamecka & Graf, 1978; Underwood & Schulz, 1960; Winnick & Daniel, 1970). The result of this manipulation (improved memory for generated words) has been referred to as the generation effect.

The approach used herein, that of generating and reading a contextual sentence rather than the target word, is fairly novel. However, a recent study by Grix (1992) used a similar approach and found that memory improvements were larger when the contextual sentence was generated than when the contextual sentence was read. The current study further investigates whether or not this expected memory-enhancing effect of sentence generation extends to individuals with acquired brain-damage.

In an effort to make a priori predictions regarding brain-damaged patients, a thorough search of the literature revealed only two studies of word generation in brain-damaged samples. Both studies were conducted on subjects with dementia of the Alzheimer's type (Malcolm, Jean, & Sands, 1989; Mitchell, Hunt, & Schmitt, 1986). These studies found that the normally robust effects of self-generation were unobtainable in this patient population. Before these results and their implications are explored, the distinction between word generation tasks, which have been studied in more depth, and the sentence generation task used in this study, must be further clarified.

There are two important differences between word generation tasks and sentence generation tasks. The first distinction is based on the type of processing involved in the encoding (learning) phase. In most word generation tasks, encoding instructions call for a highly constrained search and decision process resulting in the generation of a single, specific word. Although less constrained, generation of a contextual sentence is a higher level of processing than word generation, requiring the search for a meaningful sentence frame and the specific words to fill it. The second distinction between word and sentence generation tasks is based on the task demands during the retrieval phase. In most studies of the generation effect, the target of later memory testing is the word that was generated. In the current study, the generated material is tested in only one of three memory tasks (cued sentence recall). In the other two retrieval tasks (free recall and recognition), it is the experimenter-provided *stimulus* cues that are the memory targets rather than the read and generated *responses.* Furthermore, the cued recall task in this study is different from that of word generation studies, since our to-be-remembered material (sentences) is longer and more complex than the normally requested single-word responses. Thus, it is the generation of contextual sentences and their effect on both memory for words used as cues and memory for the sentences themselves that is of interest in this study. In sections to come we will discuss the encoding and retrieval phases of our experiment in more depth.

Despite the differences highlighted above, we presume that there are some similarities in the processes involved in word and sentence generation procedures and in their resulting effects upon memory. Most relevant to this study is the fact that both involve self-generation which is expected to enhance memory. Thus, since the investigation of of sentence generation as a possible memory-enhancing technique is a fairly novel problem, we will extract concepts from explanatory theories that have been brought to the investigation of the word generation effect and which seem most applicable to our study.

First, since our interest here involves the use of contextual sentences, we must also have an understanding of how lexical context exerts an effect on memory. Context effects indicate that words are usually learned better when they are encoded within a context than when they are learned alone (Tulving & Gold, 1963). Reading a sentence is one way in which words may be semantically connected, and thus one way of providing a context for a word. Reading verbal material activates associates in long-term memory and this activation provides rapid access to related concepts that have been linked to the stimulus through previous experience (Kintsch, 1988; Neely, 1991; Norris, 1986). Thus, one way in which context is believed to exert its effect is by forming associations between the target and its context and perhaps also by *re-activating* associations in long-term memory.

In this study, both reading and generating sentences frame the target words and activate associations. The difference between the conditions is that in reading a sentence, at least some of these associations are provided by the experimenter, whereas in generating a sentence, the activated concepts are created by the subject alone, presumably based on links to the stimulus through previous experience. Thus, it is the activation process and the resulting activated associations that are manipulated by having subjects either read or generate a contextual sentence utilizing a target word. Theories of the generation effect, discussed below, differ in their emphasis on whether it is the activation process or the activated associations that are responsible for the obtained memory-enhancing effect of learning while generating.

Context effects have been studied in different types of patients with brain damage and have indicated that patients with severe memory impairments may be unable to use semantic context in the way that normals can (Baddeley, 1982; Jacoby, 1982; Winocur & Kinsbourne, 1978). Although this may be the case for the amnesic patients utilized in such studies, it may not be the case for patients with memory abilities which lie across the continuum from intact to defective. The distinction we wish to make here is between individuals who are unable to store or retrieve almost any information on explicit tasks (i.e., patients with dementia or amnesia) and individuals with focal brain damage who can store and retrieve information, but at a lower level than normals.

Before we begin our discussion of the processes involved in the encoding phase of the experiment, we want to emphasize that this study is *process-oriented*, as opposed to *product-oriented.* Product-oriented studies of context manipulations would concentrate more on that (context) which is generated as opposed to that (context) which is read. Since our focus was not on the product, we have let the content of the context sentences be very open-ended. That is, there were very few constraints on the type of sentences that were to be read, and generated, both in terms of length and content. The only requirement was that the stimulus word (which varied in emotionality) was to be included in the sentence. By contrast, we have concentrated our efforts on delineating and analyzing those processes which may underlie the effect of sentence generation, and on analyzing the subject and stimulus variables which may modify this effect.

Encoding phase analysis

The encoding phase of this experiment involved three different instructions: to read words, to read sentences, and to generate sentences. Thus, although the two learning conditions (Read and Generate) differ in the way in which sentences are applied to target words, the conditions are similar in that they both involve the initial stage of reading single words. Thus, we begin by first presenting a model describing the process of reading words, which also applies to reading words within a sentence. We follow this by the presentation of a model describing the process of generating sentences.

The process of reading words and sentences. A useful model of processing language was presented by Harris and Coltheart (1986) and utilized concepts from the logogen model proposed by Morton (1969, 1978). These models are used in our description of the processes involved in visualizing printed words at input and producing them as output in auditory speech, or in less formal terms, in the process of reading aloud. In this description, ideas are also incorporated from other language theorists where it seemed necessary to do so.

In order for a printed word to be spoken aloud, the reader must complete two or three intermediate steps. The first step is termed visual word recognition. Visual word recognition involves matching the word's orthographic presentation to a lexical entry in one's verbal lexicon (also sometimes referred to in the literature as mental lexicon, internal lexicon, or mental dictionary; Harris & Coltheart, 1986). The verbal lexicon is an individual's internalized system of knowledge about words. Although there is one lexical entry for each word in an individual's vocabulary, some theorists have proposed that each item in the lexicon contains (and/or is listed by) at least four kinds of word features: meaning, syntax, morphology, and form (Levelt, 1989). There may also be additional properties stored with an item, such as pragmatic, stylistic and affective features that will make one entry more likely to be accessed than another (Levelt, 1989).

Although here we are discussing the verbal lexicon in the context of reading, the same verbal lexicon is an important construct in the production and memory of words and sentences. This is because individuals have only one verbal lexicon (at least for one language; Harris & Coltheart, 1986), but there are several routes whereby individual lexical entries in the verbal lexicon can be accessed. For example, in Morton's logogen model (1969, 1979) of the mental lexicon, each lexical entry has a corresponding "logogen" which is sensitive to a variety of different sorts of information which may arise from the auditory system (a spoken word or sound), the visual system (a printed word or a picture), or from one's internal semantic memory system (any of the concepts that have been associated with that word in the past). Morton postulated that a logogen 'fires' (a lexical entry is accessed) when it has collected enough evidence (information) which corresponds to the lexical entry. Thus, logogens have resting thresholds, and whenever the total amount of evidence exceeds this threshold a logogen fires resulting in two effects: (1) the lexical item may be produced, either in written or spoken form; and (2) the lexical item enters the larger semantic/cognitive system. Thus, if a word has been read aloud, we know that its lexical entry has been accessed from the verbal lexicon, and that at least some aspect of that word has entered the semantic/cognitive (memory) system.

In Harris and Coltheart's model (1986) of reading, three aspects of each lexical entry in the verbal lexicon are important. These are the orthography (i.e., spelling), phonology (i.e., pronunciation), and semantics (i.e., meaning) of the word. For individuals with an intact language system, these three sub-systems of the mental lexicon are assumed to communicate efficiently with each other. Thus, for example, the ability to read a word aloud depends upon effective communication from the orthographic input system to the phonological output system. This process is assumed to occur very quickly and, for most individuals, automatically (MacKay & Osgood, 1959).

Whether or not the semantic component of a word is accessed automatically during this process has been a topic of much research. Recently, priming studies have demonstrated that the semantic component of a word (or at least a part of that component) is also automatically accessed, even if instructions to understand or remember the word are not made clear (Roediger, 1990). During the process of reading, the lexical entries may also undergo more elaborative processing via connections to the larger semantic/cognitive system. In reading single words, examples of such elaborative processing include making associations between the word(s) and past experiences, making a mental picture of the word, and inferring deeper or alternate possible meanings of the word.

In reading a sentence, therefore, it seems reasonable that the semantic components of several words are automatically encoded. However, sentences also convey aspects of meaning beyond those implicit in single words (Caplan, 1992). For example, while reading a sentence, there is integration of the individual concepts via the syntactic structure of the sentence (how the words are grammatically connected) and the use of pragmatics (inferences about the world such as who the information is coming from, why the information is being read; Brown, 1980). Additional information is used to form a higher-order concept of the read sentence. The new, higher-order concept may then be related to past experiences, which may in turn cause further elaborative processing of the sentence, etc.

We wish to highlight the point that this additional semantic/cognitive analysis may or may not occur during reading depending upon the intention or inclination of the individual and depending upon what other cognitive processes an individual is simultaneously engaged in. Thus, reading may also occur on a very superficial level. Examples of superficial reading are when one scans a page of verbal text for a particular word, or when a reader's attention is drawn to internal or external stimuli precluding deeper analysis of the words and sentences he or she has read. Instructions given to a reader can also substantially influence a reader's level of processing (Craik & Lockhart, 1972) so that he or she may be induced to read on a superficial level (a lower level of processing which involves a much weaker activation of the semantic/cognitive system) or on a deeper level (a higher level of processing, which involves a much stronger activation of the semantic/cognitive system). It has been demonstrated that the more semantic analysis a read word or sentence receives, the better that material will be remembered (Craik & Tulving, 1975).

During the encoding phase of the current experiment, subjects were instructed to read the words and sentences, but only to remember the words. Subjects were not instructed to perform any additional activity with the read sentences, nor was a method employed of analyzing how deeply the read sentences were processed. In terms of the individual target words, however, the subjects were warned of a future memory test, and thus may have engaged in some sort of strategy to remember the words. This strategy may have merely involved internal re-accessing of the verbal lexicon via rehearsal. Alternatively, subjects may have employed one of a variety of semantically-based organizational strategies with the target words.

Before proceeding to our analysis of the processes involved in sentence production, we should mention that the logogen model is but one model of how words are activated (accessed) in the process of reading, speaking, or remembering. Goldman's (1975) model postulated that words are accessed by the use of discrimination nets that check for the presence or absence of stimulus features in a binary branching tree. Also, Miller and Johnson-Laird (1976) offered a model whereby decision tables are utilized in which words are selected by pairing conceptual features with the semantic features of lexical items in a pair of matrices. The scope of this paper does not permit an analysis of these models, and thus we move forward in our description of the second encoding condition of the experiment, that of generating a contextual sentence.

The process of sentence generation. Garret (1975, 1976, 1982) has developed an information-processing model to describe the encoding of generated sentences. This model incorporates most of the ideas mentioned in other models (e.g., Levelt, 1989) and is more comprehensive. Thus, we use Garrett's five-level model of sentence generation as a framework for this discussion, and, as above, we will incorporate information from other sources where explanation seems necessary.

In the process of speech generation, thoughts are converted into linguistic form. However, the process of formulating the structure of a sentence begins with simply an intention to communicate a message. In word and sentence generation tasks, this intention is stimulated by an experimental instruction and lexical cue. As discussed above, the cue (in this case a target word) will automatically activate some of the semantic concepts associated with it. Also, acting upon instructions to generate, the subject will actively perform some type of additional semantic/cognitive analysis of the word in order to arrive at an idea for a sentence. Garret (1982) referred to this as the message-level representation of a sentence, and it is an abstract, semantic, non-linguistic precursor of the final sentence.

This message level representation can vary in innumerable ways. Even when given a target word to use, there are an immeasurable number of messages which can be produced because an individual unit of language can be combined in an infinite number of different ways (Harris & Coltheart, 1986). However, the subsequent processes are limited because only some of these combinations will be legal according to grammatic and pragmatic rules (Brown, 1980). Thus, once an idea (intention, message) is formed, the next process in Garret's model involves the creation of a "functional predicate/argument structure" composed of the agent, the act and sometimes the acted-upon. Simultaneously, the verbal lexicon is again accessed for some possible content words that correspond with elements of the message level representation. This process involves matching aspects of the conceptual idea to semantic representations (features) of lexical entries (Caplan, 1992). These two processes result in a functional-level representation of the sentence.

The next step is to decide upon the details of the specific sentence to be produced. This includes the creation of a "planning frame for the sentence". An example of a simple planning frame is "The [noun] [verb]ed [adverb]. The selection of particular planning frames commits the speaker to use certain function words and not others, depending upon what tense the sentence is planned in and whether it is in the active or passive form. At the same time, there is a final pass through the lexicon to retrieve the correct morphological forms of the content words (nouns, verbs, adjectives, or adverbs) which were selected from the lexicon earlier. The position-level representation of a sentence is said to have occurred when the frame is filled in by these specific words. It is probably also at this level that superfluous elements get deleted in order to increase communicational efficacy and reduce it to a fully grammatical, comprehensible sentence (Taylor & Cameron, 1987).

At the fourth level, the phonetic rules of the specific language of use are applied to the position-level representation in order to create the corresponding phonetic-level representation. For example, phonetic rules concerning the different pronunciation of the letter "t" in such words as "little" and "truck" are specified. Finally, the articulatory-level representation is generated from the phonetic level via a set of instructions from the speech musculature which cause the sentence to be spoken.

By reviewing these stages, one can see that both the functional level and positional level of Garret's model require decisions based on syntactic (grammatic) factors. Other theorists have recognized that the syntactic category of a word (nouns, verbs, adjectives) may be important in the earliest stages of sentence planning since the process of matching concepts to words is likely to differ in some ways for different sorts of words. For example, "the concepts corresponding to common nouns are quite different from those that correspond to abstract nouns. The former, but probably not the latter, can activate visual images that may become part of the mediating process between concepts and words" (Caplan, 1992, p.106). In this same vein, we see that if a verb or an adjective is a target word, it forces the subject to specify a person or object associated with it. Likewise, if the target word is an adverb, it forces the subject to specify a verb associated with that adverb. Thus, altering the syntactic category of target words forces one to search for different types of words, even in the production of the simplest sentences.

Furthermore, it seems obvious that only words of a particular syntactic category can be chosen for certain positions in a sentence. Thus, if one wants to utilize a particular word and it does not correctly fit into the proposed sentence frame, then the subject must either transform the word morphologically into a different syntactic category (e.g., transform it from a noun to a verb) or choose a different word for that syntactic position. Conversely, if one must use a specific word in its current syntactic state (as in the current experiment), then the sentence frame is constrained by the necessity of fitting around that syntactic structure.

Pragmatic (communicative) factors are most likely interwoven into each one of these stages of sentence generation as well. Pragmatic factors are those aspects of language processing which stem from general knowledge about the world and about the way in which people normally convey information in language (Harris & Coltheart, 1986). For example, if we begin at the message level, the idea of a sentence will differ depending upon *why* the message is to be conveyed. At the functional level, different content words may be chosen (altering *what* you want to say). At the positional level, there are different ways of rearranging the sentence depending upon *how* you want that message to be expressed (e.g., which part of the sentence you want to emphasize will determine if you choose to use an active or passive form). Finally, at the phonetic level, one may choose to inculcate the proper enunciation of the words or a slurred version. All of these choices are based on the speaker's knowledge of the world, their knowledge of their audience, and their idea of how language should be modified based on particular environmental contexts.

Inherently, sentence production involves word production. However, there are obviously several aspects of producing sentences which are not involved in the more simple process of generating single words. For example, in Garrett's model, one can see where the process of single word generation ends and where additional processes involved in sentence generation begin. In brief, not only must subjects access more words from the verbal lexicon, but he or she must determine how to combine them in a way that is syntactically and pragmatically correct. Thus, we have the additional demands of communicational efficacy (getting one's point across) and grammaticality that are not involved in simple word generation. These demands are not mutually exclusive, for to speak effectively one must try to inculcate the conventions and rules of grammar (Taylor & Cameron, 1987). In this instance, we have added one more rule, that of fulfilling the criterion of integrating a specific target word into the sentence. Thus, from the outset, subjects must structure their sentential output in order to include the target word, make it grammatical, and make it communicative.

Theories of the generation effect.

Although there have been several theories proposed for the memory-enhancing effects of *word* generation, most of these theories have one of two common themes. We present these theories below and relate them to the proposed memory-enhancing effect of *sentence* generation.

The generation effect is a result of increased activation of the semantic lexicon and/or increased activation of semantic memory. As described above, the process of sentence generation requires activation of concepts in semantic memory which are associated with the target word and activation of specific words in the verbal lexicon to express those concepts. During the process of deliberate sentence production, there appear to be several communications between the verbal lexicon and the larger semantic memory system. The goal of these communications is that specific words associated with specific concepts are relayed in a logical and syntactically correct manner.

Even in the studies of the word generation effect, where there are far fewer linguistic processes required, there are a number of researchers (e.g., Gardiner & Hampton, 1985; Greenwald & Johnson, 1989; Jacoby, 1983;) who emphasize either activation of the verbal lexicon and/or activation of the semantic memory system in explanatory theories of the memory-enhancing effect obtained. Such theorists maintain that it is the increased semantic analysis enjoyed by the generated words that is responsible for the resulting improvement in memory performance. Thus, for example, Hara, Neumann, and Tajika (1989) found that the generation effect occurred only for words (meaningful stimuli) and not for nonwords. Since the processes involved in sentence generation are more complex than those involved in word generation, proponents of these theories would most likely predict that the enhancing effects of sentence generation would be even larger than those of word generation, because the processes involved in sentence generation would induce even greater semantic analysis of the target.

Advocates of these theories posit that it is the *meaningfulness* of the response and its relation to the stimulus that is important in the generation effect (Gardiner & Hampton, 1985; Greenwald & Johnson, 1989; Jacoby, 1983). Findings from word generation studies which emphasize the importance of the connection between stimulus and response are particularly suited to the current investigation of how a response (in this case, the context) influences memory for the stimulus (in this case, a target word). For example, Gardiner and Hampton (1985) found that a generation effect was obtained only when the stimulus and the generated response converged to become a functionally-integrated unit. Since pairing words with sentences inherently implies the formation of an integrated stimulus-response (S-R) unit, the utility of this concept applies to our study only if we can say that sentences that are generated are somehow *better* integrated with the target than sentences which are read. Our previous analysis of reading and generating sentences does suggest that the target-context (S-R) units in the self-generate condition may attain greater functional integration by being processed on a deeper level (via greater semantic analysis) than the target-context (S-R) units in the read condition.

Studies which have found a generation effect for the stimulus cue, as well as the generated response, provide the best evidence for these associative interpretations (Greenwald & Johnson, 1989). However, studies which show that the generation effect does not extend to the cues (e.g., Slamecka & Graf, 1978) are problematic for such theories. Thus, since we expect to find an effect of context generation both for the stimulus cue and for the generated response, these theories, which attribute to the generation process greater semantic analysis of the cue-response relationship, may be useful in interpreting our predicted findings.

The process of self-referencing and the resulting strong effects upon memory (Rogers, Kuiper, and Kirkner, 1977) may also be an intervening concept related to the generation effect. That is, asking a subject to generate a sentence may activate the rich and meaningful concept of the self, which may induce a deeper, more effective form of processing than that which occurs when reading sentences created by someone else. Thus, the proposed increase in meaningfulness enjoyed by the generated material, or by any part of that material, may be due to the re-activation of connections from one's own repertoire of experience.

One way to test the theory that deeper processing is responsible for the generation effect is to alter the level of processing demands at test time. By doing this, Jacoby (1983) found a generation effect in recognition memory even when there was a negative generation effect in a perceptual identification task with the same stimuli. Since emphasizing perceptual demands resulted in a reverse generation effect, Jacoby (1983) offered evidence for the importance of increasing the activation of semantic features in generating material. She concluded that the generation effect occurs because "it requires more processing of meaning and this more meaningful processing produces a higher level of retention" (p.663). McClelland and Pring (1991) replicated and extended the findings of Jacoby by finding a generation effect in free recall and recognition tests and a reverse generation effect in perceptual identification tests and word-stem completions tasks (McClelland & Pring, 1991).

Although these experiments studied the effects of word generation, the findings are applicable to the study of sentence generation as well. An explanation of sentence generation effects, based on differences in derived meaningfulness of material, would state that given instructions only to read, subjects process the material at a comparatively superficial level and thus upon direct testing, the memory traces for the materials are weak. Instructions to generate, however, encourage the subject to examine the target word on a deeper semantic level in order to search memory and the verbal lexicon for appropriate concepts and words, and hence the memory traces for these materials are comparatively strong (McElroy & Slamecka, 1982).

The association between meaningfulness and improvements in memory is hardly a new concept. Increasing the meaningfulness of any context will result in increased memory for the target items. A relevant example is the finding by Marslen-Wilson and Tyler (1980) in which study words were correctly identified faster in a subsequently-presented meaningful sentence than a non-meaningful sentence. Thus, the connection between meaningfulness of the target words and access to semantic memory stores is an important one, since it is through this connection that words obtain the attribute of meaningfulness. Deficits in semantic memory, therefore, may impinge upon the degree to which a word attains meaningfulness. If we assume that material that is read normally does not enjoy deep semantic analysis (without instruction or intention to do so), then deficits in semantic memory would impinge more on the generate condition and may thus yield a null or reverse effect of generation in patients with memory impairments.

The problem is two-fold and relates to the familiar distinction between storage and retrieval. First an individual must have concepts stored somewhere in semantic memory that are related to the target, and also one must be able, on demand, to use the target cues to retrieve these concepts. These basic steps are required before the subject can even begin to integrate the word and its associations into a coherent sentence. Theories which emphasize the activation of semantic memory would find it necessary for both adequate stores of memory to exist, and for the ability to integrate these prior concepts with the target cue, in order to form a functional unit.

At the basic or minimal level of requirements, then, in order to obtain an effect of sentence generation, one must have an adequate memory store from which to choose concepts relevant to the target word. This was proven in two studies of patients with dementia of the Alzheimer's type. In the first study, Mitchell, Hunt, and Schmitt (1986) tested 10 patients with Alzheimer's disease, 12 younger adult controls, and 12 older adult controls. Both control groups remembered more generated than read material in both free and cued recall. The group with dementia, however, showed no such advantage for generated material.

In the second more exhaustive study, 18 patients with Alzheimer's disease, 48 younger adults, and 48 older adults were given an intentional and an incidental list-learning task in a variety of different encoding and retrieval conditions (Malcolm et al., 1989). Again, control subjects demonstrated clear generation effects and patients with dementia did not. Investigators in both studies concluded that semantic memory is an important variable in the generation effect and that basic deficits in semantic memory will preclude the advantageous effects of generation procedures.

These findings are pertinent to our investigation since the patients in the current study are likely to have memory impairments. Our subjects are not demented, however, because such subjects would have been excluded from the study. Thus, what remains to be seen is how functional a memory system one must have, in order to enjoy the memory-enhancing benefits of generation. Another interpretation of the findings from these studies shifts the focus toward other processes involved in generating linguistic material, such as activation of the verbal lexicon, which may also be impaired in Alzheimer's disease. Accessing the verbal lexicon is a step which is equally important in generation, and it is different from activating non-linguistic semantic concepts. As we demonstrate in the following section on brain damage, lexical access and activation of semantic memory should not be blurred in explanatory theories since they are distinct, separable processes.

If lexical activation is also an important component in the effect of generation then it would follow that if the instruction to generate were *not* followed by a successful activation of the mental lexicon, then the generation effect would not be obtained. There is conflicting evidence regarding the importance of the generated response in the effects of generation. Buyer and Dominowski (1989) found that subjects who could not generate phrases from number cues did not exhibit a benefit from the unsuccessful generations. Slamecka & Fevreiski (1983), on the other hand, found that word generation effects were maintained even when the correct word was not successfully generated.

Thus, theories evoking the importance of increased meaningfulness of generated materials also view activation of the verbal lexicon and/or activation of the semantic memory system as important in the obtained effect (improvement in memory) that is often found when learning occurs in a generate condition.

<u>The generation effect is a result of increased effort during the generation procedure</u>. Several other investigators have rejected theories of the generation effect based on meaningfulness and contend that the word generation effect is due to the degree of cognitive effort required in obtaining the correct solution (Ayers,

1991; Hertel, 1989; McFarland, Frey, & Rhodes, 1980; Mitchell & Hunt, 1989; Roenker, Wenger, Thompson, and Watkins, 1978; Tyler, Hertel, McCallum, & Ellis, 1979). Effort has not been directly indexed or measured empirically during generation tasks (e.g., via EEG, functional imaging, or measures of autonomic arousal), and thus, the basis for this theory is derived from the manipulation of task demands and inferences about the effort required in different conditions.

For example, Gardiner, Smith, Richardson, Burrows, and Williams (1985) have shown that as the number of letters required for completion of a word increases, retention also increases. Similarly, Buyer and Dominowski (1989) found that retention increased as the cognitive effort required to complete a phrase increased. The proposal is that the amount of effort required in generating a word (or phrase, or sentence), in contrast to the amount of effort required in reading, may lead to better retention in the generate condition. As was said of the theories based on meaningfulness, this theory is also well suited to explain the effects of sentence generation because of the relatively smaller amount of effort required in reading a sentence, as compared to the effort required in searching for appropriate associations of the target words and then searching for the particular words to make a sentence. Furthermore, if the effect of generating depends upon degree of cognitive effort, then sentence generation may have an even larger memory-enhancing effect than word generation, since there are several more processes involved in sentence generation than in word generation. We should point out, however, that not *all* of the processes involved in sentence generation are effortful.

As may be inferred from our earlier description of the processes involved in sentence generation, different components of the process are automatic, while others are more controlled. The distinction between controlled and automatic processing and its relation to effort is fundamental to cognitive psychology, and is based in a firm research tradition (LaBerge & Samuels, 1974; Posner & Snyder, 1975; Schneider & Shiffrin, 1977). We will first provide Levelt's (1989) definitions for automatic and controlled processes and then see how they relate to the component processes of reading and generating. "Automatic processes are executed without intention or conscious awareness. They also run on their own resources; i.e., they do not share processing capacity with other processes. Also, automatic processing is usually quick, even reflex-like; the structure of the process is "wired in", either genetically or by learning (or both). This makes it both efficient and, to a large extent, inflexible; it is hard to alter automatic processes. Since automatic processes do not share resources, they can run in parallel without mutual interference." (Levelt, 1989, p.20-21)

"Controlled processing demands attentional resources/working memory, and one can attend to only a few things (the items in Working Memory) at a time. Attending to the process means a certain level of awareness of what one is doing. Human controlled processing tends to be serial in nature, and is therefore slow. But it is not entirely fixated in memory. In fact, it is highly flexible and adaptable to the requirement of the task." (Levelt, 1989, p.21)

One process which is automatic in healthy individuals, and is common to both the generating and reading of speech, is lexical access. The only difference is that during the course of reading, lexical entries are accessed through visual recognition of the printed words, while during the course of generating, lexical entries are accessed through concepts in semantic memory. We know that lexical access normally occurs very rapidly since, during the course of natural conversation, speech production takes place at a rate of between 100-200 words per minute (MacKay & Osgood, 1959). Words are selected at that rate from the many tens of thousands of words in the mental lexicon. Thus, there is just no time to consciously weigh all of the alternatives before deciding on a word and therefore this high-speed accessing requires parallel processing (Levelt, 1989). All of the models describing lexical access have recognized that parallel processing must occur (Garret, 1982; Goldman, 1975; Miller & Johnson-Laird, 1976; Morton, 1979) and have assumed that the process of lexical access is largely automatic in a language-competent individual.

If we further analyze the component processes involved in sentence generating and in sentence reading, we see that those components which are similar in the two conditions are the processes which are considered automatic, rapid and effortless. These are the processes of accessing the verbal lexicon, converting the accessed lexical unit into a phonetic representation, and sending that message to the oral musculature for speech production. However, the additional processes that are involved in sentence generation, which are not involved in reading, are the ones that are more effortful and controlled. These are the cognitive decisions made about the accessed words during the planning and intermediate stages of sentence production.

The difference in effortful processing required in read and generate conditions begins at the first stage of Garret's (1982) sentence production model, i.e. the message level representation. Thus, although several concepts may be automatically activated upon reading a stimulus word, only one will intentionally be chosen to communicate. Since an intentional activity is, by definition, under central control (Bock, 1982; Carr, 1979; Fodor, 1983), the greater effort involved in the process of generation begins while the idea of the sentence is being conceived. The individual who is generating the sentence will next invest his attention into matters of planning what to say to get one's point across, and finally into how to say it.

The fact that generating speech involves more time-consuming, controlled processes than reading speech was evidenced by Goldman & Eislet (1968) who found that the greater number and length of pauses during self-generated speech, as compared to read speech, was related to the amount of cognitive planning involved in speech generation. When subjects were induced to generate speech without such pauses, that is, with less time to plan, the result was a much greater number of logical and syntactical errors.

Furthermore, a review of the processes involved in sentence generation indicate that there are two more passes through the lexical access system in the search for appropriate words and word forms which do not occur in reading sentences. In this experiment, those searches are further constrained by the semantic and syntactic nature of the target word. In reading, by contrast, one need not conceive of an original idea, choose the precise words, or figure out how to put them together.

Therefore, due to the decreased number of cognitive demands (controlled processes), there is normally less effort involved in reading. In relation to the current study, when the subject is in the read condition, his or her attention may be focused on the task at hand or may be partially invested elsewhere, leading to decreased memory for the material at test time. When the subject is in the generate condition, however, his or her attention will necessarily be invested into those controlled processes involved in planning a sentence. The increase in attention toward the material at encoding will presumably lead to increased memory for that material at test time.

The investigators in a study which manipulated the effort required during reading (as opposed to most studies which manipulate aspects of generating) suggested that the generation effect is due to increased effort put forth during the generation procedure, but that just as much effort is employed in any strategy employed to remember verbal material (Begg,Vinski, Frankovich, & Holgate, 1991). In the Begg et al. (1991) study, subjects were instructed to act on the read material in an effortful way (using imagery) and this abolished the word generation effect. That is, instructing subjects to imagine the read materials resulted in the same amount of recall as instructing subjects to generate material.

Another concept related to effort is that of attention and limitations upon attentional capacity. Thus, there has been speculation that instructions to generate induce a change in *which* material is remembered, as opposed to the *amount* of remembered material (Burns et al., 1990; McDaniel, Waddill, & Einstein, 1988; Schmidt & Cherry, 1989). That is, instructions to generate may simply shift the subject's focus of attention away from read materials and towards generated materials. In the process of such a shift, encoding in the read condition would be lowered due to limits on the capacities of attention. Although this is a plausible explanation for the word generation effect found in several studies using a within-list design for the read/generate variable, the concept does not readily apply to this study because our material is presented to the subject in a between-block design. This paradigm is presented in more detail in a later section. What is important to understand here, however, is that subjects are not shifting back and forth between reading and generating. Rather, the subject is in a particular condition for a fairly lengthy block of time, and block of material, before shifting to the next condition. Thus, an explanation of the generation effect based on shifts of attention away from reading does not readily apply to this study.

Furthermore, in studies which have been able to induce a non-effect of generation, it is only the memory performance in the read condition that is altered, not a decrease in the performance in the generate condition. For example, in the paradigm utilized by Begg et al. (1991) described above, instruction to imagine the read material did not detract from the level of recall performance in the generate condition. Also, when given intentional instruction to remember in each condition, it is the improvement in the read condition that has obliterated the effect of generation in such studies (e.g., McDaniel et al., 1988; Watkins & Sechler, 1988). The memory performance in the generate condition remained the same across these different task instructions. These findings do not support theories focusing on effort as the crux of the generation effect, since along with the concept of limited capacities on attention, increasing processing demands in one task should have decreased processing demands in the other.

It should be acknowledged, however, that theories relating to effort and arousal need not necessarily inculcate a shifting-of-attention hypothesis. Subjects may still be at different levels of arousal in the two conditions which are unrelated to the contiguity between these conditions. That is, overall levels of arousal may simply be higher during generate conditions, without "draining" any of the attention and effort put forth during reading. Heightened arousal in the generate condition may arise from the *instruction* to generate, or it may result from the *effort* involved in the generational processes.

Presumably a target word is made more distinctive when it is processed during this more active state (Hertel, 1989; Tyler et al., 1979). This is similar to the the "tagging" process discussed by Bower (1981) in relation to memory for emotional words and concepts. Bower also discussed how concepts are made "hot", and easier to retrieve, if they are processed during particular internal states. Here we are relating ability to retrieve memories at test, to optimal levels of arousal during encoding. The relationship between arousal and memory has been of interest for decades. The general concept of relating arousal to performance was depicted in Hebb's (1955) inverted-U shaped curve, where at the lowest and highest extremes of arousal performance is low. The center of the curve, corresponding to the most optimal level of arousal, is where performance is the best.

Although the concept of relating arousal levels to memory is logical and has some basis in animal literature (e.g., Levine, 1966), the search for a systematic relationship between arousal and memory in man has not been very fruitful (Shors, 1992). What the research has revealed is that there are several factors which can easily affect this relationship. For example, as cited previously, many studies have implicated test interval as an important variable in this equation (Kleinsmith & Kaplan, 1963). Such studies have generally shown that increasing arousal causes decreased immediate recall and increased delayed recall. Since we employ an immediate and delayed procedure, a generation effect that is found only on the delayed test would support a theory of increased levels of arousal during the generate condition.

Furthermore, several subject variables (or individual difference factors) can further complicate the relationship been arousal and memory, such as trait anxiety (Kleinsmith & Kaplan, 1964). Thus, individuals who rate themselves as highly anxious, perform better under low-arousal conditions, whereas individuals who rate themselves as low-anxious operate better under high-arousal conditions. If instruction to generate is inducing a higher level of arousal, then intermediary factors, such as personality, may influence the effect of generation on memory performance.

Unfortunately, in the current study we do not provide a measure of physiological arousal and, therefore, we can only make inferences about arousal from the effects obtained herein. In the future, however, we hope to obtain physiological measures of arousal during encoding and retrieval tasks, and thereby more directly investigate the importance of arousal in the effect of generation.

Studying the performance of patients with brain damage

As with any problem, there are several ways to arrive at a solution. When addressing cognitive issues or delineating a cognitive phenomenon, many experimental psychologists infer mental processing by manipulating the stimuli, tasks, or environmental conditions of an experiment and by analyzing the effect of that manipulation on normal adult performance. Another method of understanding a cognitive effect is to measure it across different groups of individuals who are divided according to a meaningful variable.

Group differences on an experimental task imply that there is something about a particular group that has an effect upon the phenomenon being investigated. For example, if males run faster than females, then there is something about "maleness" (or being male) that causes, or is associated with, faster running. In this study, we utilize groups of individuals who differ according to the presence and laterality of brain damage. If one of these groups fails to demonstrate changes in memory performance based on differences in encoding condition, then we can infer that there is something about the group factor (either presence or laterality of brain damage) that is limiting the effect of generation. Further investigation may then reveal what the limiting factor is.

We have chosen to study the performance of subjects with unilateral brain damage because of the specific functional impairments which often accompany acquired brain injury. That is, patients with damage to the left side of the brain often have deficits in language and memory, and it is likely that these deficits will impinge upon the process of sentence generation. Thus, studying the performance of patients with left brain damage may elucidate whether or not the underlying processes involved in the generation of a sentence are responsible for, or contribute to, the memory improvement that is often found when encoding involves generate procedures. Studying the performance of brain-damaged individuals with functional deficits has shed light on many cognitive processes in the past. For example, studying patients with language disorders has delineated the processes involved in sentence production (Garret, 1982), helped establish the fact that there are separate subsystems within the verbal lexicon (Morton, 1979), and greatly enhanced our understanding of hemispheric dominance for verbal and visual memory (e.g., Gazzaniga, 1970; Milner, 1972).

In the discussion which follows, we first describe the type of cognitive deficits that brain-damaged individuals may have which are relevant to our study and then describe how these impairments may lead to inefficient sentence generation. Discussion then turns toward the possible implications of such inefficient sentence generating on the results of this experiment and how such results would provide support for one of the two theories presented above. Finally, we present a method of dissociating these cognitive deficits from one another and determining their relationship to the experimental effects of interest.

Language impairments. Despite the fact that we exclude aphasic patients in this study, our patient groups, and especially those with damage to the left side of the brain, are expected to demonstrate acquired language impairments (dysphasia). These language deficits may interrupt the processes involved in sentence production, and thereby make the generation process more difficult and less successful than it is for the patients and healthy individuals without such language difficulties. Narrowing the acquired deficits down to abnormalities of speech output, patients with left brain damage may have phonemic paraphasias, apraxia of speech, anomia, semantic paraphasias, circumlocutions, and/or abnormal generation of morphological form (Caplan, 1992).

Due to the number of linguistic processes which may impinge upon the production of speech and the limited scope of this study, we chose to focus on one aspect of speech production, verbal fluency, since impairments in this ability have implications which relate both to the underlying processes involved in sentence generation and to the explanatory theories of the generation effect. By verbal fluency, we refer to the rate and ease of bringing (appropriate) words from one's internal verbal lexicon to the external speech mode. This is an ability that is often impaired after damage to left-hemisphere, anterior regions (Milner, 1975; Ramier & Hecaen, 1970).

Such deficits in word fluency are termed dysnomia or anomia, and are more commonly known as word-finding difficulties. A deficit in verbal fluency may hamper the ability to generate a sentence entirely, or deficits in fluency may detract from the quality of a generated sentence. Not only can we logically reason about the relationship between verbal fluency and sentence generation, but researchers have documented that individuals with word-finding difficulties have difficulty in producing phrases in spontaneous speech (Zangwill, 1966).

Memory Impairments. As may be inferred from our analysis of the processes involved in sentence production, verbal dysfluency is not the only method of disrupting sentence production. Stroke patients also often exhibit memory disturbances (e.g., Damasio, 1990) and these memory impairments are material specific. Thus, patients with focal lesions to the left side of the brain often have verbal impairments (Milner, 1974) in semantic and episodic memory. Semantic memory is one's store of factual knowledge, whereas episodic memory is memory of a specific event in time (Tulving, 1983). Although our retrieval tasks represent a test of episodic memory, we are focusing here on how deficits in semantic memory may impinge upon the ability to generate sentences during the study phase.

Depending on the precise location of a brain lesion, there may be damage to the semantic memory stores themselves (a depletion), or the communication to or from these stores to various other brain systems may be disrupted (a disconnection). As Russell (1963) has pointed out, even lesions in small cortical association areas (e.g., parietal lobe lesions) can have widespread consequences on verbal behavior. We propose that the consequence of damage to any aspects of the memory system may be a decreased ability for brain-damaged patients to produce a sentence given a target word.

More specifically, a *depletion* of semantic memory stores would decrease the number of associations to a target word, thereby limiting the number of ideas that can be used to plan a sentence. A breakdown in communication from the verbal lexicon *to* semantic memory stores would impinge on the degree to which target words can enjoy elaborate semantic analysis. A breakdown in communication *from* semantic memory stores to the verbal lexicon would impair sentence generation by disturbing the access to the lexical codes which correspond to the non-verbal concepts that are the precursors of an intended message.

The influence of cognitive impairments on the effect of sentence generation. So far we have discussed our expectation that subjects with left brain damage will have verbal deficits in fluency and/or memory which will make sentence generating more difficult and less successful than it will be for healthy individuals or right brain-damaged patients. The next question is how this difference in performance during encoding will relate to the difference in memory at test time. Patients with impaired ability to generate sentences are likely to differ from other subjects in the effect that generating has upon memory. If learning in a generate condition facilitates the memory of patients with verbal deficits even more so than it does for other subjects, this would provide support for the importance of effort required during generation. If learning in a generate condition does not facilitate the memory of patients with verbal deficits, this would provide support for the importance of increased meaningfulness that words presumably acquire during generation. Thus, studying the performance of patients with left brain damage will allow us to simultaneously test both of the explanatory theories presented above.

The logic is as follows. Theories emphasizing the importance of enhanced meaningfulness of generated material in obtaining a generation effect require that a stimulus response (target-context) unit be formed and semantically analyzed. If a subject has fluency and/or memory impairments, these may affect the encoding of the material in several ways: (a) he/she may not form the requested target-context unit due to severe word-finding difficulties; (b) the context may be generated but may be far less elaborate than the contexts generated by non-impaired individuals due to impoverished memory stores or decreased access to the semantic lexicon; or (c) the target-context may be formed but improperly stored due to competing cognitive demands. With regard to the last possibility, and in line with theoretical statements made by Perfetti (1985), inefficiency in any simple verbal process (e.g., deficits in lexical access) may interfere with the simultaneous integration of material into memory stores.

A broader way of stating the problem is that since the condition we expect to facilitate memory involves increasing linguistic processing, then it will be unlikely that individuals with left brain damage will benefit from this condition to the same extent as individuals without left brain damage. This is similar to the expectation that individuals with right brain damage would not benefit to the same extent as individuals without right brain damage in a condition which facilitated memory by increasing the imaginability (or in this study, the emotionality) of material.

We have already pointed out the conflicting findings regarding the issue of whether the generation effect depends upon successful generation (Buyer & Dominowski, 1989) or not (Slamecka & Favreiski, 1983). We have also discussed the failure to find an effect of generation in the performance of Alzheimer's patients (Malcolm et al., 1989; Mitchell, Hunt & Schmidt, 1986). These studies demonstrate how disruptions in one (or some) of the process(es) of generation can impinge upon the benefit normally obtained by learning in such a condition.

There is also conflicting evidence in studies of normals concerning the continuum of semantic memory capacities and the importance of these capacities on the effects of generation. For example, Reardon, Durso, Foley, and McGahan (1987) found that experts obtained a larger generation effect with material in their field of expertise and concluded that individuals with a richer knowledge base are more likely to engage in more effective conceptual processing of items in their fields of expertise. This has to do with the concept of familiarity. That is, instructions to generate were presumed to re-activate concepts already present in semantic memory and this improved memory performance. However, Peynircioglu and Mungan (1993) found the generation effect did not differ according to expert and non-expert and found that in some instances the novice showed a greater generation effect than the expert. Since these findings are contradictory, we see that the importance of having a rich semantic memory from which to re-activate previously stored concepts is unresolved.

In our study, if the memory performance of left brain-damaged patients is *not* enhanced in the generate condition or if it is *less* affected by the encoding procedure than is the performance of normal controls, this will provide support for theories emphasizing increased meaningfulness of generated material over read material acquired by increased activation of semantic memory and/or increased activation of the verbal lexicon. If, however, the left brain- damaged patients demonstrate the expected verbal impairments, and the memory-enhancing effect of sentence generation still occurs, this will provide evidence *against* the theories basing the generation effect on lexical access and semantic memory.

The performance of patients with left brain damage also has implications for theories emphasizing the importance of effort in memory facilitation obtained with generation techniques. Although we have analyzed the various components of the sentence generation process and defined each as automatic or controlled, the automatic processes that are normally considered automatic and, therefore, effortless (e.g., lexical access from semantic memory stores) are expected to be quite effortful for the patient with acquired linguistic impairments. This will increase the cognitive load of the generation task and increase the cognitive effort involved in the generation process. This increased effort should be obvious to an observer since the performance of the left brain damaged individuals would likely be slower and more laborious than that of other subjects.

Thus, if encoding words in a generate mode is more effortful for the left brain damaged subjects, then, according to theories emphasizing effort, encoding words in a generate condition should enhance memory even more so than it does for individuals who do not have to expend as much energy in the process. Thus, in order to support theories which emphasize effort, the effect of sentence generation need be larger for the left brain damaged patients than it is for the right brain-damaged subjects and healthy controls.

We have, therefore, demonstrated that studying the performance of patients with left brain damage is a way of testing these two competing hypotheses since the direction of results concerning the performance of the subjects will serve to support one theory and provide evidence against the other.

Dissociating fluency and memory impairments. Although we have established the likelihood that some of the brain damaged patients employed in this study will have deficits in verbal fluency, there are several reasons why a patient may have word-finding difficulties (Caplan, 1992). He or she may have inadequate information about the concept related to a word (a memory problem), leading to an inability to specify the word semantically and thus to activate the word that is appropriate in a given context. Alternatively, he or she may be unable to access the form of the word, even if the patient knows a great deal about the word's meaning. This would occur if there is a disturbance in converting the semantic representation of the word into the phonetic form or from the phonetic form of the word to the motor neurons (Bub, Black, Howell, & Kertesz, 1988).

Thus, although word-finding and higher-order memory difficulties both involve an interface with the controlled process that are involved in sentence generation, these processes can be separated. For example, studies utilizing anomic patients with vascular lesions have demonstrated that for most unnamed items, permanent representations were not lost, but that access to the item's name was simply unavailable on certain occasions (Butterworth, Howard, & McLoughlin, 1984; Goodglass & Geschwind, 1976). By contrast, studies utilizing anomic patients with Alzheimer's disease (Huff, Corkin & Growdon, 1986) indicate that anomia in Alzheimer's disease is often the result of a loss of the semantic representation of a concept that transcends the form in which it may be represented.

Thus, although word fluency and activation of semantic memory may both be involved in the encoding process of sentence generation, they are different and separable entities. Furthermore, since we are proposing that deficits in either one would influence memory in the same direction, a method must be included to dissociate these two processes in the current sample. This is important since a failure for the generate condition to facilitate memory may be related to one, both, or possibly neither of these contributing components of sentence generation.

To dissociate the contributing effect of these variables, we administered standardized tests measuring these processes (skills) and correlated the outcome of those tests with an index of the generation effect obtained on our experimental tasks. We arrived at this index by calculating the difference in memory scores obtained in the read and generate conditions. If measures of semantic memory and verbal fluency are both highly correlated with this index of the generation effect, we may then go on to perform further analyses (e.g., multiple regression) to determine which of these two factors is the best predictor of the outcome measures.

This method of converging data from experimental and neuropsychological tasks will yield much information: 1) Data from the neuropsychological measures will demonstrate if the patients in this study are intact in the abilities we believe to be important in the process of generating; 2) Data from the experimental measures will indicate whether the patients in this study derive a benefit in memory from sentence generation procedures; and 3) Measuring the relationship between scores on the neuropsychological tasks and indices of the obtained outcome measures of generation, will answer the question of whether the abilities we presume to be necessary in the *process* of generating, are related to the size or expression of the *effect* of generation.

Although we have already discussed the theoretical implications of a larger or smaller effect of sentence generation in the performance of the left brain-damaged patients, this final analysis will allow us to specify which of the process(es) necessary in sentence generation contribute to its memory-enhancing effect. Without this information, we would still be able to implicate intact verbal processes as either necessary in the effect, or not, but we could not be more specific. By looking at the separate scores on standardized fluency and memory tasks, and correlating each with an index of the generation effect, we can be more precise about the involvement of these processes and thus more precise in our conclusions.

Retrieval Task Analysis

As noted several times throughout the literature, finding a word generation effect depends upon the generation procedure used, and on the retention test adopted (Burns, 1992). The following discussion focuses on the retention tests used to investigate the effects of generation in this study and findings related to these types of tasks in word generation studies. We used three memory tasks: free recall, recognition, and cued recall, which make different information processing demands upon the subject and which may make one more sensitive than another in demonstrating the generation effect. In this analysis, we concentrate on the effect of sentence generation and not on the effect of emotionality since, in line with Bock and colleagues (Bock, 1986; Bock & Klinger, 1986), we view the effect of emotionality as automatic and independent of task manipulations.

Free Recall. The first retrieval task subjects encounter is free recall. Due to the nature of a free recall task, performance is expected to be low in comparison to the other two retrieval tasks. That is, in this task subjects are given no external cues to aid recall and are free to recall material in any order (Roediger, 1992). The task is simply initiated by instructions to remember all the items of a designated set which were presented during the study phase. Thus, the first step the free recall task is to search for possible items from the to-be-remembered set. A decision must then be made about each item that is retrieved in this process, since it is likely that items that were not from the original list will also be activated in the search. Although overall performance is generally lower in recall than in recognition, in the former we can be certain that a specific accurate response is not due to chance guessing. Free recall also has the advantage of providing information regarding the saliency of certain stimulus features and the strategy of the subject by analyzing the order and clustering of output.

In addition to the reasons cited above, low scores on free recall are anticipated in this study since the strategies that are normally useful in a test of this type are hampered by our design. The specific mental operations which normally assist in free recall include relational processing between the stimuli in order to organize the material into smaller, cohesive constructs or to process the material at a deeper, semantic level. In the recall of a list of words, for example, helpful processes include categorization and imagery as ways in which the words can be integrated (e.g., the words 'hat' and 'man' in a list could be remembered by picturing a man putting on a hat, or 'hat' and 'shirt' can be conceptually categorized as articles of clothing). The particular procedures we are employing in this study, however, decrease the possibility that such stimulus-relational processing may occur. That is, after every word, the subject engages in a fairly lengthy process (either reading or generating) of embedding the target word into a sentence. As soon as the sentence is either read or generated, the next word is seen. Thus, the interference of the sentences may contribute to overall low scores on this task.

However, even with overall scores, an effect of sentence generation may be obtained for the following reasons. First, this task is more similar to the encoding procedure of generating than that of reading in its demands for the generation of verbal material. Prior studies have found that increasing the similarity between the encoding and retrieval phases results in better memory performance (Blaxton, 1985; Jacoby, 1983; Roediger, Weldon, and Challis, 1989). This is referred to as transfer appropriate processing (Morris, Bransford, & Franks, 1977).

Second, although we have not provided for stimulus-relational processing in our creation of this task, our generation instructions are very open-ended, and hence it is possible that subjects will generate sentences which are similar to one another, or are similar simply in their relation to the subject (i.e., self-referential; Rogers et al., 1977). This, in turn, could facilitate a generation effect by enhancing memory preferentially in the generate condition. Thus, if the generation effect is elicited in a free recall task, then it may be the "self" part of self-generation, or the relatedness in the products of generation which contribute to these improvements in memory.

Recognition. Our second retrieval tasks a yes/no word recognition test, where subjects are required to identify stimulus words that were seen during the encoding phase of the experiment and distinguish them from stimulus words that were not seen. The main difference between this task and the free recall task is that the subject need not search for the words, but rather the main effort is only in the decision process. As such, it is expected that subjects will recognize many more items than they were able to recall. In this way we can determine whether the memory effects under investigation will differ based on the differences in retrieval task difficulty. In an effort to prevent scores which reach ceiling level, we used distractor words that share very similar characteristics to the target words. This is expected to raise the likelihood of false alarms (i.e., affirmative responses to previously unseen stimuli; Underwood, 1965).

Thus, processes at encoding or test which make the stimulus words *distinctive* in relation to words not seen before, would assist in successful identification of the words on the recognition task. Several of the ideas we have discussed thus far regarding the possible means through which generation exerts its effect (e.g., greater semantic analysis, higher arousal levels) may make a word more distinctive and easier to recognize. This may be the reason why recognition tasks have been consistent in demonstrating the effects of word generation (Begg & Snider,1987; Begg, Snider, Foley, & Goddard, 1989; Graf, 1980; Hirshman & Bjork, 1988; McDaniel et al., 1988; Schmidt & Cherry, 1989).

Sentence Recall. Our third retrieval task is cued recall of sentences using the stimulus words as cues. There are several ways in which the sentence recall task can be distinguished from the two tasks above. First, it measures memory for the contextual sentences (the responses), as opposed to memory for the target words (the stimuli). Second, it is a more difficult task due to the length and complexity of the to-be-remembered material. Thus, overall scores are expected to be fairly low. The third distinguishing feature of this task is that during the study phase, subjects were only instructed to remember the stimulus words and were thus only forewarned about tests utilizing these words. The sentence recall task, therefore, is an assessment of incidental memory, in that it is testing for material that was encoded without conscious intention to do so. Since incidentally learned material is not usually remembered as well as intentionally studied material (e.g., Russell & D'Hollosy, 1992) this is an additional reason for the expectation that overall scores on this task may be low.

As with free word recall, despite the expectation of overall low scores, there is reason to believe that generation effects will occur because of the strong similarities to the task of generating sentences during the study phase. In both, words are presented visually on a screen and subjects are required to verbalize a sentence which frames the target word. In accord with the transfer appropriate processing view (Morris et al., 1977), performance on this task should, therefore, demonstrate a large generation effect, since the mental operations required at test are more similar to the encoding task of generating than the encoding task of reading.

Thus, there are several differences between our retrieval tasks, which may be related to differences in performance. Two of our tasks require search for appropriate targets, decision about the retrieved material, and reconstructions of the encoded material (free recall and cued sentence recall), whereas one involves only the decision processes (recognition). Two of our tasks measure memory for target words (free recall and recognition), while one (cued recall) measures memory for sentences. Finally, two of the tasks test for material learned under intentional conditions (free recall and recognition) while one tests for material learned incidentally (sentence recall). Our analysis of these task differences will assist in our interpretation of the results if effects of emotionality or generation are obtained in one task and not another.

Limitations of generation effects

As we initially proposed, there may be similarities in the underlying processes responsible for both word and sentence generation effects. Therefore, it is useful to mention the limitations of the word generation effect, in order to about whether the expected effect of sentence generation in this study would be limited in these ways as well.

One prominent limitation on memory improvement in studies of the word generation effect, is that it generally applies to the generated responses only and not to the stimulus cues (Begg et al., 1989; Graf, 1980; Slamecka & Graf, 1978). Although there are instances where the stimulus cue also enjoys better memory in the generate as compared to the read condition, they are much fewer in number (Greenwald & Johnson, 1989; Schwartz, 1971). Thus, we may ask: Does the memory-enhancing effect of sentence generation extend to the stimulus words as well? If sentence generation is identical in its effect upon memory, then we would only obtain dissociative effects of learning condition in the sentence recall task, since that is the only task directly measuring the generated response.

Another limitation of the generation effect is that it is often small or unobtainable in tasks of free recall (e.g., Burns, 1992; McDaniel et al., 1988; Schmidt & Cherry, 1989). An explanation for this limitation is based on the same principles as mentioned above in the discussion of the free recall task. That is, the encoding procedures do not readily allow for relational processing between the target items. Although our targets are the stimuli, whereas in word generation tasks the targets are the responses, the targets in both paradigms lack a relation to one another. It remains to be seen whether this limitation will extend to the effects of sentence generation.

Another prominent limitation of the word generation effect is its inconsistency in a between-list design (Slamecka & Katsaiti, 1987). That is, when all of the words in one list are encoded in a generate condition, and all of the words from a comparable list are encoded in a read condition, the generation effect may, or may not, be obtained. Usually, the effect *is* maintained if testing procedures are of the recognition type (Hirshman & Bjork, 1988; Nairne, Riegler, & Serra, 1991; Slamecka & Katsaiti,1987). However, as stated above, the free recall procedure is less reliable in obtaining the effect, and this is especially the case if the words are presented in a between-list design. Under such conditions, the effect of generation simply fails or is reversed so that words in a read condition are recalled better than words in a generate condition (Nairne et al., 1991; Schmidt & Cherry, 1989). This has been termed a negative generation effect or a reverse generation effect . By contrast, when a free recall procedure is paired with a within-list design, (i.e., generate and read conditions in the same list of words), an effect of word generation can sometimes be obtained (e.g., Begg & Snider, 1987; Hirshman & Bjork, 1988). This is a good example of how conditions at encoding and retrieval can interact and be manipulated to obtain very different findings.

Thus, we wish to be clear about both our encoding and testing procedures, so that the discussion of our findings or future replications of this procedure will not obscure these issues. In this study we are using a between-list design for the context variable and a within-list design of the emotionality variable. To be even more specific, we may refer to our design as a within-list, between-block design for the learning condition (read/generate) variable. That is, all subjects received a 48-word list at study, which was presented in four blocks separated by free-recall trials after every 12 words. In the first two blocks presented, the instructions were either to generate a sentence after reading a target word, or to read a sentence after reading a target word. Thus, for the first 24 words (presented in two 12-word blocks), the subjects were in the same encoding condition. The subjects were then in the remaining condition (either generate or read) for the last 24 words (again, in two 12-word blocks). The point we wish to emphasize is that this was a between-block design, as subjects remained in the same condition for a lengthy period of time and there were test trials between conditions.

Despite the possible limitations of a between-block design (based on the previously cited findings in word generation studies), we decided to employ this design after piloting a within-block procedure on healthy, young adults (college students), who found the task to be somewhat confusing. Based on these observations, which were taken quite seriously since students are accustomed to various testing procedures, we assumed that the within-block manipulation of the learning condition would possibly be even more confusing for healthy older controls, and especially confusing for stroke patients. Thus, it will be interesting to determine if limitations of the word generation effect in word recall tasks and between-block designs will extend to the sentence generation effect, or whether the sentence generation effect will be more robust and less dependent on particular task conditions at study and at test.

Learning condition and stimulus emotionality

We have already discussed the contradictory findings regarding emotionality effects and cognitive task manipulations. We have also discussed the implication of these findings for theories of the affective/cognitive relationship. In this section we focus of the specific relationship which may occur between stimulus emotionality and sentence generation.

Interactions between stimulus type and learning condition have been found in word generation studies. For example, Peynircioglu and Mungan (1993) altered stimulus type by utilizing words that varied along a familiarity continuum. In the read condition, familiar words were remembered better than unfamiliar words. However, in the generate condition, familiar and unfamiliar words were equally likely to be remembered. These findings are congruent with the possibility that the processing induced by generation may impede the processing of other types of information that is given to the read items. In relating this idea to our study, since reading may not be so effortful (Tyler et al., 1979), there may still be resources available to process other components of stimuli, such as familiarity or emotionality. However, generating sentences may be such an effortful procedure, that there are no attentional resources remaining to process other components of stimulus words. Since brain-damaged patients often have decreased resources of attention and memory, they may show a greater interference effect, so that in such a situation, either the emotionality or the generation effect may occur, but not both. Normal adults, on the other hand, may demonstrate both effects, but as in the Peynircioglu and Mungan (1993) study, there may be an interaction such that the emotionality effects occur only in the read condition. This result would support cognitive primacy theories or simultaneous processing theories of cognitive/affective relationships since the effects of emotionality would be impinged upon by cognitive task demands.

In an effort to make more specific predictions regarding the interaction between the effects of generation and emotionality, a careful search of the literature found no studies which varied both the emotionality of material and the encoding condition. However, three studies have examined whether mood-dependent memory differed in a self-generated versus repeated condition. Eich and Metcalfe (1989) hypothesized that because mood is an internal stimulus, it might be a more efficient cue for internally generated responses. These investigators reported a strong mood-dependent memory effect in free recall when subjects had to generate their own response words but only a weak effect when subjects merely repeated response words. Conversely, on a recognition task, there was mood-dependent memory for self-generated targets, but mood-dependent memory was found for repeated targets. Thus, mood-dependent effects on memory were stronger in the repeat condition of a recognition task, but the same effect was stronger in the generate condition of a recall task. These findings were replicated by Beck and McBee (1995). However, Bower and Mayer (1989) were unable to find mood-dependent memory differences based on different encoding conditions (read vs. generate) in either recall or recognition tasks. These findings suggest that the relationship between emotion and learning condition is unstable and dependent on particular procedures.

Another study investigating interaction effects between emotion and learning condition (Schefft & Biederman, 1990) found that for subjects with both depressed mood and low resourcefulness, the facilitative effect of self-generation was reduced. However, when subjects were high-resourceful, depressed mood did not dampen the generation effect. Although these studies indicate that the effects of generation can be influenced by subject variables, their applicability to the current study is limited by our focus on the emotionality of *material* rather than on the internal mood state of the subjects. However, given these findings for mood-dependent memory effects (see Blaney, 1986 for a full review of the topic) we felt it was advantageous to assess the mood states of our subjects at study and test time. If mood does influence memory performance, a control of this measure should be employed (e.g., by using it as a covariate in our analyses).

Subject Variables of Secondary Interest

There are other subject variables that could also influence results. Fortunately, in our effort to obtain well-matched samples, the characteristics of our subjects permitted us to analyze some of these variables. That is, our total sample was a fairly evenly matched for gender (32 males, 28 females), and there was fairly even distribution of lesion sites across the two brain-damaged groups. Thus, in this study, besides the group factor of laterality, we also analyze the effect of gender and utilize the lesion method to determine which particular lesion locations are associated with failure to obtain one of the desired effects. To quote from Damasio and Damasio (1989), "the essence of the lesion method is the establishment of a correlation between a circumscribed region of damaged brain and changes in some aspect of an experimentally controlled behavioral performance" (p.7).

Thus, we intentionally employed patients who have suffered a cerebrovascular accident (CVA) with two purposes in mind, one more general and one more specific. The first reason was to determine whether memory-enhancing conditions, such as sentence generation and stimulus emotionality, would apply to victims of brain damage in the same way as they apply to normal healthy individuals. The second reason for utilizing this sample was due to the relative specificity of the brain injury resulting from a CVA, in comparison to the many other types of brain damage which are more diffuse in nature (e.g., tumors, traumatic head injury, and Alzheimer's disease). By definition, a stroke is a "focal neurological disorder of abrupt development due to a pathological process in blood vessels" (Walton, 1977).

Despite this relative specificity of injury, it is difficult to discuss patients with brain damage as a homogeneous group, even those with unilateral brain damage resulting from stroke, since the same origin of injury can cause vastly different effects depending upon several factors, such as intrahemispheric location of injury and the presence of subcortical damage. Even injury to the same area may have different consequences based on individual subject variables, such as age, gender, premorbid intelligence, and environmental stressors. Such subject variables increase the complexity of investigating particular behaviors and relating them to cortical sites in the brain. In this study, we have attempted to control for such potentially confounding variables via two methods. First, we employed strict selection criteria for subjects so that many variables were controlled for simply by limiting subjects with the presence of particular characteristics (see Methods section for a full list of exclusion criteria). Second, specific subject variables, such as gender and intrahemispheric lesion site, were analyzed for their impact upon the results. A review of the literature pertaining to these particular variables is presented below and provides justification for our exploratory analysis of these additional factors.

Since both processes of memory and emotion depend on the cooperative participation of neuronal assemblies that reside in specialized cortical and subcortical brain systems, a decision was made early in the selection process of this study to use only those stroke patients whose damage involves primarily cortical sites, as opposed to those patients with pure or extensive subcortical damage. This decision was made so as not to confound the results and to study a group of relatively homogeneous patients. Therefore, while acknowledging the importance of subcortical structures, such as the amygdala and hippocampus, in emotional and memory processing, respectively, we focus only on *cortical* sites in our review of the particular brain regions which may participate in the effects under investigation. To specify further, we review frontal and temporal lobe involvement in processing emotion and memory. This will be followed by a review of the literature concerning gender and its effects on emotion and memory.

The Frontal Lobes

The frontal lobes have been found to participate in both the acquisition of new material and in the processing of emotion. The specific role of the frontal lobes in each of these areas is reviewed below.

The frontal lobes in emotional processing. The frontal lobes are aptly situated for emotional processing as they have more extensive anatomical reciprocity with limbic structures than any other cortical region (e.g., Kelley & Stinus, 1984; Nauta, 1964). Accordingly, for spontaneous expressions, greater deficits have been observed in patients with anterior lesions than those with posterior lesions (Kolb & Taylor, 1990; Weddell, 1990). Several alterations in emotional behavior, such as disinhibition, are also associated with frontal lobe damage produced by closed head injury (Levin, Goldstein, Williams & Eisenberg, 1991) or CVA (Starkstein & Robinson, 1991). In terms of depressed affect, Robinson et al. (1984) and Sinyor et al. (1986) found that in the acute stages of a stroke, severity of depression was significantly related to proximity of the lesion to the frontal pole. However, the direction of this relationship differed based on laterality of lesion site. For patients with left brain damage, depression was associated with lesions closest to the frontal pole and for those with right brain damage, depression was associated with lesions farthest from the frontal pole. Other studies, however, have found a negative relationship between depression and proximity of lesion to the frontal pole regardless of side of lesion (Eastwood, Rifat, Nobbs, & Ruderman, 1989; House, Dennis, Warlow, Hawton, & Molyneux, 1990; Lipsey, Robinson, Pearlson, Rao, & Price, 1983; Robinson et al, 1985; Starkstein, 1987). Thus, the association between anterior regions and depression is, as of yet, unclear.

Some researchers (e.g., Davidson, 1992; Heller, 1993) have made a clear distinction between different aspects of emotional processing based on caudality (the anterior-posterior dimension of brain anatomy). According to this model, the interpretation of emotional information is associated with specialized processing of the right posterior (parieto-temporal) region (e.g., Heilman et al., 1975; Ross, 1985). By contrast, experiential aspects of different emotions are associated with activation of the frontal regions, which is sometimes asymmetrical according to valence (see Davidson, 1984). This model has not been supported, however, by studies which have found deficits in emotional lexical processing in right brain-damaged subjects regardless of caudality (Blonder et al., 1991; Bloom et al., 1993; Borod et al., 1996; Borod, Andelman, et al., 1992; Cimino et al., 1991). Such studies suggest a more diffuse control of emotional processing within the right hemisphere.

Despite these contradictory findings in brain-damaged humans, several lesion studies on non-human primates, as reviewed by Hornak, Rolls, and Wade (1995), have demonstrated a clearer picture of the contribution of the frontal lobes to emotional processing and emotional behavior. In their review of the literature, Hornak et al. (1995) suggest that one way in which the orbitofrontal cortex is important in emotion is through its involvement in *emotion-related learning* and the ability to learn from external reinforcers. Furthermore, in their study of a group of human patients with ventral frontal lobe damage and socially inappropriate behavior, Hornak et al. (1995) found that this group also had impairments in the identification of facial and vocal emotional expression and a reduction in emotional responsiveness, in comparison to a brain-damaged group without frontal lobe involvement. Other studies of frontal lobe patients have also found reduced autonomic responsiveness in these subjects (e.g., Damasio, Tranel, & Damasio, 1990). As autonomic responsiveness is a measure of arousability, these separate findings support the notion that changes in arousal accompany or are responsible for changes in emotional behavior, and that intact frontal lobes are necessary for normal arousability and for normal emotional and social behavior. Thus, patients with frontal lobe damage may be less arousable and hence less responsive to the manipulation of learning condition or to the manipulation of stimulus components, such as emotionality.

The Hornak et al. (1995) study also found a strong positive relationship between the degree of altered emotional experience and the severity of the behavioral problems in their patients. This provides some evidence against the theory of separate neural systems for the expression and perception of emotion. However, Hornak and colleagues also found that there was a dissociation between the ability of patients to respond appropriately to emotional information and the ability to verbalize emotional experiences. That is, although the frontally-damaged patients displayed inappropriate behavior and deficits in expression identification, they were, nevertheless, able to utilize language in a fairly normal fashion to describe their past and current emotional feelings and behaviors. Thus, the same study provides evidence for and against separate neural systems for expression and perception of emotion. This latter finding suggests that perhaps it is only the *verbal* expression of emotion that involves a separate neural system. This makes sense in light of the strong left hemisphere involvement in verbal explanations that may not be involved in the other aspects of behavioral emotional expression. Damasio et al. (1990) also found that the frontally-damaged subjects in their study were able to verbalize emotional pictures even when they failed to respond to the emotional charge of the pictures.

The frontal lobes in memory processes. Memory functions have also been ascribed to the prefrontal cortex (the area rostral to the precentral gyrus) based on years of lesion studies with monkeys dating back to the 1930's and on studies of patients with frontal lobe damage (Luria, 1969). Numerous studies have since defined the prefrontal cortex as an area which is specialized for short-term or working memory (Squire, 1986) and as an area which is involved in "working on" the information it obtains in particular ways. For example, the prefrontal cortex has been implicated in organizing information, in suppressing interfering stimuli, and in responding rapidly to changes in environmental demands (Squire, 1986).

Patients with damage to the frontal region have been found to engage in behaviors which are incompatible with storing information in the most beneficial manner. For example, patients with frontal lesions tend to be impulsive, they tend to fix on one feature of a multidimensional scene, they have difficulty organizing their own behavior, and they "forget to remember" (Hecaen & Albert, 1978). Frontal lesions have been associated with deficits in memory when the task is not merely to recall or recognize isolated events "but to remember the order of contextually similar events or to suppress the memory of many similar, interfering events in order to remember some of them" (Squire, 1986, p.356).

The concept of suppressing some events to remember others is particularly apt to the experiment described herein, since the memory system will be overloaded during the encoding phase and the subject will, necessarily, only remember some of the material that is presented. The question becomes whether or not patients with frontal lobe involvement will be able to benefit from the particular conditions of the experiment which are believed to normally enhance memory, namely increasing emotionality of a stimulus and generating rather than reading a contextual sentence. Thus, although the main focus of our study is to examine differences in lesion laterality and its effects upon memory, we will also examine the effect of frontal lobe damage in light of the evidence for frontal lobe involvement in both memory and emotional processing.

The Temporal Lobes

The temporal lobes have also been implicated in both memory and emotional processing. Furthermore, although damage to either frontal or temporal regions can disrupt these functions, the role of the temporal lobes in emotion and memory is different from that of the frontal lobes and is described below.

Temporal lobe involvement in emotional processing. Several decades ago, Penfield and others reported that stimulation of the anterior and medial temporal cortex produced feelings of fear (e.g., Penfield & Japer, 1954). More recently, Bear and Fedio (1977) presented evidence that temporal lobe epilepsy is often associated with alterations in affect and personality.

In 1990, Kentridge and Aggleton reviewed the involvement of the temporal lobe in emotional processing. They pointed out that bilateral anterior temporal lobectomy in monkeys has produced emotional changes characteristic of a Kluver-Bucy syndrome (Horel, Keating, & Misantone, 1975), which is characterized by an unnatural lack of emotional reactivity and a lack of appropriate social behavior

(Kluver & Bucy, 1938). The most accepted explanation of this syndrome is that temporal lobectomy leads to an uncoupling of sensory and affective systems, which results in a failure to assign reinforcing signals with the appropriate causal stimulus (Kentridge &Aggleton, 1990). A behavior pattern of hypoemotional reactivity also emerged when fibers from the visual system were *disconnected* from the temporal lobe (Downer, 1961; Doty, Negrao & Yamaga, 1973) emphasizing that lesions in different cortical areas can produce similar behaviors depending upon where cell bodies exist and where their fibers extend to.

An additional important finding by Horel et al. (1975) was that lesions of the *posterior* temporal neocortex did not produce the behavioral alterations that occurred subsequent to lesions of the *anterior* portion of the temporal lobe. Unfortunately, as one can imagine, behavioral research with humans who have suffered a naturally occurring lesion is far less precise than the research with lesions produced in animal experimentation, and one can only infer which cell bodies, fiber tracts, and chemical systems are affected, even in such focal brain damage as that resulting from a cerebrovascular insult. Thus, in the analysis of temporal lobe involvement in this study, we were unable to differentiate between anterior and posterior temporal lobe lesions, which could obscure the potential effects of these factors.

Temporal lobe involvement in memory processing. The temporal region has also been linked to memory since at least the 1950's when medial bilateral resections of this area were conducted in an effort to relieve intractable seizures in a series of patients (Scoville & Milner, 1957). Furthermore, work with monkeys has shown that bilateral damage to the *medial* temporal region causes severe memory impairment (Mishkin, 1978). Through studies of both patients and animals, functions that have been ascribed to the temporal lobes include the establishment of long-term memory at the time of learning and the consolidation or elaboration of memory after learning so as to permit effective retrieval (Squire, 1986).

Since the current study involves elaborative (context) conditions and measures of memory, temporal lobe involvement is an important variable to investigate. The findings above would imply that patients with temporal lesions may not benefit from the changes in the context conditions employed herein. Furthermore, and as may be expected from the various functions ascribed to these different brain regions, functional dissociations have been found between patients with frontal and temporal lobe brain damage. Patients with temporal lobe damage have been found to have deficits in recognition memory but no additional difficulty with judgments of the temporal order of stimulus presentation (Squire, 1986). Frontal lobe patients, on the other hand, have been found to have difficulty in making recency judgments, but were normal at familiarity judgments (Squire, 1986). Thus, as in studies of frontal lobes, there is converging evidence from both human and animal studies that the temporal lobes play an important role in memory and emotion.

Gender

Finally, we address the issue of gender. The issue of gender appears sporadically throughout the literature of both emotion and memory. In light of the findings presented below, and since we employ both male and female subjects, we felt it was important to include an analysis of gender effects.

Gender and emotion. Research suggests that females react more intensely to the same level of emotional stimuli than do males (Diener, Sandvik, & Larsen, 1985; Frodi, Macaulay, & Thome, 1977; McLean, 1981). Women have also been shown to demonstrate more facial expression of emotion than men (Buck, Savin, Miller, Caul, 1972). However, at the physiological level, females have demonstrated fewer autonomic responses than males (Buck et al., 1972; Craig & Lowrey, 1969). Thus, there are gender effects in both internal and external responses to emotional stimuli, however, the direction of these effects differs depending upon the type of stimuli and the responses which are measured. Furthermore, some studies have found females to be more *accurate* than males on emotional tasks (Duda & Brown, 1985; Hall, 1978; LaFrance & Banaji, 1992), while others have found no differences in accuracy (Borod, Andelman, et al., 1992; Eviatar & Zaidel, 1991), but a difference in the latency of response to emotional stimuli, with males responding faster than females (Eviatar & Zaidel, 1991).

Sackeim et al. (1982) examined 119 case reports of unilaterally brain-damaged patients with pathological laughing or crying and found that pathological laughing occurred more often in males and in such cases almost always with left-sided damage. Females, on the other hand experienced more pathological crying and this occurred with both left and right hemisphere damage. These results raise the possibility that the two sexes differ in the degree to which mechanisms subserving positive and negative emotional states are lateralized.

Some studies with normals also suggest that females are less lateralized than males for emotional processes, just as they are for linguistic processes, particularly when the emotional stimuli are capable of being verbally encoded (Graves et al., 1981; Safer, 1981). However, other studies suggest the opposite, that females may be *more* lateralized than males in emotional functioning (e.g. Ladavas, Umilta, & Ricci-Bitti, 1980; McKeever & Dixon, 1981; Saxby & Bryden, 1982; Strauss & Moscovitch, 1981). Still other studies that have analyzed gender have failed to find any gender effects in the laterality of emotional processing of stimuli (Carmon & Nachson, 1973; Herrero & Hillix, 1990; King & Kimura, 1972; Ley & Bryden, 1982; Mahoney & Sainsbury, 1987, Shipley-Brown et al., 1988; Strauss, 1983).

Although an attempt was made to further relate the issue of gender to the current study, my review of the literature involving emotion and verbal memory revealed only one study which analyzed the effect of gender (Borod, et al., 1996). This study found no interactive effects of gender and emotionality of material, or gender and laterality. No other reviewed study of the emotionality effect analyzed gender differences (Amster, 1964, Anooshian & Hertel, 1994; Bock, 1986; Bock & Klinger, 1986; Burke et al., 1992; Cimino, et al., 1991; Ellis, et al., 1971; Heuer & Reisberg, 1990; Parkin et al., 1982; Rubin & Friendly, 1986; Semenza et al., 1986; Silberman et al., 1983; Strongman & Russell, 1986; Wapner et al., 1981; Wechsler, 1973; Winnick & Archer, 1974). Thus, there is a paucity of data regarding the effect of gender on the relationship between emotion and memory and between these variables and laterality. In the current study, therefore, one reason for analyzing gender differences is to determine whether gender influences these relationships. Additional impetus for analyzing gender comes from a review of the literature concerning the relationship between gender, language, and memory.

Gender, Language, and Memory. Research has shown that in general, but with much overlap, females outperform males in verbal skills (Burnstein, Bank, & Jarvik, 1980; Gaddes & Crockett, 1975), and males outperform females in spatial skills (McGee, 1979). There are varying accounts to explain these gender differences. Some of these explanations relate to lateralized developmental differences between the sexes, some relate to anatomical differences, and some relate to the rate of disabilities and impairments found subsequent to developmental and acquired brain damage.

Theories relating to developmental differences are based on findings which indicate an earlier acquisition of language function in female children and an earlier maturation of physical features in female adolescents. Both of these differences are believed to be the result of earlier cerebral maturation in females and slower cerebral maturation in males. Most (Carter-Saltzman, 1979; Levy & Reid, 1978; Waber, 1976, 1977; Witelson, 1977), but not all (Buffery & Gray, 1972), researchers conclude that this earlier cerebral maturation by females results in more diffuse functional organization and that the slower maturation rate by males results in more lateralized functional organization. Waber (1976) provided evidence for this theory by reporting that regardless of sex, early-maturing adolescents performed better on tests of verbal than spatial abilities, whereas the late-maturing performed in an opposite fashion.

Other theories regarding gender differences are based on anatomical studies. Although there are those that refute the idea of sex differences in human neuronal circuitry or architecture (e.g., Heir, 1981), some evidence does exist for anatomical differences between the sexes. For example, Wada and Rasmussen (1960) reported that males demonstrated greater asymmetry in the planum temporale and the frontal operculum than females. Goleman (1978) and McGuinness and Pribram (1978) have provided evidence that gender differences arise when different levels of sex hormones act on particular brain structures, such as the connection between the amygdala and the frontal lobe. These theorists propose that these amygdala-frontal lobe fibers are part of the arousal system and that such differences are responsible for the greater cognitive flexibility and verbal ability of females. Additionally, sex differences have also been found in the number of cortical and subcortical connecting fibers *between* the hemispheres and in the relation of these fibers to functional abilities (Lansdell & Davie, 1972).

These differences have prompted research and debate regarding the laterality of functional brain organization in the two sexes. Such studies have confirmed that asymmetry of function is greater in males than in females (e.g., McGlone, 1980).

That is, right-handed males seem to have verbal operations more isolated to the left hemisphere, while right-handed females are more likely to show some language functioning in the RH as well as the LH. Gur et al. (1982) also showed differences between males and females in the blood flow of the two hemispheres during the processing of verbal and visual information. Tachistoscopic viewing studies and dichotic listening studies of normal adults have consistently demonstrated greater asymmetry of responses in males than in females (e.g., Lake & Bryden, 1976). Furthermore, Harris (1978) reviewed the electrophysiological data and concluded that the differences in the shape of auditory evoked potentials are greater in the LH than in the RH, and that this asymmetry is more pronounced in females.

Studies from brain-damaged individuals have also provided evidence of gender differences in laterality of brain organization. McGlone (1977) reported three times more men than women with left-hemisphere lesions (strokes and tumors) were classified as aphasic. Furthermore, when aphasics were eliminated from her sample, depressed verbal intelligence and memory were found in males with left- but not right-hemisphere lesions and in females with either left- *or* right-hemisphere lesions. McGlone interpreted these results as indicating greater functional asymmetry in males than in females. Milner (1974) also reported greater functional asymmetry in males than females. But unlike McGlone, Milner interpreted this effect as small, especially in relation to the effect that side of lesion has upon performance of verbal and spatial skills. A related issue is that there is a greater incidence of developmental disabilities in males than females (e.g., Witelson, 1977) possibly because of more redundancy of functions across the hemispheres in females.

More recently, Kimura (1984) also found *intra* hemispheric gender differences in functional impairment following unilateral brain damage. In Kimura's (1984) examination of 216 patients with LH brain damage, she found that speech disorders in women occurred more frequently from damage to the anterior part of the left hemisphere than from damage to the posterior part. Men, on the other hand, showed roughly similar patterns of disordered speech when brain damage was in the anterior or posterior portion. It should be noted that there are also researchers (e.g., Snow & Sheese, 1985) who have failed to find *any* gender differences based on either inter- or intra-hemispheric location of brain damage.

In an effort to make a priori predictions for differential gender effects in this paradigm, my review of the literature found only one word generation study of the which analyzed gender. Beck and McBee (1995) used 32 male and 32 female participants and found no main or interactive effects of gender on either recall or recognition performance. No other study of the generation effect reviewed analyzed gender differences, and most failed to even mention gender in the description of their subjects (Begg et al., 1991; Burns, 1990, Burns, 1992; Buyer & Dominowski, 1989; Carroll & Nelson, 1993; Gardiner & Hampton, 1985; Gardiner & Hampton, 1988; Greenwald & Johnson, 1989; Grosofsky, Payne, & Campbell, 1994; Kinoshita, 1989; McClelland & Pring, 1991; Moser, 1992; Nairne et al., 1991; O'Neill, Roy, & Tremblay, 1993; Peynircioglu & Mungan, 1993; Riefer, Hu, & Batchelder, 1994; Serra & Nairne, 1993; Slamecka & Graf, 1978; Soraci et al., 1994; Toth & Hunt, 1990; Tulving et al., 1982.)

Thus, as was seen in the emotional memory literature, it is obvious that the variable of gender has received very little attention in the study of generation effects. Due to this paucity of information, and since there is some evidence of gender effects in memory performance and in the lateralization of memory functions, we felt it was important to explore gender differences in the current study.

Subject Variables of Tertiary Interest

We have just discussed how particular dichotomous variables may interact with the memory-enhancing effects under investigation. That is, patients with lesions in the frontal or temporal lobe may fail to benefit from memory-enhancing effects to the same degree as patients without such lesions. Also, female subjects may respond differently to the conditions than males. Each of these factors may also interact with the expected effect of laterality. For example, the emotionality effect may only fail to be exhibited by patients with right temporal lobe lesions or right frontal lobe lesions.

Another interesting question is how subject variables which are more continuous relate to these two experimental effects. That is, almost all of the research that has been conducted on both of these phenomena has been conducted on young, healthy adults, who are presumably bright or at least of average intelligence. Thus, the question remains as to their applicability to older adults and to adults with functional impairments. The current sample of healthy older adults and patients with various acquired impairments provides an opportunity to see whether individuals of various functional ability are differentially affected by these manipulations. Thus, in conjunction with the experimental tasks, various functional abilities were assessed via standardized neuropsychological tests, including two measures of comprehension, two measures of fluency, three measures of memory, one measure of attention, and two measures of general intelligence.

Since altering both stimulus emotionality and learning condition are believed to exert memory-enhancing effects in normal individuals, the question being posed is whether individuals who are mentally compromised will derive the same benefit from such manipulations as those with intact brain functions. There are three possible answers to this question: (1) Individuals with abilities ranging from high to low will have the same degree of benefit from these manipulations because the underlying mechanism of such manipulations transcends specific abilities and relates more to overall arousability. (2) Individuals with higher cognitive abilities will be more affected by such manipulations since such manipulations depend upon the ability of an individual to incorporate and utilize information in ways that depend upon specific cognitive functions. (3) Individuals with lower cognitive abilities will be more affected by such manipulations since these manipulations may provide alternate routes to memory not available on standardized cognitive tasks and because their baseline level of memory allows more room for improvement. In order to answer this question, the standardized measures of cognitive ability listed above will be correlated with indices of the emotionality and generation effects.

We will also explore the relationship between indices of the experimental effects and other continuous subject variables such as personality, social functioning, mood, age, education, and occupation. These subject variables, which are sometimes referred to as individual-difference variables (Hartley, 1986), are admittedly eclectic, but the idea was to cast as broad a net as possible to determine which avenues should be chosen for further investigation using this relatively novel paradigm. Thus, this particular aspect of the dissertation is exploratory since we make no specific predictions regarding each measure and its relationship to the experimental effects. Those variables which consistently correlate with the obtained effect across task would be worthy of further analysis regarding their predictive value.

Predictions of this Study

One of the main thrusts of this study was toward a determination of the relative viability of two neuropsychological views of the processing of emotion: the right hemisphere and valence theories. The first maintains that all emotional processing is a right hemisphere function, while the second asserts differences in hemispheric dominance based on valence. A second, equally important interest was in determining the viability of two theories of the generation effect: the first maintains that lexical activation and semantic memory are critical for the effect to be obtained, while the second attributes the effect of generation to the amount of effort deployed. Our final interest was toward a determination of the relative viability of three views of the cognitive/affective relationship: The first views emotional processing as more primal and independent of cognitive processing, the second views emotional processing as dependent on cognitive processing, and the third views the processing of cognitive and affective aspects of the environment as continuous and simultaneous.

In the present study we investigated these theories by examining the effects of stimulus and encoding manipulations on memory in normal and brain-damaged adults. Based on the analysis of our task requirements and subjects' presumed abilities, our predictions were as follows: First, we predicted that in comparison to left brain-damaged and normal subjects, the right brain-damaged subjects would fail to exhibit an improvement in memory for emotional, as compared to neutral, stimuli. Second, we predicted that in comparison to right brain-damaged and normal subjects, the left brain-damaged subject would fail to exhibit an improvement in memory for stimuli encoded in generate, as compared to read, contexts. Our final prediction, in accord with emotional primacy theories, was that these two memory-enhancing effects would not interact.

Methods

Subjects

All subjects were volunteers and signed informed consent forms. Subjects received monetary compensation for their time and effort upon completion of the study and incurred no costs for participation. Subjects were recruited from Mount Sinai Medical Center, Burke Rehabilitation Hospital, stroke clubs, flyers in recreational facilities, newspaper advertisements, and individual neurologists.

There were 255 CVA patients and 44 normal controls recruited for this study. Potential subjects were screened in person, over the telephone, or via medical chart review with hospital board approval (see Appendix A for the initial screening inventory). Unilateral cortical CVA was documented by the verbal summary of either a CT or MRI scan. Due to the high incidence of affective disorders subsequent to CVAs, subjects with post-stroke affective disorders were not excluded.

Individuals who had less than 12 years of education were excluded, since the stimulus words were originally rated by college students (Toglia & Battig, 1978), and the generalizeability of the ratings for individuals with less education is unknown. To control for hemispheric dominance of language, all subjects were native English speakers and were right-handed from birth by self report. Individuals who learned English after age 6 or who were left-handed or ambidextrous were excluded. If there was any lack of clarity regarding handedness, a brief handedness questionnaire was utilized (Coren, Porac, & Duncan, 1979; see Appendix B).

Of the potential patients, 198 were excluded due to at least one of eleven exclusionary criteria. Table 1 lists these criteria and the number of patients excluded due to each criterion. Additionally,17 patients met all criteria, but were

Table 1.

Exclusionary criteria for potential brain-damaged subjects.

	#subjects ruled out
1. Neurological complications	10
2. Psychiatric history *	9
3. Low Education	7
4. Non-native English speaker	11
5. Left-handed or ambidextrous	12
6. Brainstem Involvement	12
7. Bilateral involvement	30
8. Subcortical damage only	49
9. Negative imaging scan	18
10. Cognitive impairment	9
11. Severe aphasia	31
12. Not interested	17

Note. *includes substance abuse

not interested in participating. Twenty-four potential normal controls were excluded due to either one of the first five exclusionary criteria or because they did not match the patients on the demographic variables judged to be of potential importance (see below).

A single two-hour testing session or two one-hour sessions were arranged for the 63 persons who passed all criteria. Three of these subjects (two with left brain damage, one normal control) performed so poorly on the standardized or the experimental tasks that they were excluded from final analyses. Each of these subjects was either amnestic, severely aphasic, or demented. Sixty subjects remained in the study for the final analysis.

Participants included 20 stroke patients with right brain damage, 20 stroke patients with left brain damage, and 20 matched control subjects. Variables used to match the groups included age, gender, race, education (number of years in school), and occupation (measured by the Hollingshead [1977] rating scale). For the two brain-damaged groups, caudality of lesion (i.e., whether the lesion location is anterior or posterior) was also utilized in the matching process. Classification as anterior/posterior indicates that the frontal lobe was damaged, with or without involvement of the temporal, parietal, or occipital lobes. Classification as posterior indicates that there was no frontal lobe damage, and that damage was limited to one or more of the posterior regions (temporal, parietal, or occipital lobes). These classifications are used in some of the statistical analyses.

Demographic information for all groups can be found in Table 2. As demonstrated in this table and confirmed by statistical analysis, there were no significant differences among the three groups in terms of age, gender, education, occupation, race, or months post onset (for the brain-damaged groups). This reflected our strict criteria and matching process. Subjects had an average age of

Table 2.

Demographic characteristics of subjects.

	NC (n = 20)	RBD (n = 20)	LBD (n = 20)	F / t / X^2	p
Age	64.67 (11.60)	64.85 (9.64)	65.25 (12.39)	F = 0.02	.983
Education	15.83 (2.75)	14.35 (2.72)	14.50 (2.87)	F = 1.87	.163
Occupation	6.44 (2.25)	6.20 (2.19)	6.45 (2.63)	F = 0.22	.800
MPO		32.70 (27.84)	32.75 (26.56)	t = 0.01	.994
Gender	9M, 11F	10M, 10F	13 M, 7F	X^2 = 1.79	n.s.
Race	3AA, 17W	6AA, 14W	3AA, 17W	X^2 = 1.88	n.s.

Note. Numbers in cells represent means; numbers in parentheses represent standard deviations; NC = normal control group; RBD = right brain-damaged group; LBD = left brain-damaged group; Gender: M=male, F=female; Race: AA=African American, W=White; Education = number of years of formal school training; Occupation = Hollingshead Occupation Scale; MPO = months post onset of stroke.

64.90 years (ranging from 37 to 83 years), an average of 15.02 years of education (ranging from 12 to 20 years), an average Hollingshead occupational rating of 6.45 (ranging from 1, indicating unskilled labor, to 9, indicating major professional work), and for the brain-damaged subjects, an average of 32.73 months post onset of injury (ranging from 2 to 106 months). Thirty-two males and 28 females participated in the study. Forty-eight of the participants were Caucasian and 12 of the participants were African American.

Lesion locations and several post-stroke symptoms were gleaned from the patients' medical records, which were obtained with patient consent. These patient characteristics are listed in Table 3. As indicated in this table, the brain-damaged subjects did not differ in the proportion of subjects with subcortical involvement (referred to as verticality of lesion), frontal lobe involvement (caudality of lesion), hemiplegia, facial paralysis, visual problems, hemispatial neglect, post-stroke seizure history, or post-stroke depression (as analyzed with 2 x 2 Chi square tests). However, there was a higher proportion of right brain-damaged subjects with sensory loss and a higher proportion of left brain-damaged subjects with post-stroke language disturbances (analyzed with 2 x 2 Chi square tests).

As indicated in Table 3, two of the right brain-damaged patients had a language disturbance at the time of testing, as observed by the examiner. One of these patients had severe dysarthria, while the other had dysarthric speech and mild comprehension problems. In the left brain-damaged sample, 13 subjects had language disturbances at the time of testing, which could be classified as mild expressive, mild receptive, or mixed (expressive and receptive) language disorders. The patients with mild expressive language disorder exhibited fluency deficits, while the patients with mild receptive language disorder exhibited comprehension deficits. These classifications were based on the observations of

Table 3.

Stroke-related characteristic of the patients.

	RBDs	LBDs	Chi-squared value	Significance
Verticality	16C; 4SCC	17C; 3SCC	0.00	n.s.
Caudality	11A/P; 8P	8 A/P; 11P	0.42	n.s.
Hemiplegia	17	15	0.16	n.s.
Facial Paralysis	12	7	0.16	n.s.
Sensory Loss	15	10	8.53	**
Visual Deficits	6	6	0.10	n.s.
Neglect	5	3	0.24	n.s.
Current Language Deficits	2	13	8.90	**
Post-stroke Language Deficits	9	19	9.64	**
Seizure History	5	3	0.24	n.s.
Depression	6	8	0.11	n.s.

Note. All information was derived from legally-obtained medical chart records.
Verticality: C=cortical only; SCC = subcortical & cortical
Caudality: A/P=anterior or anterior and posterior damage; P=posterior damage only
Hemiplegia: number of subjects with history or presence of hemiplegia
Facial Paralysis: number of subjects with history or presence of facial paralysis
Sensory Alteration: number of subjects with hyper or hypo sensory symptoms
Visual Problems: number of subjects with history or presence of hemianopsia or visual neglect
Language Now: number of subjects with presence of any language difficulties
Language in Past: number of subjects with history of stroke-related language difficulties
Seizure History: number of subjects with post-stroke seizure history
Depression: number of subjects with post-stroke depression/current or past
**$p<.01$

the examiner and, when available, on recent medical records. The number of left brain-damaged subjects with each type of language disturbance is listed in Table 4.

Table 4 and 5 also lists specific lesion information and classifications based on this information for left brain-damaged subjects and right brain-damaged subjects, respectively. Thus, there were at least 8 patients that could be classified as having right hemisphere anterior/posterior damage, left hemisphere anterior/posterior damage, right hemisphere posterior damage only, and left hemisphere posterior damage only. Care was also taken to specify the particular cortical lobes which were lesioned so that subjects could be further divided into those with and without temporal lobe damage.

Materials

Neuropsychological Tasks. In addition to the main experimental tasks, which are described in detail below, several neuropsychological tasks were administered during the testing session to assess basic functional abilities (derived from Borod, Welkowitz, & Obler, 1992). These included: the short form of Raven's Progressive Matrices ([Ravens] Raven, 1960) as an estimate of non-verbal intelligence; the information subtest of the WAIS-R ([WAIS-Info] Wechsler, 1981) as an estimate of verbal intelligence; Attention and Memory subtests of the Mattis Dementia Rating Scale ([MDRS-ATTN, MDRS-MEM] Mattis, 1976) to rule out dementia; immediate and delay conditions of the Logical Memories Subtests of the Wechsler Memory Scale-Revised ([LMI, LMII] Wechsler, 1987) for a standardized assessment of verbal memory; the Complex Ideational Material subtest and the Reading Sentences and Paragraphs subtest of the Boston Diagnostic Aphasia Examination ([BDAE-C.I.M., BDAE-READ] Goodglass & Kaplan, 1983) to assess auditory and reading comprehension; the Schedule for Affective Disorders and Schizophrenia-

Table 4.

Specific lesion information for the patient participants with left brain damage.

S#	Frontal Lobe	Temporal Lobe	Parietal Lobe	Occipital Lobe	Temporal Lobe Involvement	Caudality	Language Disorder
1.		+	+		yes	P	no
2.		+		+	yes	P	no
3.		+	+		yes	P	yes (M)
4.	+	+	+		yes	A/P	yes (M)
5.			+		no	P	no
6.	+	+			yes	A/P	yes (E)
7.		+			yes	P	yes (R)
8.		+			yes	P	no
9.	+	+			yes	A/P	yes (E)
10.			+	+	no	P	no
11.		+		+	yes	A/P	yes (E)
12.		+	+	+	no	A/P	yes (M)
13.			+	+	no	P	yes (E)*
14.		+	+		no	A/P	yes (E)
15.		+	?	?	x	A/P	yes (E)
16.			+		no	P	no
17.	+		+		no	A/P	no
18.			+	+	no	P	yes (E)
19.			+	+	no	P	yes (E)
20.					x	x	yes (E)*

Note. All classifications are based on the written summary of CT or MRI scans. + indicates the presence of a lesion in this area. ? indicates the possibility of a lesion in this area. Caudality = whether the patient is classified as having anterior/posterior (A/P) damage or as having posterior damage only (P). x indicates that the patient could not be classified based on the available information. Patient #20 has no + or ? since the only information available indicated a MCA (middle cerebral artery) stroke, thus we only used subject #20 in the analysis of the LBD group as a whole. Diagnosis of language disorder was based on the examiner's observations and/or recent medical records. E = mild expressive language disorder; R = mild receptive language disorder; M = mixed, i.e. both mild expressive and mild receptive disturbances; * these two patients had minimal language deficits.

Table 5.

Specific lesion information for the patient participants with right brain damage.

S	Frontal Lobe	Temporal Lobe	Parietal Lobe	Occipital Lobe	Temporal Lobe Involvement	Caudality
1.	+	+	+		yes	A/P
2.	+	+	+		yes	A/P
3.	+	+	+		yes	A/P
4.	+		+		no	A/P
5.	+	?	?		x	A/P
6.	+		+		no	A/P
7.	+	+	+	+	yes	A/P
8.	+	+	+		yes	A/P
9.	+				no	A/P
10.	+		+		no	A/P
11.	+	+	?		yes	A/P
12.				+	no	P
13.			+		no	P
14.			+	+	no	P
15.		+	+	+	yes	P
16.				+	no	P
17.			+		no	P
18.			+		no	P
19.			+		no	P
20.					x	x

Note. All classifications are based on the written summary of CT or MRI scans. + indicates the presence of a lesion in this area. ? indicates the possibility of a lesion in this area. Caudality indicates the patient is classified as having anterior/posterior (A/P) damage, or as having posterior damage only (P). x indicates that the patient could not be classified based on the available information. Patient #20 has no + or ? since the only information available indicated MCA (middle cerebral artery), and thus, we only used this subject in the analysis of the RBD group as a whole.

Lifetime (SADS-L; Endicott & Spitzer, 1978) for an in-depth assessment of psychiatric history; and the Controlled Oral Word Association task ([FAS] Benton & Hamsher, 1976) and Animal Naming tasks of the BDAE ([Animals] Goodglass & Kaplan, 1983) to obtain measures of verbal fluency.

In addition, in order to assess current mood two questionnaires were administered. The short form of the Beck Depression Inventory ([BDI] Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) was administered directly before the experimental tasks and a short form of the Positive and Negative Affect Scale ([PANAS], Watson, Clark, & Tellegen, 1988) was administered directly after the experimental tasks. These assessments were included since the effect of an individual's mood at test time on memory performance may overshadow the effects of specific types of brain damage on memory for words of different valence types. Based on findings of mood-dependent memory (for a review, see Blaney, 1986), scores on the positive mood portion of the PANAS scale were expected to correlate with memory scores for positive material on the experimental tasks. Likewise, scores on the negative mood portion of the PANAS scale, and scores on the BDI, were expected to correlate with memory scores for negative material on the experimental task.

Finally, subjects were also asked to rate their current social life on a three-point scale (see Appendix N). This rating scale was included to obtain a measure of the self-reported level of social functioning of subjects involved in this study. General knowledge of the functional status of these subjects may be useful in comparison of the subjects in this study to those in similar studies.

Main Experimental Tasks. The major focus of the study used 96 target words as stimuli, arranged into two 48-word lists (see Appendix C). The words were obtained from Toglia and Battig's (1978) Semantic Word Norms, where words were rated on seven variables. Pleasantness was the main variable of interest in this study.

Intensity and valence of emotionality were controlled for via the pleasantness (P) scale. Words that were rated above 5.5 on the 7-point P scale were regarded as positive in valence; words with ratings below 2.5 on the P scale were regarded as negative in valence; words with ratings between 3.75 and 4.25 on the P scale were regarded as non-emotional or neutral. Intensity of valence was controlled for by choosing positive and negative words from the same extreme points on the scale.

Other variables known to affect memory (concreteness, familiarity) were also utilized for matching and control purposes. Concreteness was controlled for since the right hemisphere has been found to be dominant for creating and processing images (Seamon & Gazzaniga, 1973) and since there may be a high association between images and emotions (Grossberg & Wilson, 1968; Horowitz & Becker, 1971). Imaginability or concreteness of words was controlled for via the concreteness (C) scale. Words that were rated above 5.5 on the 7-point C scale were regarded as highly concrete; words with ratings below 2.5 on the C scale were regarded as abstract; words with ratings between 3.75 and 4.25 on the C scale were regarded as mid-concrete. On the familiarity (F) scale, the criterion for inclusion was that each word was rated above a five on the seven-point F scale and was thereby subjectively judged as a familiar word. Syntactic category (nouns, adjectives, verbs) was also controlled, as patients with linguistic impairments may have difficulty with words from one syntactic category more than another. For example, patients with right brain damage may have difficulty with adjectives, since they tend to omit adjectives in their discourse (Joanette, Goulet, Ska, &

Nespoulous, 1986).

Thus, each word was chosen for its emotionality, valence, concreteness, familiarity, word length (5-9 letters) and syntactic category . Each 48-word list (see Appendix D) contained 16 positive, 16 negative, and 16 neutral words; 15 nouns, 18 verbs and 15 adjectives; 18 abstract words, 12 mid-concrete words and 18 highly concrete words. It was confirmed by independent t-tests that the two lists were equated for pleasantness, concreteness, word length, and familiarity (See table in Appendix D). We refer to these as our stimulus characteristics.

The 48 words from each list were then divided into four blocks of 12 words each (see Appendix E). Each block was equally represented by the stimulus characteristics. It was confirmed by one-way ANOVAs that the four blocks within each list were equated for pleasantness, concreteness, word length, and familiarity (See table in Appendix E).

Sentences were created by the examiner to accompany each of the words (See Appendix F). These sentences were utilized in the Read condition of the study phase. The sentences were created in accord with the emotionality and valence of the target words. For example, for positive words, positive sentences were created. Thus, the valence of the overall sentence was concordant with the emotionality and valence of the target word.

Experimental Procedures

In this experiment there were two encoding conditions and three retrieval tasks. Each subject learned material in both conditions and completed all three retrieval tasks.

1. Learning Words and Sentences. In the encoding or test phase of the experiment the subject was directed to a 65xxM Ager notebook computer where instructions were displayed (see Appendix G). Each subject was then presented

with words from only one of the two 48-word lists. In each of the four word-blocks, the twelve words were randomized and individually displayed, one at a time. Subjects were instructed to read the word aloud when it appeared on the screen (to ensure proper attention and reading of the word), and then the examiner pressed the space bar.

The subjects were initially expected to press the space bar and perform more independently. However, upon piloting the procedure on stroke patients, we found that impaired motor control led to multiple presses which in turn caused the skipping of stimulus words. Therefore, the instructions were altered so that the examiner pressed the space bar when the subject completed reading. The examiner's finger(s) were upon the space bar throughout the entire learning section, and the bar was pressed immediately after the subject finished speaking. For conformity and control, this procedure was followed with control subjects, as well.

Two of the four word-blocks of the list were presented in the generate condition, and the other two word-blocks were presented in the read condition. In the generate (G) condition, after each word was read, a blank screen appeared and the subject orally generated a sentence using the stimulus word. As soon as the sentence was complete (or, in rare cases, when the subject indicated that he could not generate one), the examiner pressed the space bar again, causing a new word to appear on the screen. This process was repeated twelve times, once for each word in a block.

In the read (R) condition, after reading the stimulus word, depression of the space bar prompted a sentence to be displayed on the screen. The subject read the sentence aloud, and the examiner depressed the space bar again. Subjects remained in the same condition (G or R) for two consecutive blocks, followed by two blocks of the remaining condition. Four setup files were created in the computer program so that lists and order of conditions were counterbalanced across subjects.

2. Free Word Recall. After each block of 12 words, a blank screen appeared and the subject was asked to orally recall as many words as possible from that block. Subjects' oral responses were recorded via audiotape during the testing procedure and later transcribed. Total time for the combined learning and free recall portions of the experiment was between 10 and 20 minutes depending upon the length of time subjects took to generate sentences and recall words.

3. Distraction Task. After all four word-blocks and free-recalls were completed, the subject began working on the Raven's Matrices Task. The subject was given a self-response form in order to minimize interaction with the experimenter. Raven's Matrices was intended as a non-emotional, visuospatial task that would distract the subject from rehearsing any of the previously learned words, provide 15 minutes of delay before recognition, and provide an estimate of overall intelligence. After this allotted time the subject was interrupted and asked to begin the recognition task. Several subjects were working on the last item or two of the Raven's and permitted to finish. Most subjects completed four of the five sections and were instructed to complete the fifth section later in the session.

4. Recognition Task. In the recognition task, all 48 of the words from the previously presented list (old words) were randomized and mingled in with the 48 words from the unseen list (new words). These 96 words were presented individually, one after the other, on the computer screen. The subject was instructed to indicate if he/she recognized the word from the previous task by saying "yes" if seen before and "no" if not. "Yes" and "No" labels were taped onto the keyboard of the computer, and the examiner depressed these keys whenever a

response was emitted. This portion of the experiment took approximately five minutes.

5. Sentence Recall Task. At the completion of the recognition task, another set of instructions appeared on the screen (see Appendix H). Words from blocks one and four (24 words) of the originally viewed list were re-randomized within-block and presented on the screen. As intended, one of these blocks was originally in the generate condition, and thus the object was to recall a self-generated sentence. The other block of words was in the read condition, and thus subjects had to recall sentences they had previously read from the computer screen. The first and last blocks were utilized since we thought these words may have been remembered better than the words from the two internal blocks. (Although it is possible that for the patients only recency effects would occur and not primacy effects).

After reading each word aloud, the subject was instructed to recall the sentence orally, or any part or idea thereof, which had accompanied the stimulus word. Each word remained on the screen until the subject finished his/her response. This portion of the experiment lasted between five and ten minutes, depending upon the number of sentences recalled. All responses were audio taped and later transcribed.

Total test time was approximately two hours. This included all neuropsychological and experimental tasks. In order to ensure accuracy of scoring, an audiotape recorder was running throughout the experiment, and all responses were later verified.

Data Analysis

Scoring Procedures

Free Word Recall. The words from the four word-blocks were combined for an overall recall score and all words were coded for three of the stimulus characteristics described above: valence, concreteness, and part of speech (although the latter two variables were not analyzed in this study). A key to the codes and coded word lists are found in Appendix I and were used in the scoring of all three retrieval tasks. All raw scores were converted into percentages. For example, if a subject recalled 4 negative words, he received an accuracy score of 25% for recall of negative words, since there were 16 negative words presented.

Recognition. There was a computer-programmed scoring of the recognition task which reported correct responses according to stimulus characteristics and condition in which the words were learned (generate, read). Since the matched, alternate list served as the distractor list, the words had the same stimulus characteristics. Thus, false alarms were also calculated and scored according to the variables of emotionality and valence.

Sentence Recall. Responses on the sentence recall task were compared with the original sentences that were read and generated by each subject. If the sentence recalled incorporated at least one idea from the original sentence it was awarded partial credit. Sentences which were close to verbatim or incorporated at least two of the ideas from the original sentence were awarded full credit. Two independent raters scored the sentence recall task, and a third rater participated when a discrepancy occurred (approximately one-third of the time). These raters were female, right-handed, had an average age of 27, and were naive about the identity of the subjects. All full and partial credit responses were then coded according to the stimulus characteristics of the word cues which evoked the sentence (Appendix I).

Statistical Analysis of Experimental Data & Experimental Design

Analyses of Variance. For each of the three experimental retrieval tasks, there was an analysis of variance (ANOVA) conducted with a 3 (group) x 2 (learning condition) x 2 (stimulus type) mixed factorial design. The group factor was a between-subject factor, and the condition and stimulus factors were within-subject, repeated measures. The three levels of the group factor were normal control subjects, left brain-damaged subjects, and right brain-damaged subjects. The two levels of the learning condition factor were generate sentence condition and read sentence condition. The two levels of the stimulus variable differed in the two sets of analyses of variance (ANOVAs) applied to the data. In one set of ANOVAs, the third factor was stimulus emotionality, represented by the two levels of neutral words and emotional words (emotional words are the average number of positive and negative words). In a second set of ANOVAs, the third factor was valence of the stimulus, represented by the two levels of positive words and negative words (no neutral words in this analysis). The dependent variable measured in each of the three tasks was the percentage of correct responses.

Although we had no a priori predictions concerning false alarms, it was noticed that the subjects in the pilot study committed more false alarms in response to emotional stimuli than in response to neutral stimuli. Thus, an additional dependent variable, false alarms, was measured in the recognition task with a 3 (group) x 2 (stimulus type) mixed ANOVA. The results and discussion thereof are presented in Appendix Q.

We further analyzed other independent variables, such as gender, caudality of lesion (i.e., involvement of frontal lobes), and involvement of temporal lobes. These group variables were chosen for analysis due to their possible influence upon both effects under investigation. The additional analyses including these variables are similar in design to the analyses described above except in the substitution or addition of the group (subject) factor which will be specified in the results section.

For each of the standardized tasks, a one-way ANOVA was performed to determine whether group differences in performance were significant. F, df, and p values for all ANOVAs are reported whenever significant results or trends emerged. In all cases, results were considered significant if p < or = .05. A result was considered to represent a statistical trend if p > .05 and p < .10. Non-significant results are not reported in the text. However, readers interested in examining the full set of results are referred to Appendix L which lists all ANOVAs conducted with the emotionality variable, as well as the related F and p values obtained. Appendix M lists all ANOVAs conducted with the valence variable, as well as the F and p values obtained.

Correlational Analyses. Pearson's product moment coefficients were calculated to analyze the relationship between basic functional abilities involved in the process of generation (i.e., fluency and memory) and an index of the generation effect (see below) on each retrieval task. This analysis will yield a better understanding of the sentence generation effect and insight into the possible limitations of this effect. If several of these correlations are significant, further analysis of these variables will be warranted.

Also, in light of frequent findings of mood-dependent memory, and in order to index the possible intervening factor of (depressed) mood on overall performance, correlations were obtained between assessments of mood and overall performance on the three tasks and between assessments of mood and performance in particular valence conditions (e.g., assessment of negative mood was correlated with memory for negative words). If there is a strong indication that mood-dependent memory may be an operative factor in this experiment, further analysis of mood will be warranted.

Finally, in an effort to search for factors which may be related to the experimental effects and which may, therefore, warrant in-depth exploration in the future, we calculated a correlational matrix including many of the subject (individual-difference) variables measured in this study. Variables in the correlation matrix included demographic factors of age, occupation, and education; measures of mood and ability (the neuropsychological measures described above); measures of personality and social life; concordance between emotionality of generated sentences and target words; and indices of the generation and emotionality effects on each of the tasks.

For indices of the emotionality and generation effects, we used an equation that is similar to one often used in indexing the effect of laterality (e.g., Graves et al., 1981). Thus, an index of the emotionality effect (referred to as the emotionality quotient or EQ) was obtained by the equation: correct responses for emotional material (E) minus correct responses for neutral material (N) divided by total number of correct responses, or (E-N)/(E+N). Likewise, an index of the generation effect (referred to as the generation quotient or GQ) was obtained by the equation: correct responses for material learned in a generate condition (G) minus correct responses for material learned in a read condition (R) divided by the total number of correct responses, or (G-R)/(G+R).

Results

The current study examined memory for words varying in stimulus type (positive, negative, and neutral) and varying in condition under which they were encoded (read context or generated context) in patients with unilateral cortical brain damage and healthy, demographically matched controls. We utilized three direct memory procedures (free recall, recognition, and sentence recall) to test for the memory-enhancing effects of manipulating the stimulus and encoding variables. We predicted that patients with RH damage would fail to exhibit the enhancing effects of stimulus emotionality and that patients with LH damage would fail to exhibit the memory-enhancing effects of generation. We were also interested in determining how these memory-enhancing effects would interact with one another and if that relationship would be affected by brain damage. In addition, gender and intrahemispheric lesion site were examined for their possible contribution to the performance of our subjects. Finally, measures of basic functional abilities were assessed by neuropsychological tasks for screening purposes, in order to better understand the abilities of our subjects, and in order to determine if these abilities were related to the effects obtained in this investigation.

Analyses of Variance

Performance on Neuropsychological Tasks

The means and standard deviations for the three primary groups on each of the neuropsychological tasks are listed in Table 6. The BDI, PANAS, and the two subtests of the BDAE scores are listed as percentages (number of [correct] responses / total possible [correct] responses). All other scores are percentiles based on normative data. As can be seen in this table, the normal control group (NCs) performed better than the brain-damaged groups on each of the tasks. Furthermore, the group of subjects with right brain damage (RBDs) performed

Table 6.

Mean percentile scores on neuropsychological tests for normal control, right brain-damaged, and left brain-damaged subjects.

Task	NC (n=20)	RBD (n=20)	LBD (n=20)
WAIS-Info*	80.81 (25.07)	60.40 (27.84)	59.11 (27.79)
Ravens	79.17 (29.65)	56.08 (34.76)	68.20 (34.67)
MDRS-Attn	75.05 (28.50)	60.40 (34.61)	61.10 (35.71)
MDRS-Mem*	71.40 (31.15)	60.05 (39.57)	42.20 (34.83)
LM I**	65.30 (24.96)	56.45 (23.23)	38.10 (21.19)
LM II*	67.55 (28.65)	54.85 (22.74)	46.55 (18.70)
BDAE - C.I.M.^{T}	93.34 (11.97)	85.42 (12.05)	83.35 (16.23)
BDAE - Read	96.50 (6.71)	91.58 (11.19)	88.00 (17.95)
FAS***	82.30 (23.13)	42.84 (29.85)	36.00 (37.09)
Animals***	64.72 (28.24)	38.98 (34.53)	20.10 (23.31)
BDI	7.44 (7.48)	12.69 (12.44)	8.97 (10.70)
PANAS - Pos	67.00 (13.40)	60.33 (17.72)	63.10 (13.56)
PANAS - Neg^T	23.90 (4.79)	30.11 (10.62)	29.10 (10.79)

Note. NC = normal control group; RBD = group with right-brain damage; LBD = group with left-brain damage; numbers in cells represent means; numbers in parentheses represent standard deviations; Pos = positive; Neg = negative; See Methodology section for full names of all tasks;
$^T p < .10$; $^* p < .05$; $^{**} p < .01$; $^{***} p < .001$.

better than the group of subjects with left brain damage (LBDs) on most tasks. The significance of these differences, or lack thereof, are indicated in Table 6 and are described in the sections below organized by function of task assessment. For each task, a one-way ANOVA was conducted with group (NC, RBD, LBD) as the between-subjects variable. Significant ANOVAs were followed by post-hoc tests, which consisted of multiple pairwise comparisons of the Tukey HSD type.

Measures of Intelligence. The group differences in performance on the WAIS-Information subtest were significant (F (2, 56) = 4.05, p = .023). Post-hoc tests revealed that performance of the NC subjects (mean percentile = 80.81) was significantly better ($p<.05$) than that of the RBD subjects (mean percentile = 60.40) and the LBD subjects (mean percentile = 59.11). Group differences on the Raven's Progressive Matrices task were not statistically significant.

Measures of Attention and Memory. On the MDRS attentional measure, there were no significant group differences. On the MDRS memory measure there were significant group differences, F (2,57) = 3.47, p = .038, with post-hoc tests revealing that only the difference between the LBD group (mean=42.20) and the NC group (mean=71.40; p=.031) were statistically significant.

On a free recall task of short paragraphs (LM I), there were significant group differences in performance as well, F (2,57) = 7.165, p = .002. In this case, the LBD group (mean = 38.10) performed more poorly than both the RBD group (mean = 56.45) and the NC group (mean = 65.30). These two latter groups did not differ. On the delay version of this task (LM II), performance differences among the groups were also significant, F (2,57) =3.98, p = .024, with the LBD group (mean = 46.55) performing significantly more poorly than only the NC group (mean = 67.55).

Measures of Language Comprehension. The difference between the groups on the BDAE-C.I.M. (a test of oral comprehension) represented a statistical trend, F

(2,57) = 3.02; $p = .057$, with post-hoc tests revealing, again, a trend ($p=.06$) for differences between the performance of LBD and NC groups only. On the reading comprehension subtest (BDAE-READ), group differences were not significant.

Measures of Verbal Fluency. There was a highly significant group effect, F (2,56) = 11.97, $p = 0.000$, for performance on the semantic fluency task (Animal naming), where subjects must generate words within a specific category. Performance of the LBDs and RBDs was not statistically different, but both LBDs (mean = 20.10) and RBDs (mean = 38.98) performed more poorly than the NC group (mean = 64.72). Likewise, there was a highly significant group effect, F (2,56) = 13.30, $p = 0.000$, on the phonemic fluency task (FAS), where subjects must generate words beginning with a particular letter. The LBDs (mean = 36.00) and the RBDs (mean = 42.84), again, both performed significantly more poorly than the NCs (mean = 82.3).

Measures of Mood. Self-reported symptoms of depression (BDI scores) were highest in the RBD group and lowest in the NC group, but the differences were not significant. RBDs also reported more negative feelings on the PANAS and this group effect represented a statistical trend (F [2,55] = 2.61, $p = .083$). Post hoc tests revealed that only the difference between the self-reports of the NC (mean = 23.90) and the RBD (mean = 30.11) groups was significant. There were no significant differences among the groups on the positive mood score of the PANAS.

Measures of Personality. On the latter part of the SADS-L (a screening measure for psychiatric disorders) there are questions pertaining to overall behaviors and attitudes. These answers were taken as a first approximation of self-reported personality. Results were grouped into three personality divisions: Distrustful, Rigid, and Optimistic (See Table 7). All scores are percentages as derived by number of affirmative responses divided by total number of questions.

Table 7.

Measures of self-reported personality and social life for all subjects.

	NC	RBD	LBD
Distrustful	22.25 (21.67)	17.85 (18.52)	10.00 (16.22)
Rigid	51.04 (16.41)	55.90 (20.07)	52.05 (16.82)
Optimistic	73.00 (26.36)	64.50 (27.81)	77.00 (23.19)
Social Life	1.30 (0.73)	1.45 (0.69)	1.70 (0.57)

Note. NC = normal control group; RBD = group with right-brain damage; LBD = group with left-brain damage; numbers in cells represent means; numbers in parentheses represent standard deviations.

All groups reported few signs of distrustfulness, with the LBD group reporting the least and the NC group reporting the most. These group differences were not significant. In terms of rigidity, each of the groups reported a fair amount of rigid behavior, and the groups were very similar on this measure. Also, each of the groups reported a high rate of optimistic behavior and attitude, with no differences between groups.

Social Life. Subjects were asked to rate their current social life on a three-point scale. As indicated in Table 7, subjects in all groups reported similar assessments of their level of social activity. Average ratings of all groups were in the "OK or Fine" range, indicating that most subjects engaged in a fair amount of social activities and were fairly satisfied with their level of social activity at the time of testing.

Performance on Free Recall Task

Analysis of Groups. Figure 1 shows the percentage of correct words recalled as a function of both learning and emotionality conditions in each of the groups. As depicted in this figure, the normal control group recalled more words in each condition than either of the brain-damaged groups. This was evidenced by the main effect of group, F (2,57) = 5.05, p =.010 in a 3 (group: NC, RBD, LBD) x 2 (learning condition: generate, read) x 2 (stimulus emotionality: emotional, neutral) mixed ANOVA applied to the data. Subsequent independent t-tests revealed that normal control group recalled significantly more words (mean = 39.37) than both the left-brain damaged group (mean = 27.82), t (19) = 6.57, p = .000, and the right brain-damaged group (mean = 32.30), t (19) = 2.67, p = .015. There was no significant difference in overall recall between the two brain-damaged groups.

Figure 2 shows the percentages of correct words recalled in the Generate and Read conditions for each of the groups with data collapsed across the emotionality

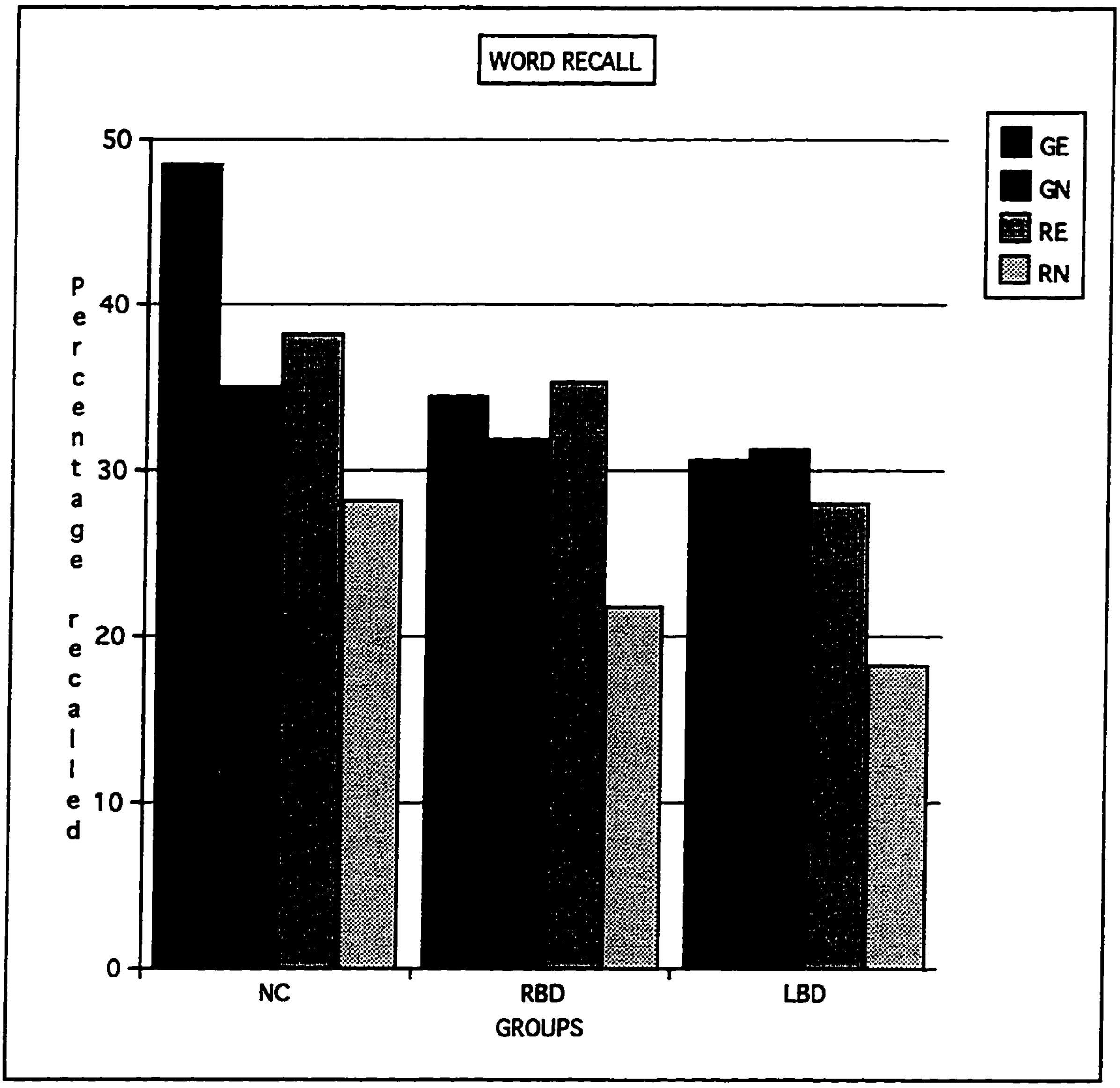

Figure 1. Percent of words recalled in each condition by normal control, right brain-damaged, and left brain-damaged groups.

GE = generate/emotional; GN = generate/neutral; RE = read/emotional; RN = read/neutral;
NC = normal control group; RBD = right brain-damaged group; LBD = left brain-damaged group

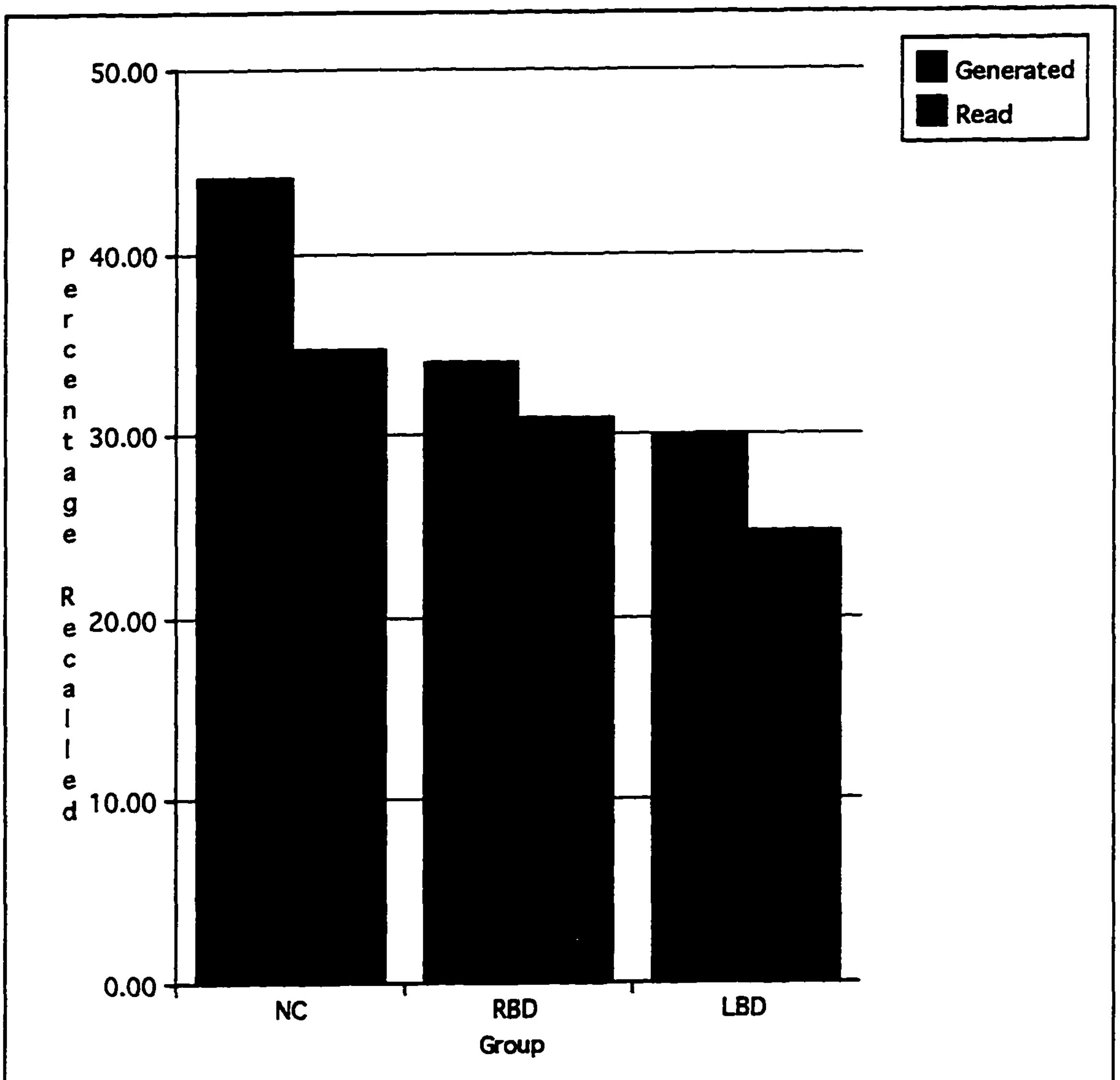

Figure 2. Percent of words recalled in Generate and Read conditions by normal control, right brain-damaged, and left brain-damaged groups.

factor. As seen in this figure, words originally encoded in the Generate condition (overall mean = 36.00) are recalled at a higher rate than words encoded during the Read condition (overall mean = 30.00). This was evidenced by a significant main effect for learning condition, F (1,57) = 15.10, p = 0.000 in the ANOVA described above. As depicted in this figure, all groups benefited from being in the Generate condition, thus there was no interaction between learning condition and group.

Figure 3 shows the percentage of emotional and non-emotional words recalled by each group with data collapsed across learning conditions. As seen in this figure, emotional words (overall mean = 35.42) were recalled at a higher rate than non-emotional words (overall mean = 27.92). This was evidenced by a significant main effect for emotionality of material, F (1,57) = 20.09, p = 0.000. Since all groups exhibited the increased recall for emotional stimuli there was no interaction between emotionality and group. There was also no interaction between learning condition and emotionality of material.

In order to explore valence effects, another 3 (group) x 2 (learning condition) x 2 (valence: positive, negative) mixed ANOVA was applied to the data using emotional stimuli only. There was no main effect of valence, nor were there group x valence effects. Thus, within each group, positive and negative words were recalled at similar rates. There was also no interaction between learning condition and valence of material. However, with the neutral material removed from the analysis, there was a trend for the group x condition interaction (F [2,57] = 2.79; p = .070). By viewing Figure 4 we see that there is a larger difference between words recalled in the generate and read conditions in the normal control group (48.44 - 38.13 = <u>10.31</u>) than there is in the RBD group (34.38 - 35.31 = <u>-0.93</u>) or the LBD group (30.63 - 26.88 = <u>3.75</u>). Thus, in memory for emotional words, generation of sentences was less effective for brain-damaged subjects than it was for normal

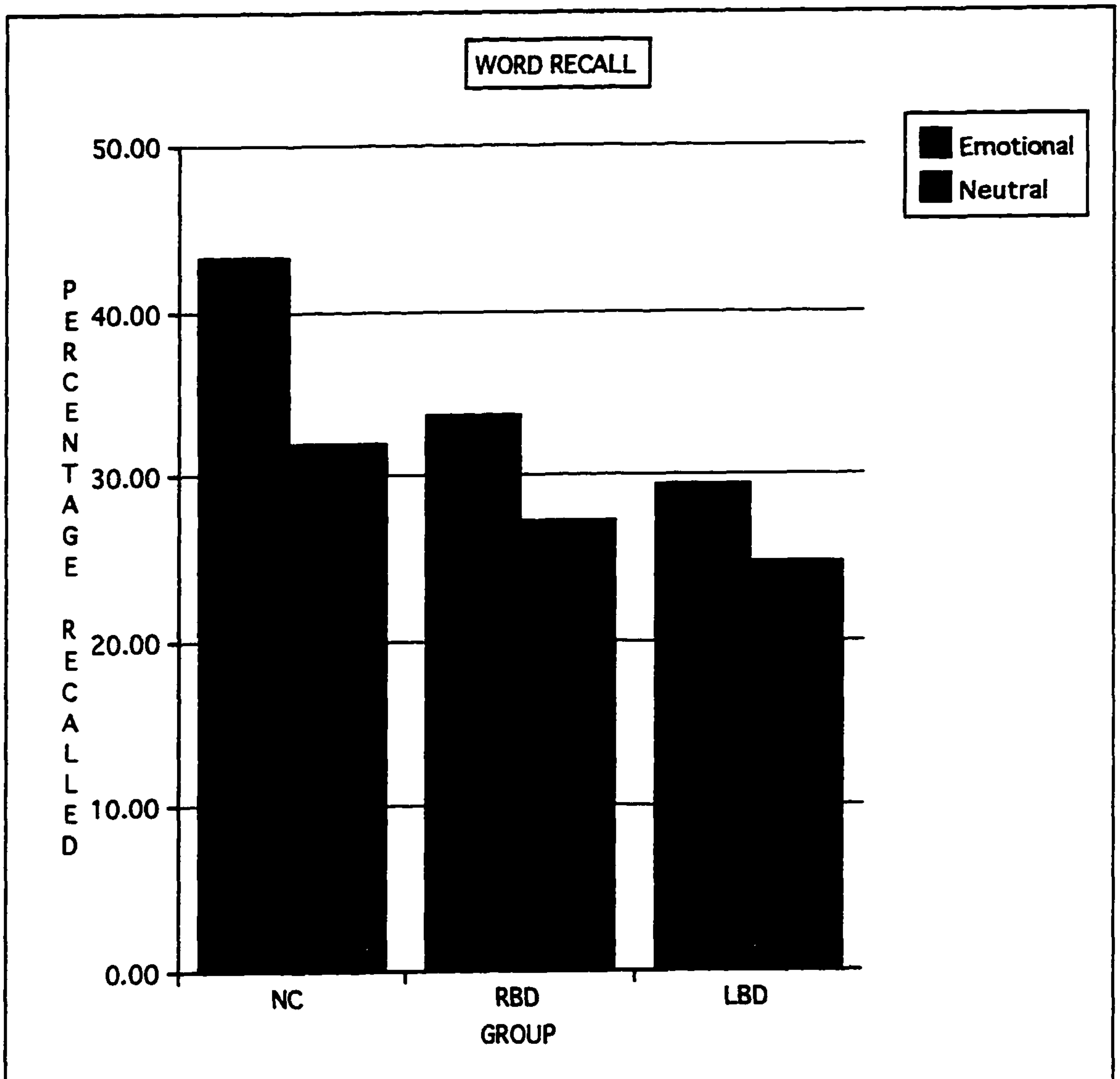

Figure 3. Percent of emotional and non-emotional words recalled by normal control, right brain-damaged, and left brain-damaged groups.

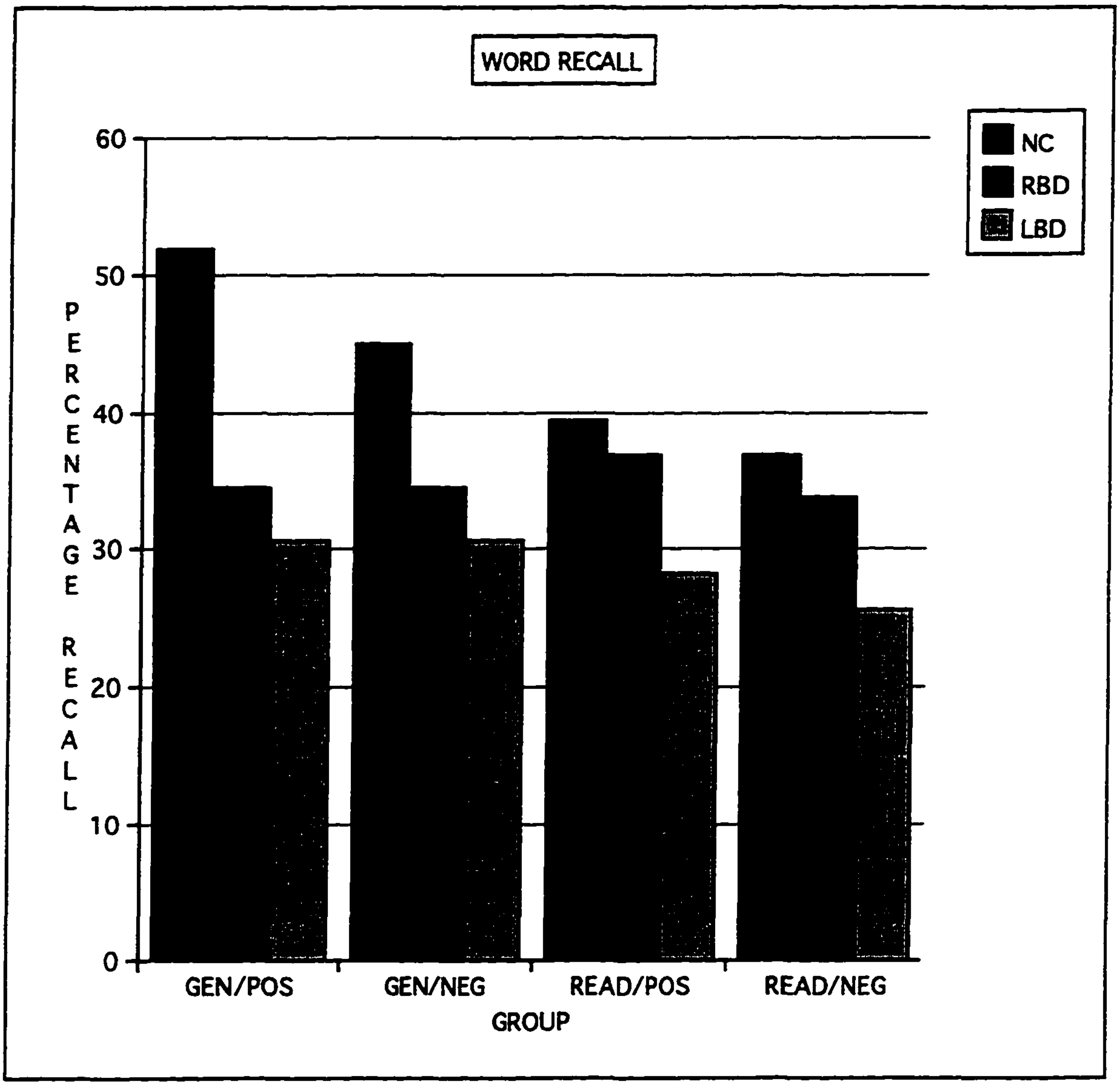

Figure 4. Percent of positive and negative words recalled by normal control subjects, right brain-damaged subjects and left brain-damaged subjects in generate and read learning conditions.

NC = normal control group (n=20); RBD = right brain-damaged group (n=20); LBD = left brain-damaged group (n=20); GEN/POS = generated condition/positive words, GEN/NEG = generated condition/negative words; READ/POS = read condition/positive words; READ/NEG = read condition/negative words.

controls.

Analysis of Caudality. Figure 5 depicts the performance of the brain-damaged subjects when they are partitioned by caudality of lesion sites. In comparing these data to those in Figure 1, we see that the performance of the patients without frontal lesions (the posterior group) is of a similar pattern to the performance of normal controls. The group with lesions which include the frontal lobe, by contrast, display a different performance pattern. These differences are most apparent in the generate condition where the emotionality effect is reversed.

When a 2 (laterality of lesion: right, left) x 2 (caudality of lesion: frontal involvement, no frontal involvement) x 2 (emotionality of material) x 2 (learning condition) ANOVA was applied to these data, laterality of lesion was not significant in main or interactive effects and thus we can conclude that when subjects are divided along the rostral/caudal dimension, the laterality factor is unimportant in the effects under investigation. Furthermore, the two patient sub-groups recalled words at a similar rate overall (anterior/posterior group mean = 28.84; posterior group mean = 31.48) as confirmed by the non-significant main effect of caudality. The main effects of emotionality of material, F (1,34) = 5.84, p = .021, and learning condition were again significant, F (1,34) = 8.58, p=.006, as they were with the total sample.

Furthermore, as depicted in Figure 6, the emotionality effect is evident only in the group without frontal involvement, while the group with frontal lesions recalled emotional and neutral words at an equivalent rate. The significance of this two-way interaction between emotionality of material and caudality of lesion was confirmed by the ANOVA described above, F (1,34) = 5.81, p = .022.

Additionally, as depicted in Figure 7, with the normal control group removed, there was also an interaction between learning condition and emotionality such

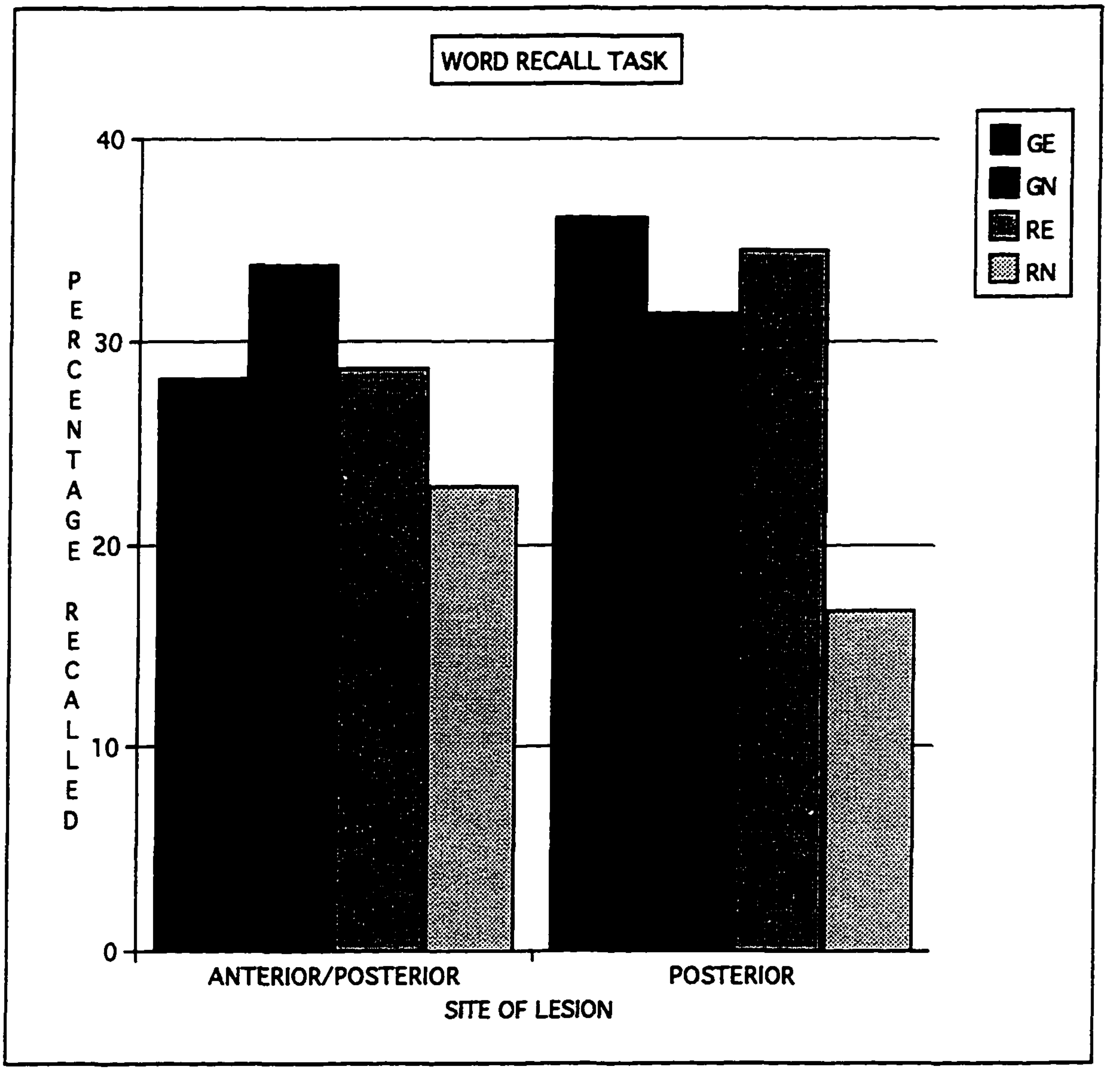

Figure 5. Mean percent of words recalled by brain-damaged subjects with lesions in both anterior and posterior regions and by brain-damaged subjects with lesions circumscribed to the posterior region.

GE = generate/emotional; GN = generate/neutral; RE = read/emotional; RN = read/neutral

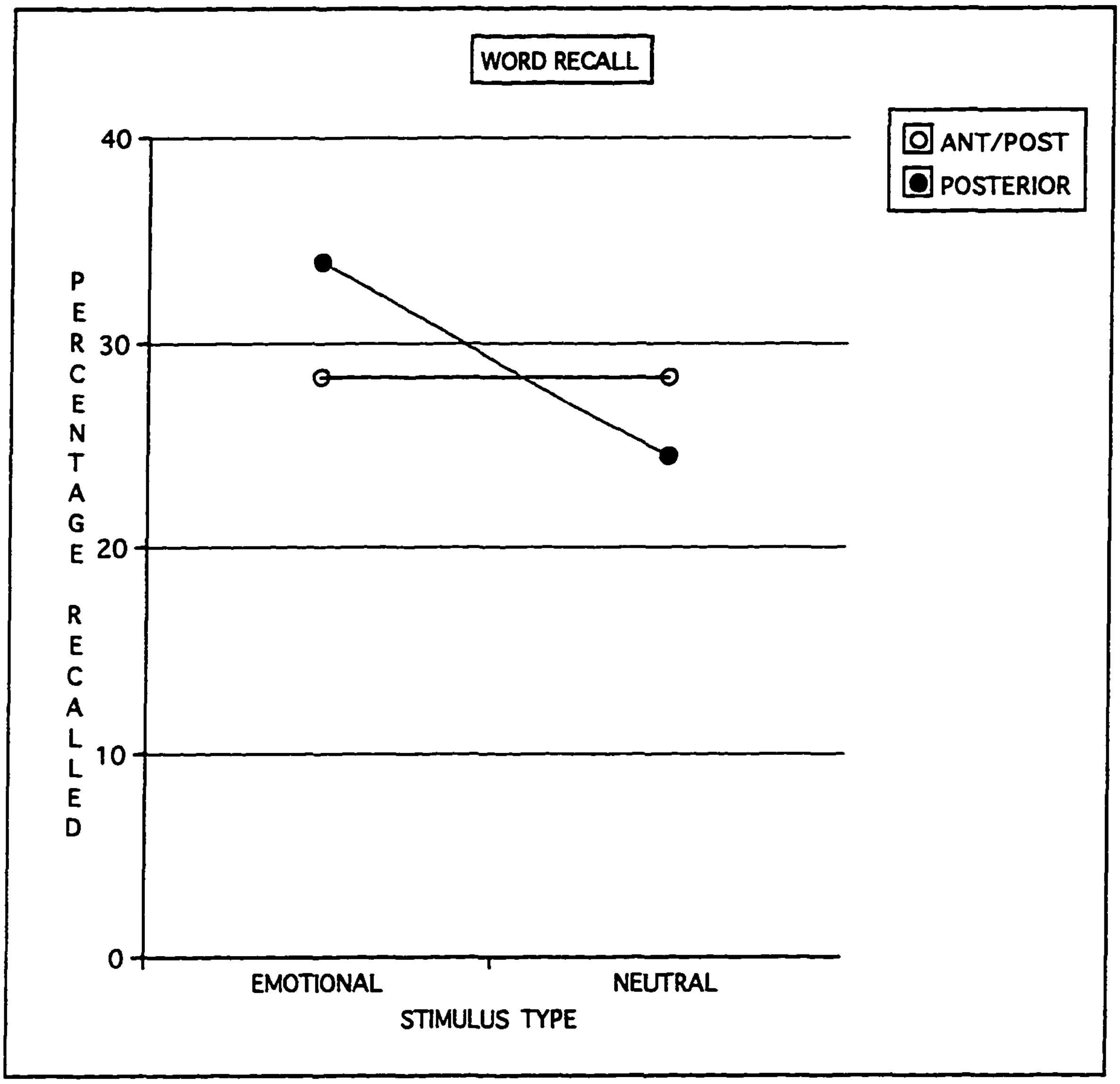

Figure 6. Interaction between caudality of lesion site and emotionality of stimulus on word recall task.

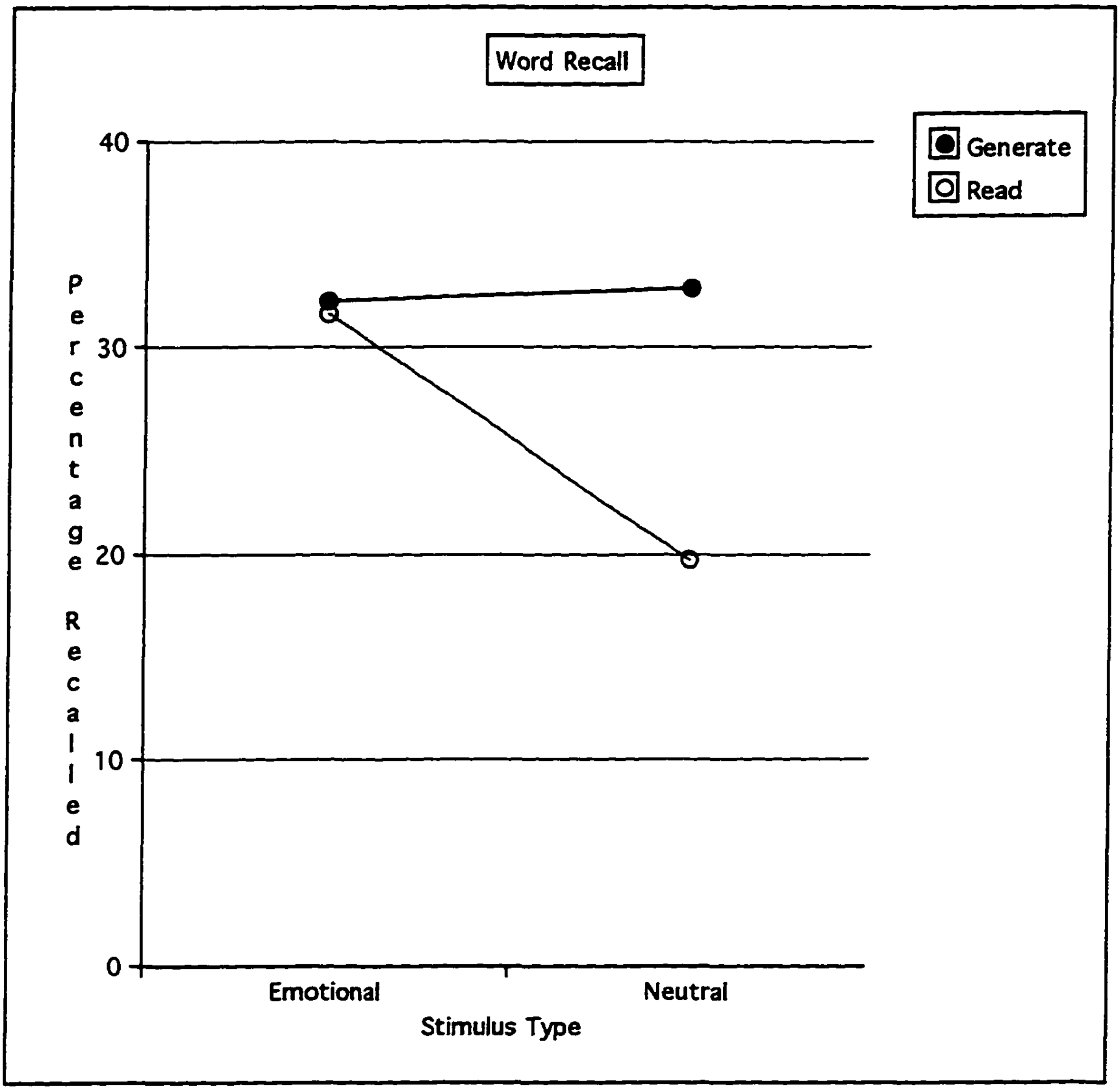

Figure 7. Interaction between learning condition and emotionality in patients only on the word recall task.

that the patient groups demonstrated the advantage of emotional material only in the Read condition. The significance of this interaction effect was confirmed by the ANOVA described above, F (1,34) = 6.62 p = .015. Follow-up analyses confirmed that in the Generate condition there was no effect of emotionality and in the Read condition there was a strong emotionality effect, t (36) = 3.54, p=.001.

The results of these analyses may be summarized as follows: In the brain-damaged group there was a strong emotionality effect in the read condition and none in the generate condition. When normal controls were included, this condition x emotionality interaction had not been exhibited. Furthermore, when subjects were divided according to caudality of lesion site, the emotionality effect was exhibited only in the group with circumscribed posterior lesions and not in the group whose lesions included anterior areas. Laterality was not a significant factor in any of these effects.

In order to assess valence effects, another 2 (laterality) x 2 (caudality) x 2 (condition) x 2 (valence) ANOVA was applied to the emotionality data. With neutral material removed, the main effect of learning condition was no longer significant. Furthermore, there was a significant caudality x condition x valence interaction , F (1,34) = 5.94; p = .020. This interaction is depicted in Figure 8. Post-hoc tests revealed that within each group the differences in valence were not significant in either learning condition. Also, within each valence type, generation effects were not significant for either group. Furthermore, negative words learned in a generate condition and positive words learned in a read condition were recalled at similar rates across groups. However, patients with non-frontal lobe lesions tended to have higher recall than frontal lobe patients when positive words were learned in a generate condition, t = 3.43, df = 36, p = .072, and when negative words were learned in a read condition, t = 3.21, df = 36, p = .081.

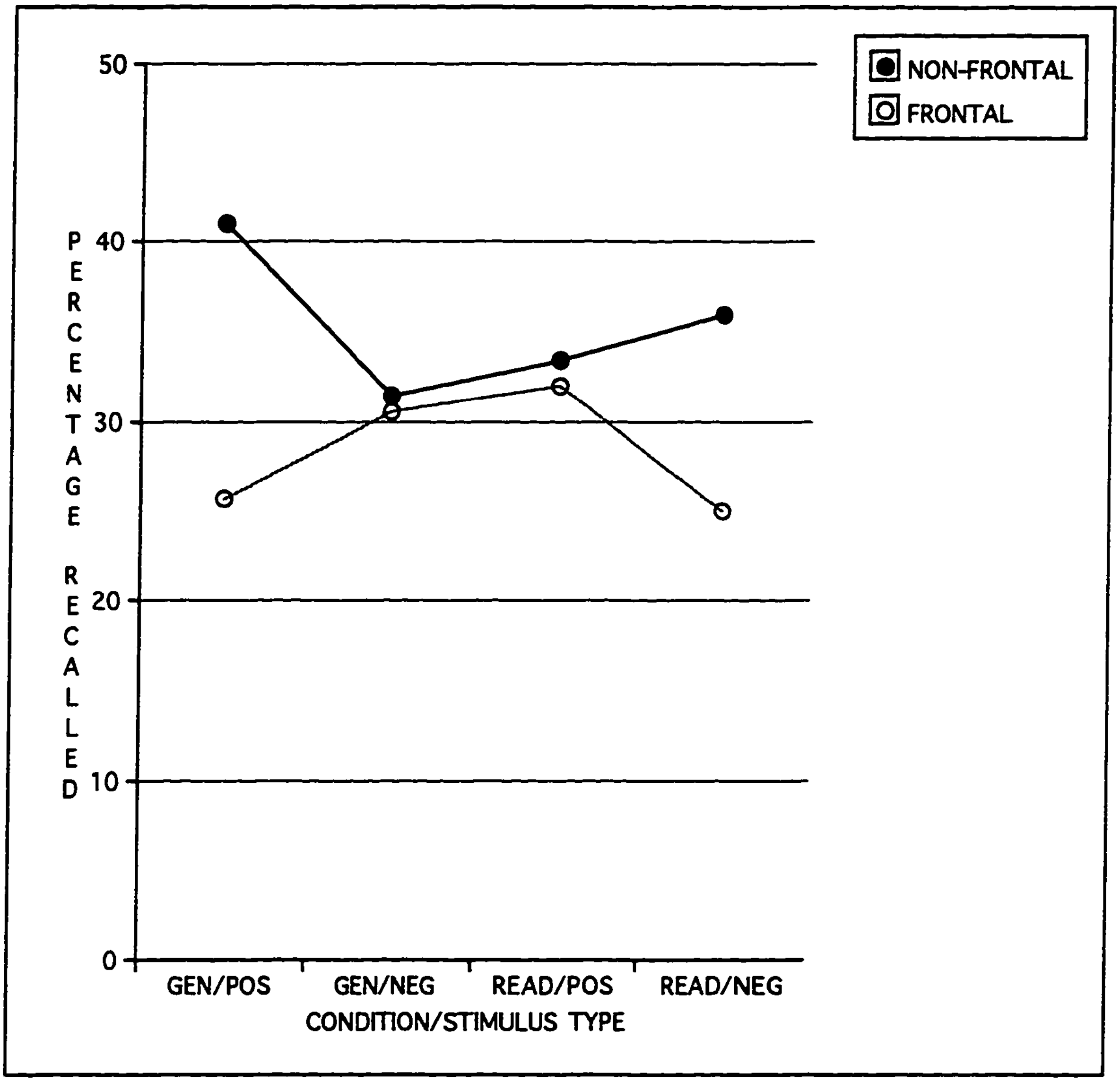

Figure 8. Percent of positive and negative words recalled by brain-damaged subjects with lesions in anterior/posterior regions and brain-damaged subjects with lesions in posterior regions only.

GEN/POS = generated condition/positive words, GEN/NEG = generated condition/negative words; READ/POS = read condition/positive words; READ/NEG = read condition/negative words. ANT/POST = subjects with lesions in anterior/posterior regions(n=19); posterior (n=19).

Analysis of Temporal Lobe Involvement. Figure 9 shows the mean recall scores for patients when they are divided by presence or absence of temporal lobe involvement. Although we can see some differences between the patients with and without temporal lobe involvement, there was no main effect of this factor when a 2 (laterality of lesion: right, left) x 2 (temporal lobe involvement, no temporal lobe involvement) x 2 (emotionality of material) x 2 (learning condition) mixed ANOVA was applied to this data. Thus, temporal lobe involvement did not affect overall word recall. This ANOVA also revealed no significant main or interaction effects involving the laterality factor. The main and two-way interaction effects of condition and emotionality are merely reiteration of those found in the previous analysis of the patient groups.

Additionally, however, as demonstrated in Figure 9, there is a three-way interaction among factors of temporal lobe involvement, learning condition, and stimulus emotionality. The ANOVA described above revealed that there was a trend toward significance in this interaction, $F(1,32) = 3.47$, $p = .072$. Post-hoc tests established that there were no group differences in any of the four combined conditions (GE, GN, RE, RN). Furthermore, although the generation effect occurred only for neutral material, this was similar across the two groups. Likewise, although the emotionality effect occurred only in the read condition, this was also similar for the two groups. However, as demonstrated in Figure 9, in the generate condition temporal lobe patients recalled more neutral than emotional words, while non-temporal lobe patients recalled more emotional than neutral material. Thus, the 3-way interaction is most likely indicative of the opposite pattern of performance demonstrated in the generate condition only, which is dependent upon whether or not patients had incurred temporal lobe damage.

In order to examine valence effects, another 2 (laterality) x 2 (temporal lobe

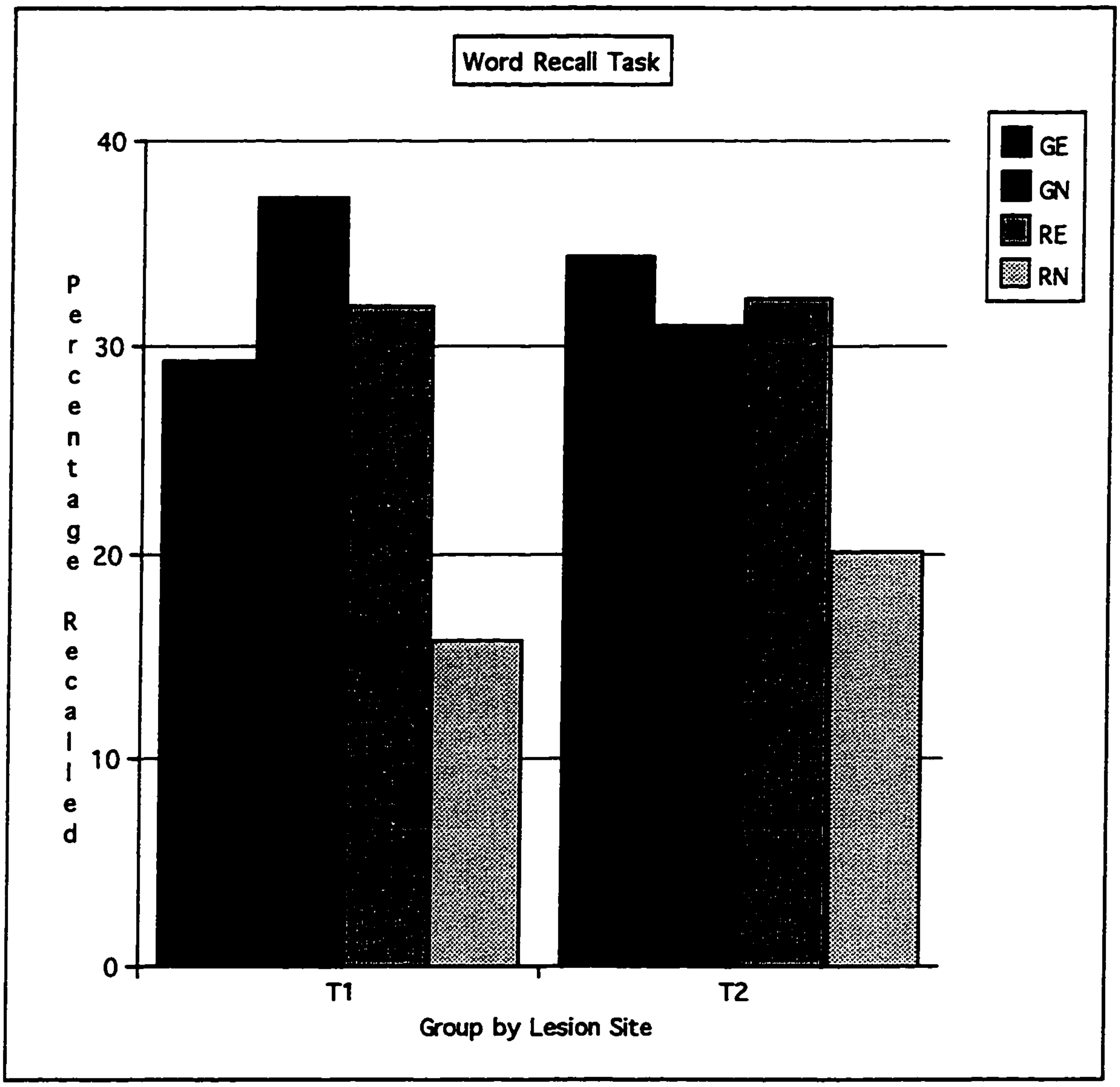

Figure 9. Mean percent of words recalled by brain-damaged subjects with temporal lobe damage (T1) and brain-damaged subjects without temporal lobe damage (T2).

GE = generate/emotional; GN = generate/neutral; RE = read/emotional; RN = read/neutral; T1 (n=16); T2 (n=20).

involvement) x 2 (condition) x 2 (valence) ANOVA was applied to the data. There were no significant main or interaction effects in this analysis (see Figure 10).

Analysis of Gender . Table 8 shows the mean recall scores for males and females in each of the within-subject conditions. We can see that in every condition, females recalled more words (overall mean = 37.43) than males (overall mean = 29.43) This main effect of gender was found to be significant (F=10.11; df=1,58; p=.002) in the 2 (Gender: male, female) x 2 (learning condition) x 2 (stimulus emotionality) mixed ANOVA applied to the data. As this analysis includes all subjects, the significant main effects of emotionality and learning condition have already been discussed. Additionally, there was no interaction between gender and emotionality. However, there was a trend toward significance for the gender x condition interaction, F (1,58) =3.26, p = .076.

As demonstrated in Table 8, the difference in recall scores between males and females was greater in the generate condition (10%-points) than it was in the read condition (5%-points). Related t-tests revealed that in the Generate condition, the effect of gender was significant , t (58) = 5.87, p =.007, while in the Read condition, the difference scores between gender groups only represented a statistical trend, t (58) = 2.50, p = .067. Thus, the gender effect (higher recall by females as compared to males) was stronger in the generate condition than it was in the read condition. In addition, post-hoc tests revealed that while the gender effect occurred for both males (t [31] = 2.23, p = .033) and females (t [27] = 3.14, p = .004), the difference between words recalled in the generate and read conditions was smaller in the males (31.51 - 27.47 = 4.04) than it was in the females (41.13 - 32.89 = 8.24). Thus, this two-way interaction also indicates that the generation effect is stronger in females than in males.

In order to examine any valence x gender interactions, a 3 (group) x 2 (gender)

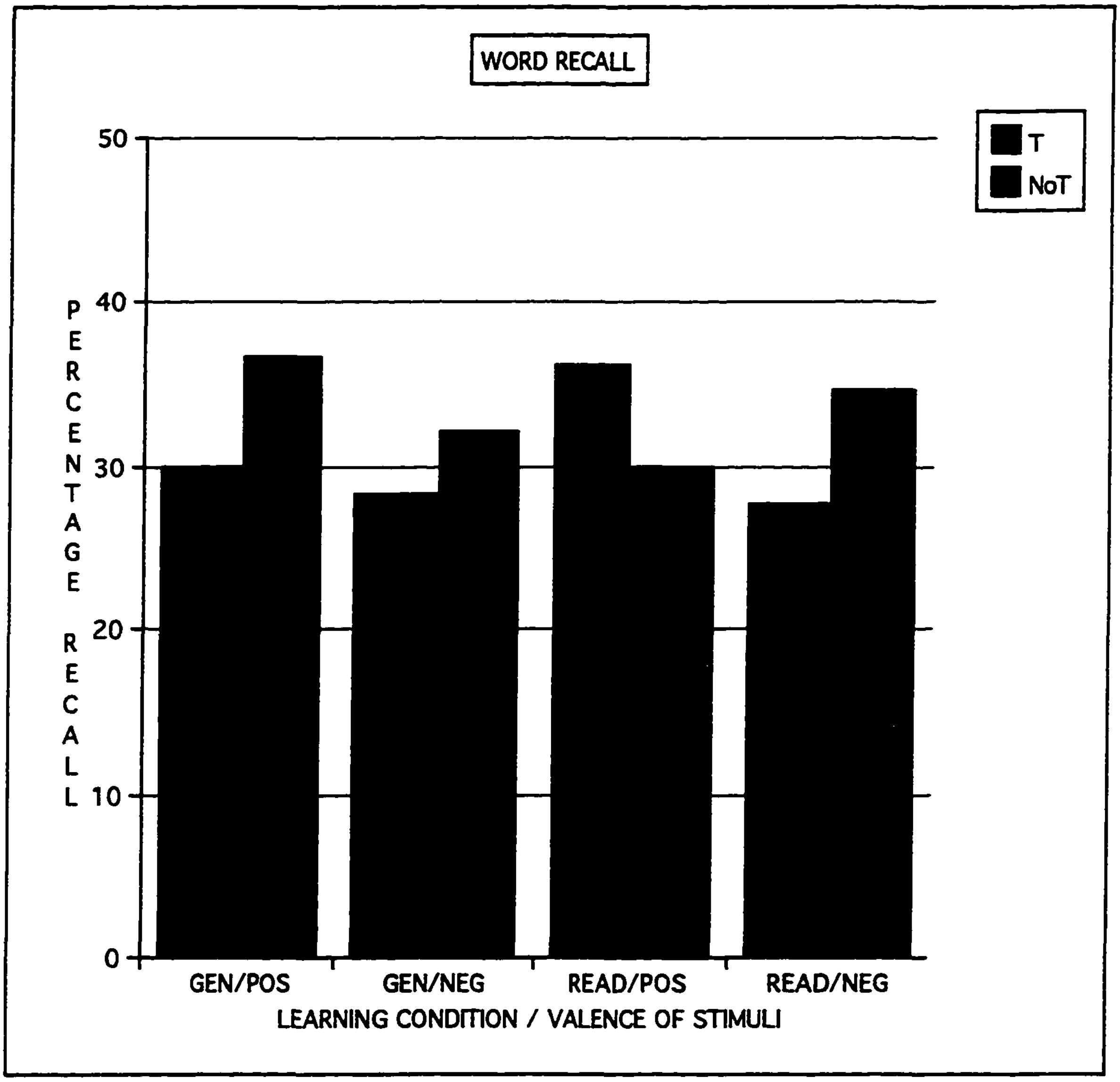

Figure 10. Percent of positive and negative words recalled by brain-damaged subjects whose lesions include the temporal lobe and brain-damaged subjects with no temporal lobe involvement.

GEN/POS = generated condition/positive words, GEN/NEG = generated condition/negative words; READ/POS = read condition/positive words; READ/NEG = read condition/negative words. T = brain-damaged subjects whose lesions involve the temporal lobe (n=16); NoT = brain-damaged subjects whose lesions do not involve the temporal lobe (n=20).

Table 8.

Mean percent of words recalled by males and females in whole sample.

	Males (n=32)	Females (n=28)
Overall Word Recall	29.43	37.43
Learning Condition		
Generate	31.51	41.14
Read	27.47	32.88
Emotionality		
Emotional	32.68	39.40
Neutral	22.85	33.26
Learning Condition / Emotionality		
Generate / Emotional	33.79	42.41
Generate / Neutral	25.78	40.63
Read / Emotional	31.56	36.38
Read / Neutral	19.92	25.89

x 2 (condition) x 2 (valence) ANOVA was applied to the data. Without neutral material, the main effect of gender represented a statistical trend, F (1,54) = 3.34; p = .073. There were no two-way interactions between gender and either learning condition or stimulus valence (See Figure 11).

In order to explore laterality x gender interactions, gender effects were also examined separately in the brain-damaged subjects (see Figure 12). The difference between genders appear similar in this analysis. This was confirmed by a 2 (laterality of lesion) x 2 (gender) x 2 (emotionality of material) x 2 (learning condition) ANOVA, where again a main effect of gender, F (1,36) =4.88, p =.034, was found indicating that female brain-damaged subjects recalled more words than male brain-damaged subjects. As in prior analyses with the brain-damaged subjects alone, the main effects of condition and emotionality were each significant, as was the interaction between them.

Also, as in the previous analysis with gender which included normal controls, there was a trend, F (1,36) = 3.90, p = .056, for the gender x condition interaction which is similarly due to the smaller score difference between genders in the read condition than in the generate condition. Additionally, there is a 3-way interaction among the factors of condition, emotionality and gender, F (1,36) = 3.44, p = .072, representing a statistical trend. Figure 12 depicts this three-way interaction. Post-hoc tests reveal that the gender effect is only maintained for neutral material learned in a generate condition, t (39) =10.94, p = .002, but not a read condition. There was no gender effect for the recall of emotional material in either learning condition. In addition, in this analysis, the generation effect was not demonstrated by male patients, and for female patients the generation effect was only maintained in the recall of neutral material, t (16) = 3.45, p = .003. The difference between recall of emotional and neutral material, however, was maintained by both genders

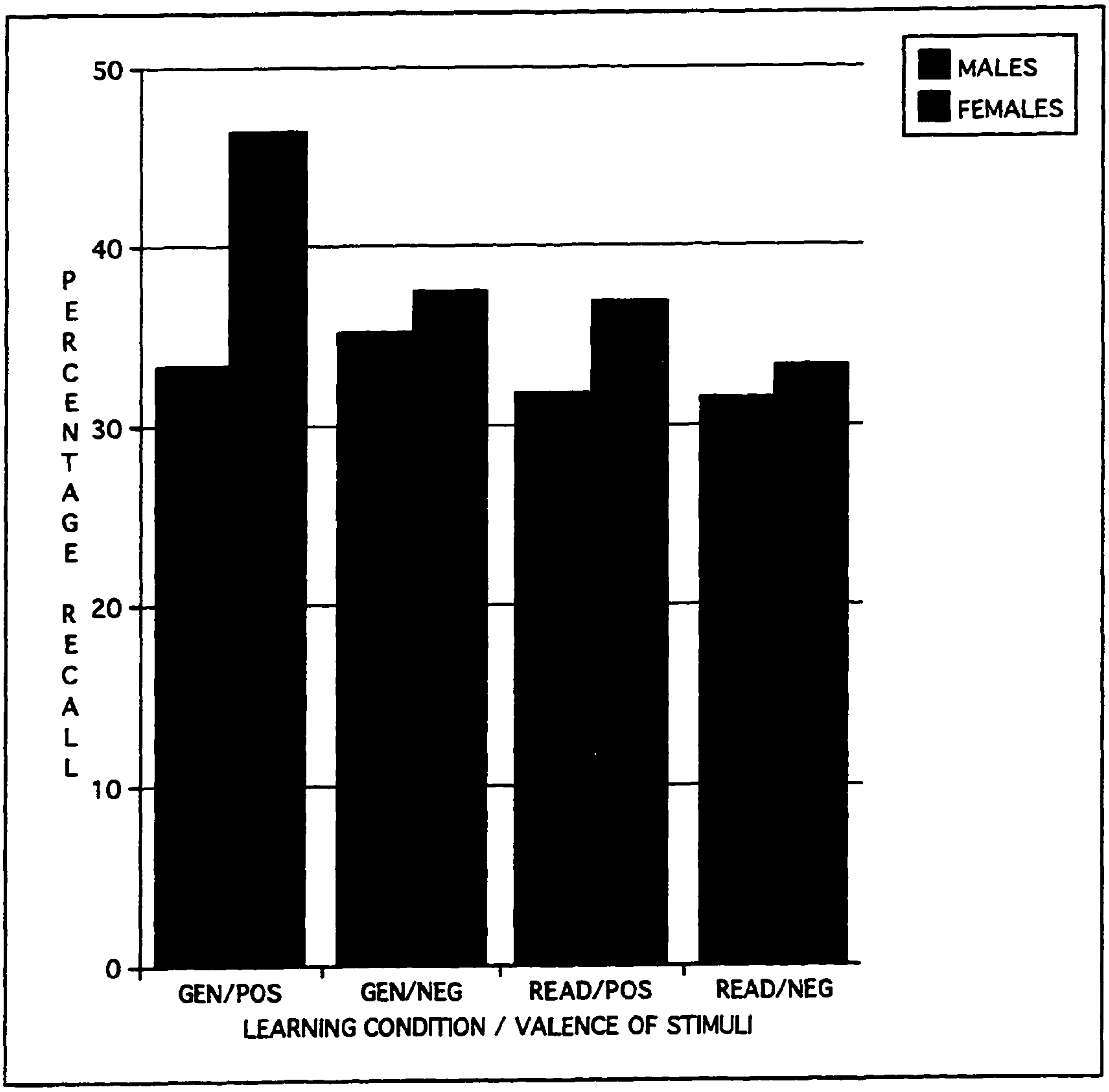

Figure 11. Percent of positive and negative words recalled by male and female subjects in generate and read learning conditions.

GEN/POS = generated condition/positive words, GEN/NEG = generated condition/negative words; READ/POS = read condition/positive words; READ/NEG = read condition/negative words. Males (n=32); Females (n=28).

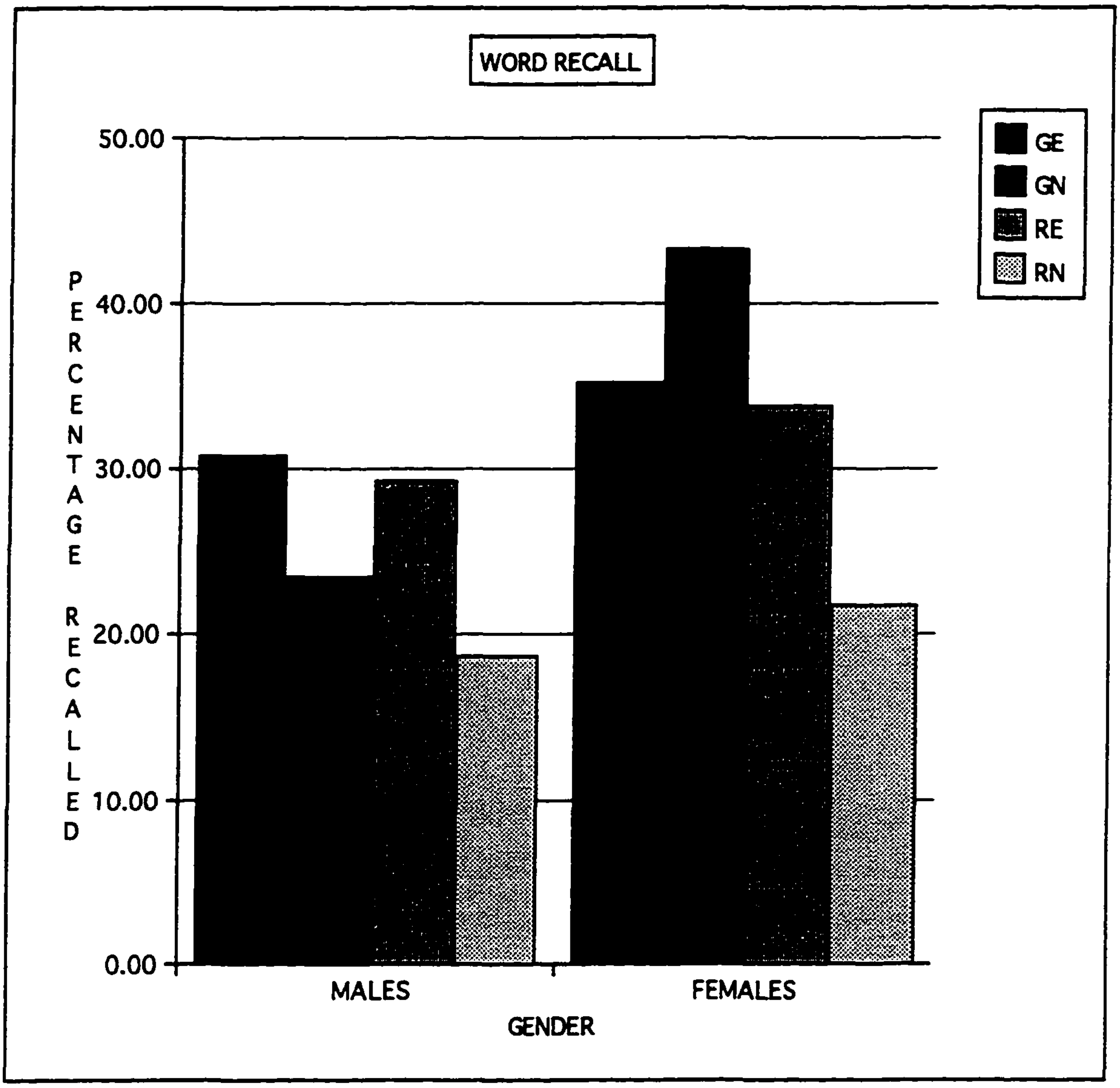

Figure 12. Mean percentage words recalled by brain-damaged males and females.

GE = Emotional / generate condition; GN = Neutral / generate condition; RE = Emotional / read condition; RN = Neutral / read condition in the read condition and by the males in the generate condition.

The influence of gender was also implicated, perhaps even more strongly, in a case-by-case analysis of the data. In this analysis, individual subjects were examined and partitioned according to their performance. That is, subjects who recalled emotional words at a higher rate than non-emotional words were compared with those subjects who recalled neutral words at an equivalent or greater rate than emotional words. These groups were examined for differences in demographic variables. Gender emerged as the most notable difference between the groups. For descriptive tables and figures of this analysis, as well as a more in-depth explanation, see Appendix K.

Gender interactions with valence were also examined in the brain-damaged sample with a 2 (laterality of lesion) x 2 (gender) x 2 (learning condition) x 2 (valence of stimuli) mixed ANOVA. There were no significant main or interaction effects in this analysis (see Figure 13). Thus, with neutral material removed from the analysis, both effects of gender and learning condition are also removed.

Performance on Word Recognition Task.

Analysis of Group. The three groups performed in a very similar manner in the recognition of previously seen stimuli (NC mean = 74.53; RBD mean = 70.31; LBD mean = 75.65). This was confirmed by the non-significant main effect of group in the 3 (Group: NC, RBD, LBD) x 2 (Learning Condition) x 2 (Emotionality) ANOVA which was applied to the data.

As seen in Figure 14, subjects recognized words at a higher rate when they had been originally learned in the Generate, rather than the Read condition. This was confirmed statistically by the significant main effect of learning condition, F $(1,55) = 75.27$, $p=0.000$, in the ANOVA described above. Figure 14 also demonstrates that emotional stimuli (mean=76.98) were recognized at a higher

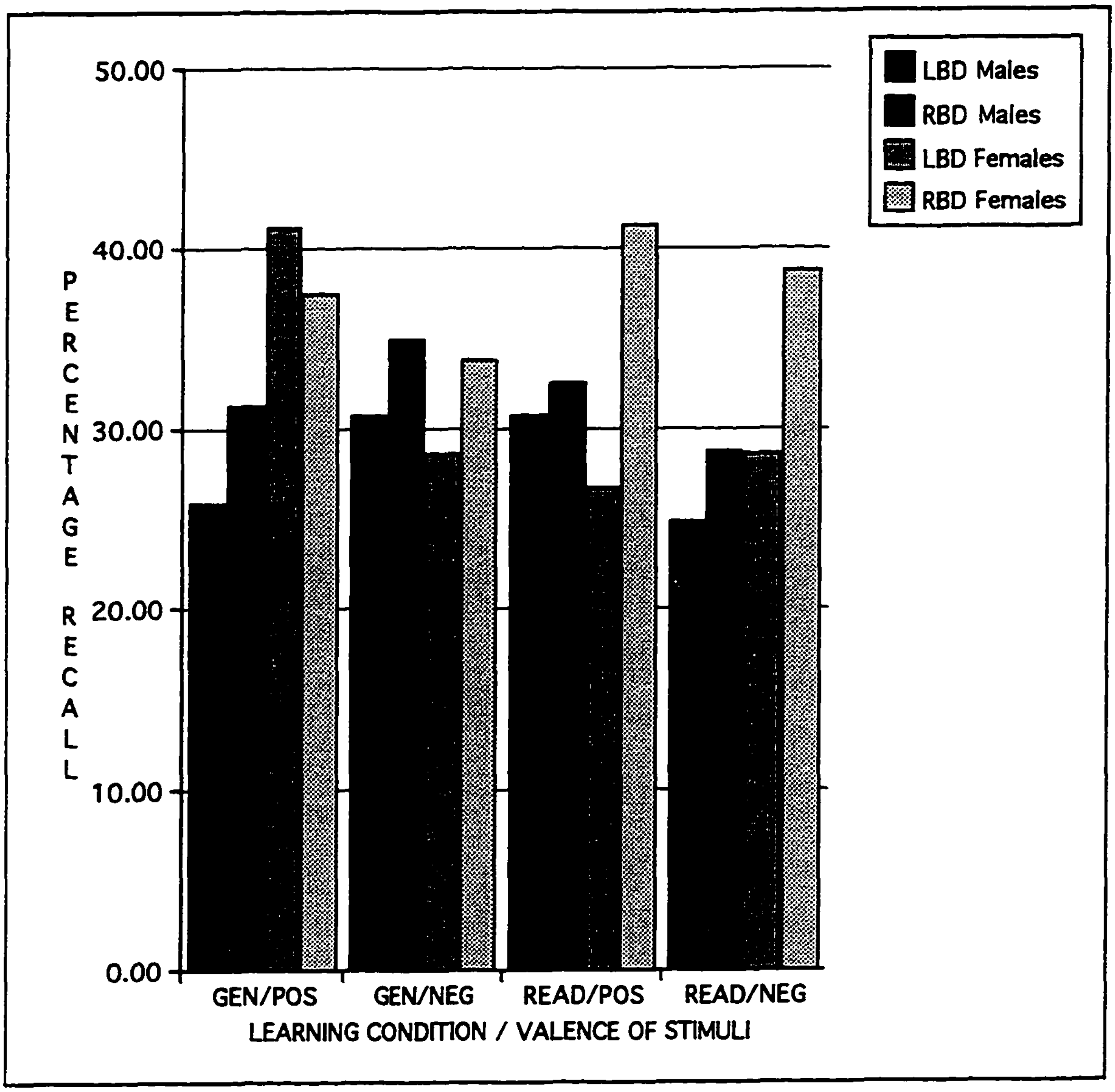

Figure 13. Percent of positive and negative words recalled by male and female patients in generate and read learning conditions.

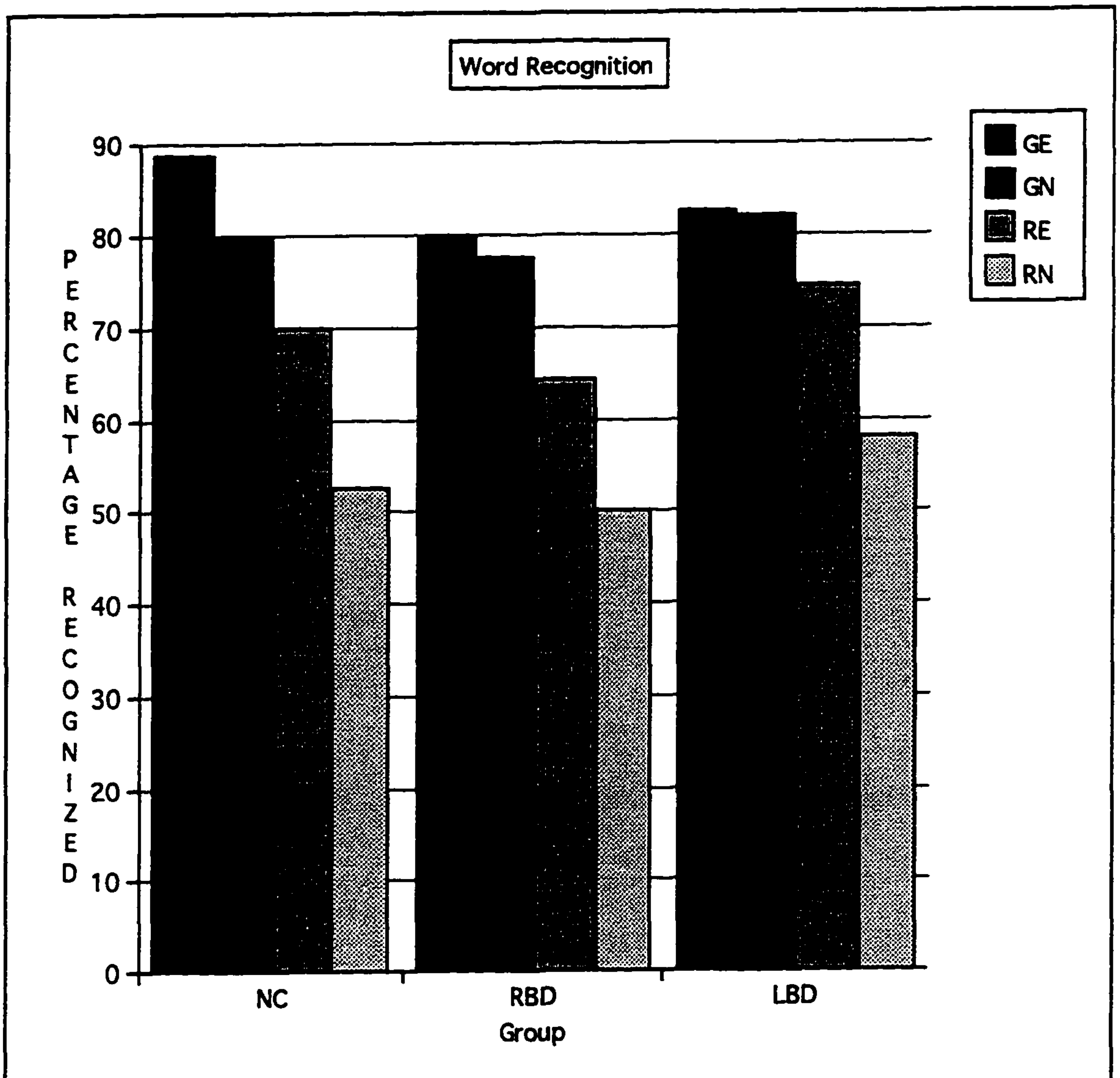

Figure 14. Mean accuracy rate for all subjects on word recognition task.

rate than neutral stimuli (mean=67.86). The significance of this difference was confirmed by the main effect of the emotionality factor in the ANOVA described above, F (1,55) = 37.08, p = .000.

Further depicted in Figure 14 is that the difference between recognition of emotional and neutral stimuli was larger when sentences were read (69.53 - 53.59 = 15.94) than when sentences were generated (83.42 - 79.48 = 3.94). Also, the difference between recognition of material learned in a generated condition and material learned in a read condition was larger for neutral stimuli (79.48 - 53.59 = 25.89) than for emotional stimuli (83.42 - 69.53 = 13.89). The significance of the interaction between learning condition and emotionality of material was confirmed by the ANOVA described above F (1,55) = 11.74, p = 0.001. Subsequent related t-tests revealed that despite this interaction, the difference between emotional and non-emotional words was significant in both the Generate, t (57) = 2.16, p = .035 and Read conditions, t (57) = 5.51, p = 0.000, and that the difference between words recognized from generate and read conditions was significant for both emotional, t (57) = 7.58, p = 0.000, and neutral words, t (57) = 6.20, p = 0.000. This interaction indicates, therefore, that the emotionality effect, while observed in both conditions, is stronger in the Read condition, and that the generation effect, while observed in both types of stimuli, is stronger for neutral words.

In order to investigate valence effects, a 3 (group: NC, RBD, LBD) x 2 (learning condition) x 2 (valence of stimuli) was applied to the emotional data (see Table 9). The main effect of condition remained and there was a trend toward significance for the effect of valence, F (1,55)=3.08, p =.085, such that positive stimuli were recognized at a higher rate than negative stimuli. There were no group effects and no interactions involving condition and valence.

Analysis of Caudality. Figure 15 depicts performance by subjects with and

Table 9.

Mean percentage scores for words recognized by normal control, left brain-damaged , and right brain-damaged subjects in all learning and emotionality conditions

	NC (n=19)	RBD (n=19)	LBD (n=20)
Generate / Positive	90.13	78.95	85.00
Generate / Negative	86.84	79.61	80.00
Generate / Emotional	88.49	79.28	82.50
Generate / Neutral	79.61	76.97	81.88
Read / Positive	74.34	65.79	74.38
Read / Negative	65.79	62.50	74.38
Read / Emotional	70.07	64.14	74.38
Read / Neutral	52.63	50.00	58.12

without frontal lobe involvement in each of the learning and emotionality conditions on the recognition task. This figure demonstrates that those without frontal lobe damage recognized more words (mean = 78.20) than the group with frontal damage (mean = 68.53). Additionally, the difference between the two groups is much larger in the Read condition (72.81 - 58.33 = 14.48) than in the Generate condition (83.55 - 78.72 = 4.83). When a 2 (laterality of lesion: right, left) x 2 (caudality of lesion: frontal lobe involvement, no frontal lobe involvement) x 2 (learning condition: generate, read) x 2 (emotionality of material: emotional, neutral) ANOVA was applied to this data, the significance of the caudality factor, $F(1,33) = 4.52$, $p = .041$, and the interaction between caudality and condition, $F(1,33) = 4.47$, $p = .042$, was confirmed.

Related t-tests revealed that although the effect of sentence generation was stronger for the patients with frontal damage than for those patients with circumscribed posterior lesions, the differences between the generate and read data were significant for both patient groups. However, the effect of caudality was only significant in the Read ($t[36] = 7.1$, $p = .011$), and not in the Generate ($t[36] = .58$, $p = .362$) condition. As there were no main effects or interactions with the laterality factor, the main and interactive effects of caudality were similar in subjects with right and left brain damage.

Figure 15 also depicts findings that are similar to those of the total sample. That is, we see that emotional material (mean = 75.22) was recognized better than neutral material (mean = 68.53) and that words in the generate condition (mean = 80.53) were better recognized than words in the read condition (mean = 65.23). Additionally, we see the interaction between learning condition and emotionality, such that the difference between recognition scores for emotional items and neutral items is larger in the Read condition (61.11 - 46.53 = 14.58) than in the Generate

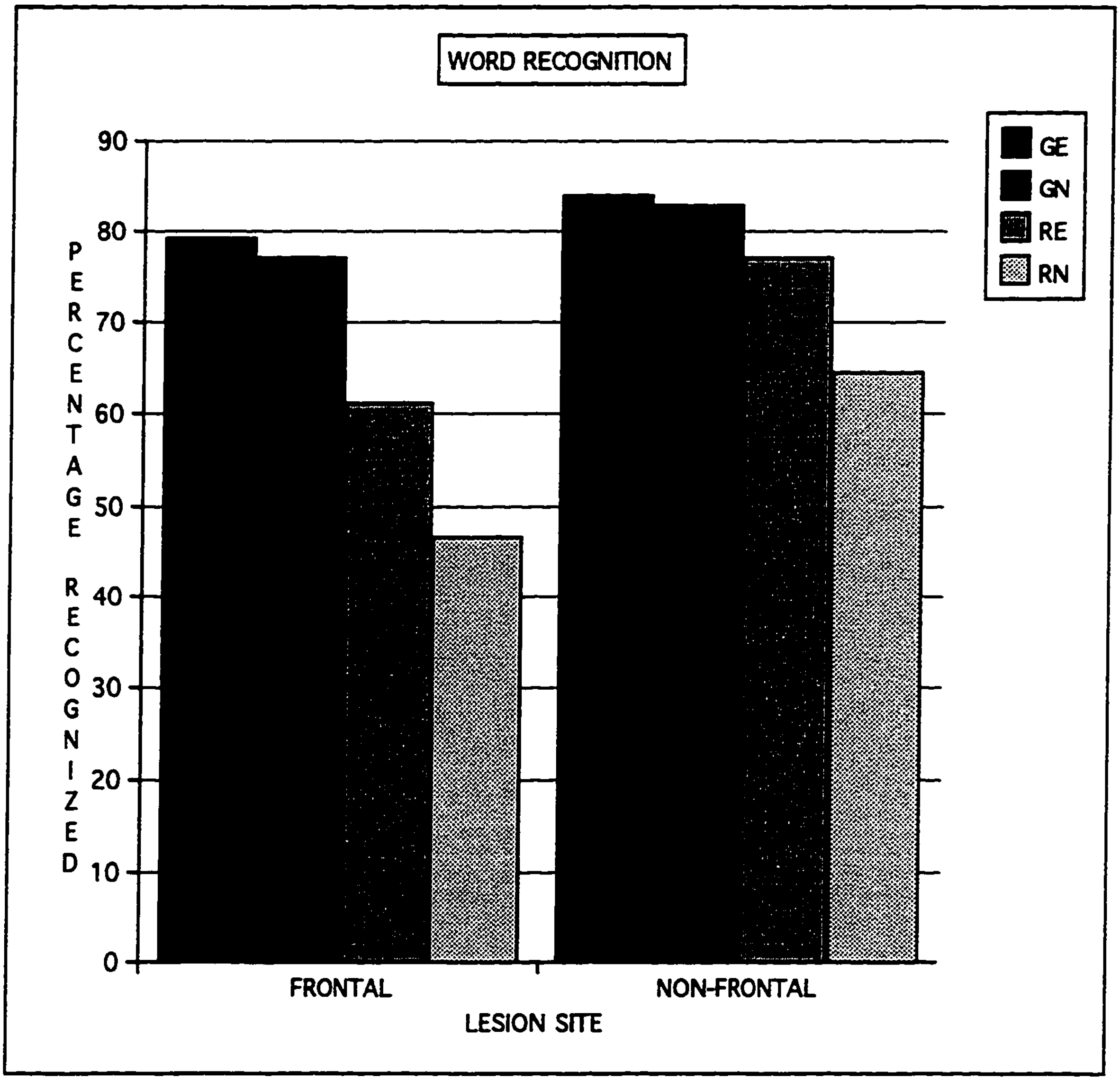

Figure 15. Mean percent of words correctly recognized by patients with frontal lesions and by patients without frontal lesions.

Frontal lobe patients (n=19); Non-frontal lobe patients (n=19).

condition (79.17 -77.08 = 2.09). The main effects of condition, F (1,33) = 49.32, p = .000, and emotionality, F (1,33) = 9.91, p = .003, and the two-way interaction between these factors, F (1,33) = 5.52, p = .025, were confirmed in the ANOVA (described above) applied to this data. In this analysis which includes only the brain-damaged patients, the follow-up analyses were more clear-cut than with the total sample. Related t-tests revealed that the difference between the recognition of words learned in the generate and read conditions was significant for both emotional (t [38] = 4.82, p = .000) and neutral (t [38] = 4.82, p = .000) words. Related t-tests within each condition also revealed that the difference between mean recognition scores for emotional and neutral words was significant in the Read condition, t (36) = 3.52, p = .001, but not in the generate condition, t (36) = .55, p = .586. The laterality factor was, again, not significant in any main or interactive effects.

In terms of valence effects, the recognition scores for positive and negative words were very similar. This was confirmed by a 2 (laterality of lesion: right, left) x 2 (caudality of lesion: frontal lesion, no frontal lesion) x 2 (valence: positive, negative) x 2 (learning condition: generate, read) ANOVA, which revealed that there were no main effects or interactions involving valence. This is different from the analysis including the normal control group, where there was a trend for valence effects (with more positive than negative words recognized) in the recognition of old stimuli. There was also a main effect of caudality which simply indicated that even with the neutral words removed, the group with anterior damage (mean = 70.89) recognized fewer words than the group with posterior damage only (mean = 80.43).

Analysis of temporal lobe involvement. Figure 16 depicts the performance of the right and left brain-damaged patients with and without temporal lobe involvement in all experimental conditions on the recognition task. As we can see from this figure, in the Generate condition, words are recognized at a similar rate across sub-groups and, as in the analysis above, there is no difference in recognition rate between emotional and neutral material in this Generate condition. In the Read condition, we see that the increase in recognition of emotional material is exhibited by three of the patient sub-groups (left and right brain-damaged patients with temporal lobe involvement and left brain-damaged patients no temporal lobe damage). The patients with right-hemisphere, non-temporal lobe damage, by contrast, recognized more words in the read/neutral condition than in the read/emotional condition.

The significance of these observations was confirmed by the 2 (temporal lobe involvement) x 2 (laterality: right, left) x 2 (learning condition: read, generate) x 2 (stimulus emotionality (emotional, neutral) ANOVA applied to the data. Although two- and three-way interactions were found, these were viewed as unimportant (although interested readers may see Appendix L) in light of the four-way interaction among temporal involvement, laterality of lesion, emotionality of material, and learning condition, $\underline{F}(1,31) = 8.03$, $\underline{p} = .008$. Multiple t-tests confirmed that the difference in recognition rate between emotional and neutral material in the Read condition was significant in all patient sub-groups, with the exception of the patients with non-temporal lobe, right hemisphere damage.

Additionally, in Figure 16 we see that the group with right temporal lobe damage (RBD-T1) performed much more poorly in the read/neutral condition than the other three groups. A subsequent one-way ANOVA for the four groups in the read/neutral condition confirmed that this difference was significant, $\underline{F}(3,31) = 2.94$, $\underline{p} = .048$. A post-hoc comparison of the means, using the conservative Tukey test (HSD), revealed that differences in recognition in the read/neutral condition were

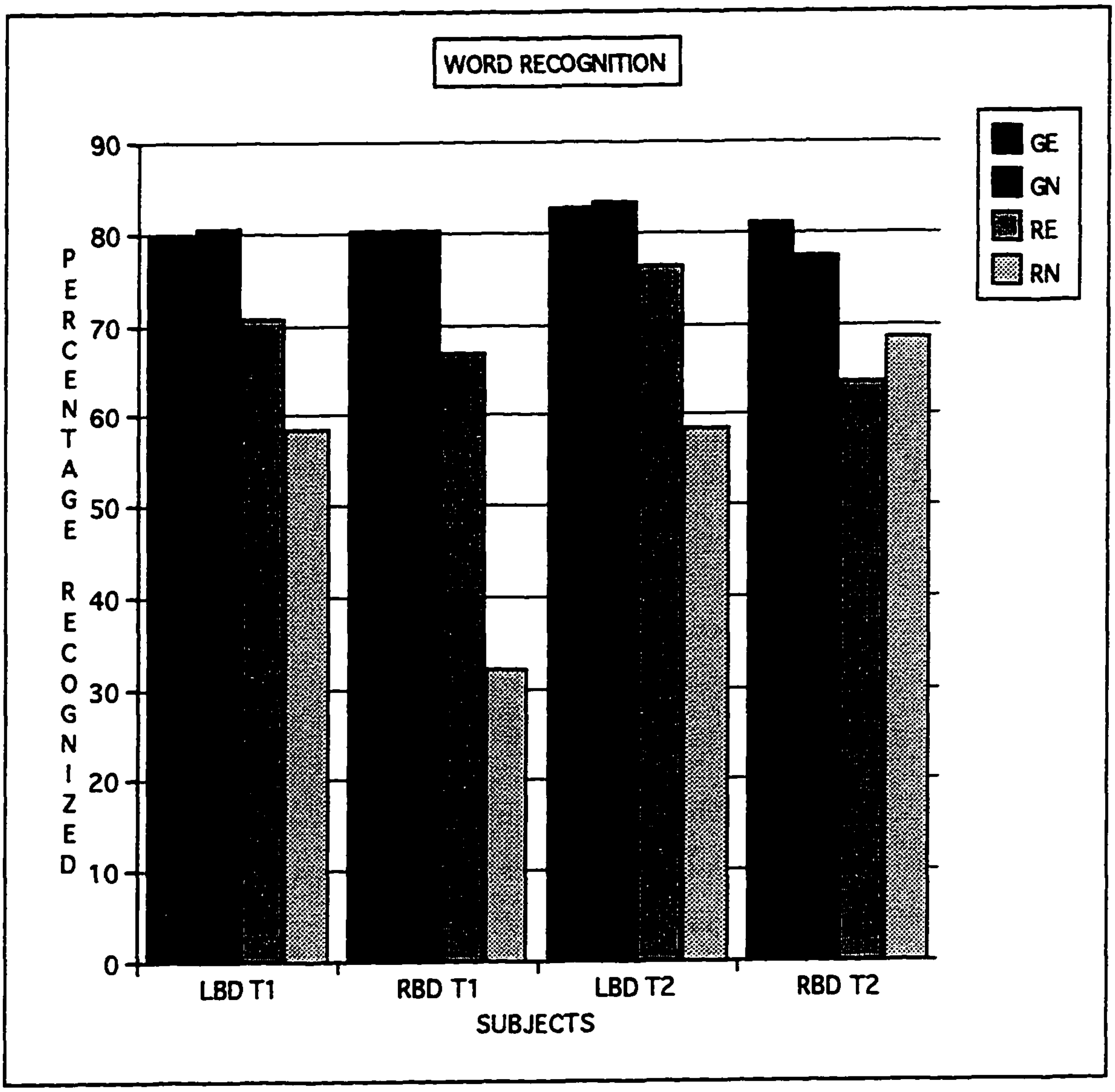

Figure 16. Accuracy Rate on the word recognition task by the right and left brain-damaged patients with (T1) and without (T2) temporal lobe lesions.

GE = Emotional / generate; GN = Neutral / generate;RE = Emotional / read; RN = Neutral / read only significant between the two types of patients with right hemisphere damage. That is, the patients with left-sided temporal lobe damage recognized the same percentage of words in this condition as their non-temporal lobe counterparts (mean = 58.33 for both groups), while the patients with right-temporal lobe damage performed much worse (mean = 32.14) than their non-temporal lobe counterparts (mean = 68.75).

When stimulus valence was analyzed across learning condition in these patients, there were no main or interactive effects of valence in the 2 (temporal lobe involvement) x 2 (learning condition) x 2 (stimulus valence) ANOVA applied to the data. The only significant effect was that of learning condition.

Analysis of Gender. When gender effects were explored on the recognition task, with a 3 (group: NC, RBD, LBD) x 2 (gender: male, female) x 2 (learning condition: generate, read) x 2 (emotionality of material: emotional, neutral) mixed ANOVA, there were no main or interactive effects involving the gender factor. Similarly, when the patients were analyzed separately to explore laterality x gender interactions, the results of the 2 (lesion laterality) x 2 (gender) x 2 (learning condition) x 2 (stimulus emotionality) mixed ANOVA applied to the data were all in the same direction as those described above and thus, for brevity, these results are not described again, but can be viewed in the summary table of analyses involving emotionality (see Appendix L).

In terms of valence effects across the two genders, two additional ANOVAs were applied to the emotional recognition data. The first was a 2 (gender) x 2 (learning condition) x 2 (valence) mixed ANOVA, involving the total sample, which revealed no gender or valence effects. The second was a 2 (laterality of lesion) x 2 (gender) x 2 (learning condition) x 2 (valence) ANOVA with just the patients and, as with the analysis including the normal control group, the only significant effect was that of learning condition.

Sentence Recall Task

Analysis of Group. Table 10 shows the percentage of sentences recalled by each of the groups in the total sample. As seen in this table, subjects elicited full-credit responses more often than partial-credit responses, t (58) = 5.48, p = 0.000. (See Methods section for a complete description of scoring procedures.) Although we originally planned to present the scores for full-credit responses and partial-credit responses separately, the important effects under investigation were identical in both credit types, and thus, for simplicity, these scores were weighted equally and added together. Thus, the scores in all of the analyses on sentence recall data reflect the percentage of sentences recalled, regardless of whether they were recalled fully or partially.

Figure 17 depicts performance of each of the primary groups in each condition. As demonstrated in this figure, the groups recalled sentences at a similar rate overall. This was confirmed by a non-significant main effect of group in the 3 (group: NC, LBD, RBD) x 2 (learning condition: generate, read) x 2 (emotionality: emotional, neutral) mixed ANOVA conducted on these data. As further seen in Figure 17, there is a large difference between the recall of generated and read sentences in both emotional and non-emotional conditions. All groups recalled generated sentences at a much higher rate than read sentences. This was confirmed by the significant main effect of learning condition, F (1,56) = 95.38, p = 0.000, in the ANOVA described above. Thus, subjects recalled over half of the sentences they had generated (58%), but less than a quarter of the sentences they had read (19%).

Furthermore, unlike the findings in the two tasks involving memory for stimulus *words*, the difference between recall of emotional and non-emotional sentences

Table 10.

Mean percent of sentences recalled by normal control subjects, left brain-damaged subjects, and right brain-damaged subjects.

	NCs (n=20)	RBDs (n=19)	LBDs (n=20)
Total Recall	44.17	37.72	33.62
Full Credit Rating	31.25	27.85	21.25
Half Credit Rating	12.92	9.87	15.33
Total Positive	45.00	37.50	33.75
Total Negative	43.75	38.16	35.62
Total Emotional	44.38	34.69	37.83
Total Neutral	43.12	37.50	31.88
Total Generate	63.78	55.48	54.58
Total Read	25.00	19.30	13.75

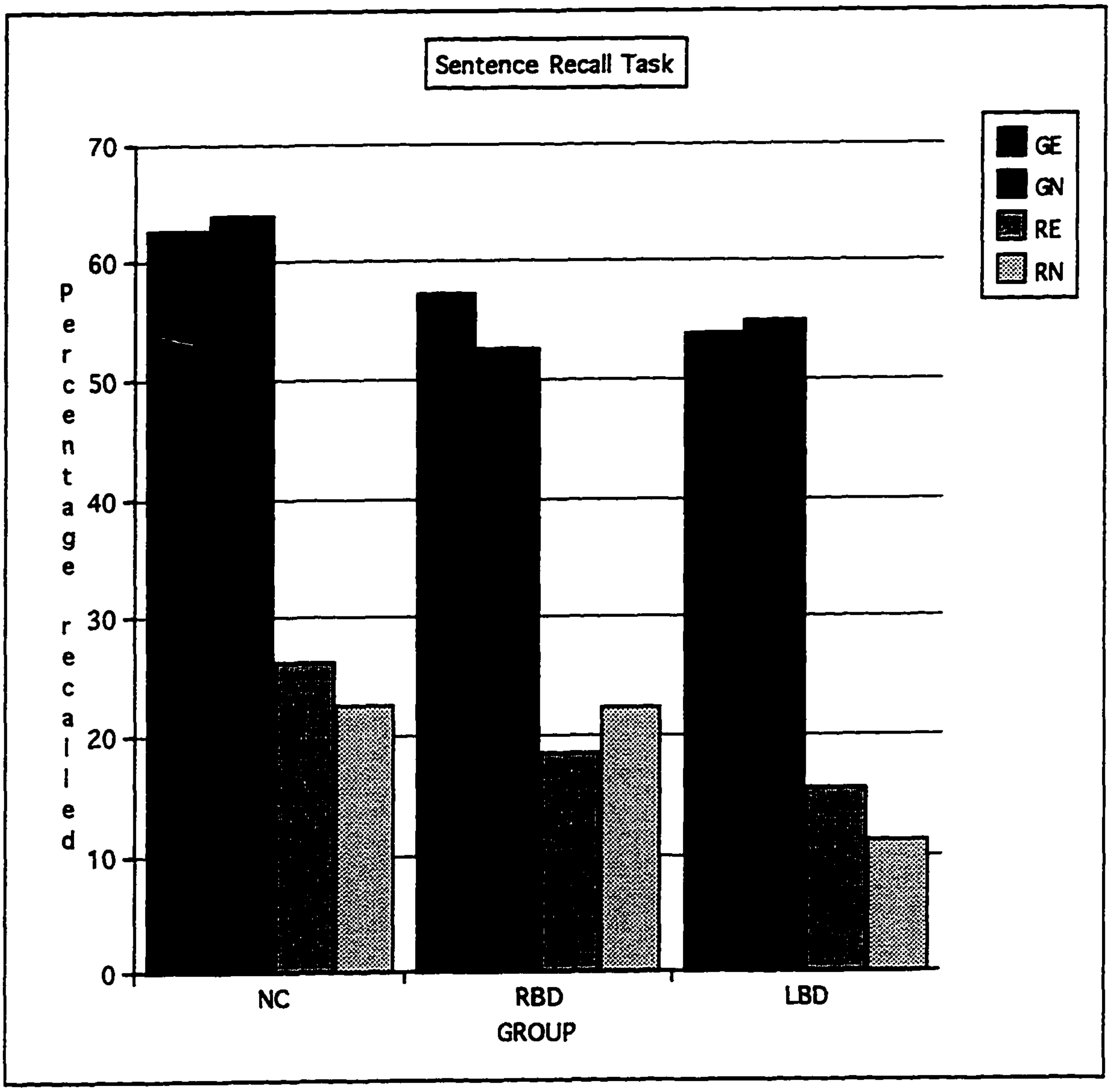

Figure 17. Mean percent of sentences recalled by normal control, right brain-damaged, and left brain-damaged subjects.

GE = Emotional stimuli / generate condition; GN = Neutral stimuli / generate condition; RE = Emotional stimuli / read condition; RN = Neutral stimuli / read condition was quite small. Subjects recalled approximately 38% of the original sentences, regardless of their emotional content. This was confirmed by a non-significant main effect of emotionality. There was also no interaction between learning condition and emotionality of material.

In terms of valence, Table 10 demonstrates that there were also no overall differences in the recall of positive and negative sentences. This was confirmed by a 3 (group: NC, LBD, RBD) x 2 (learning condition: generate, read) x 2 (valence: positive, negative) mixed ANOVA applied to the data. As in the analysis involving emotionality, the only significant effect was that of learning condition. Thus, none of the groups exhibited valence effects on this task.

Analysis of Caudality. Table 11 shows the mean sentence recall scores in each condition for brain-damaged subjects with and without frontal lobe damage. Although there were some differences in overall recall among these patient types, neither laterality nor caudality effects were significant in the 2 (caudality: frontal, nonfrontal) x 2 (laterality: right, left) x 2 (learning condition: generate, read) x 2 (emotionality of material: emotional, neutral) mixed ANOVA applied to this data. As seen in Table 11, the brain-damaged patients achieved overall scores and patterns of scores which are similar to those seen when the analysis included normal controls. This is in contrast to the additional findings (i.e., interactions) that were revealed in the word recall task when the brain-damaged subjects were analyzed separately. Thus, as we see, and as confirmed by analysis, there were no significant differences in the recall of emotional and neutral sentences and generated sentences were recalled at a higher rate than read sentences, $F(1,33) = 67.95$, $p = 0.000$.

As seen Table 11, positive and negative sentences were also recalled at a similar rate. A 2 (laterality of lesion: right, left) x 2 (caudality of lesion: frontal,

Table 11.

Mean percent of sentences recalled by brain-damaged subjects with lesions in both anterior and posterior regions, and brain-damaged subjects with posterior lesions only.

	Anterior/Posterior (n=18)	Posterior (n=19)
Total Recall	38.75	32.89
Positive	38.19	32.90
Negative	38.89	34.87
Emotional	39.58	33.89
Neutral	38.54	30.93
Generate	58.33	52.63
Read	18.52	14.48
Generate / Emotional	56.88	54.33
Generate / Neutral	59.38	50.71
Read / Emotional	19.68	14.42
Read / Neutral	17.19	15.06

nonfrontal) x 2 (learning condition: generate, read) x 2 (valence of stimuli: positive, negative) mixed ANOVA applied to the data confirmed that the valence variable did not have a significant effect upon these results and that only the effect of learning condition was significant.

Analysis of Temporal Lobe Involvement. Table 12 lists the sentence recall scores for patients with temporal and non-temporal lobe lesions of the right and left hemisphere. As demonstrated, those patients with temporal lobe damage recalled fewer sentences overall than subjects with no temporal lobe damage in each of the emotionality and learning conditions. The significance of this finding was confirmed by a 2 (laterality of lesion) x 2 (temporal lobe involvement) x 2 (learning condition) x 2 (emotionality of material) mixed ANOVA, which revealed an effect of temporal lobe involvement, $F(1,33) = 4.07$, $p = .052$, and no significant interaction of temporal lobe involvement with either emotionality of material or learning condition. There was no effect of laterality and, thus, the temporal lobe effect occurred similarly in left and right brain damaged patients.

Figure 18 depicts the mean percentage of positive and negative sentences recalled by patients with and without temporal lobe damage in each of the encoding conditions. We see here, again, that patients with temporal lobe involvement recalled fewer emotional sentences overall. We also seen that this is the case for each valence and encoding condition. However, it is obvious that the difference between sentence recall scores is greatest in the read/positive condition. These observations were confirmed by the 2 (laterality) x 2 (temporal lobe involvement) x 2 (learning condition) x 2 (valence) ANOVA applied to the emotional data. The significant main effects of temporal lobe damage and learning condition were described previously. In addition, there was no main effect of valence and no two-way interaction between valence and condition, or valence

Table 12.

Mean percent of sentences recalled by brain-damaged subjects with temporal lobe involvement, and brain-damaged subjects with no temporal lobe involvement.

	T1 (n=15)	T2 (n=20)
Total Recall	28.01	40.59
Positive	26.74	41.23
Negative	30.91	39.65
Emotional	28.82	40.44
Neutral	27.09	40.91
Generate	46.76	59.89
Read	9.96	21.30
Generate / Emotional	46.88	58.52
Generate / Neutral	45.14	62.63
Read / Emotional	10.76	22.35
Read / Neutral	11.81	19.19

Note. T1 = patients with temporal lobe damage; T2 = patients with non-temporal lobe damage.

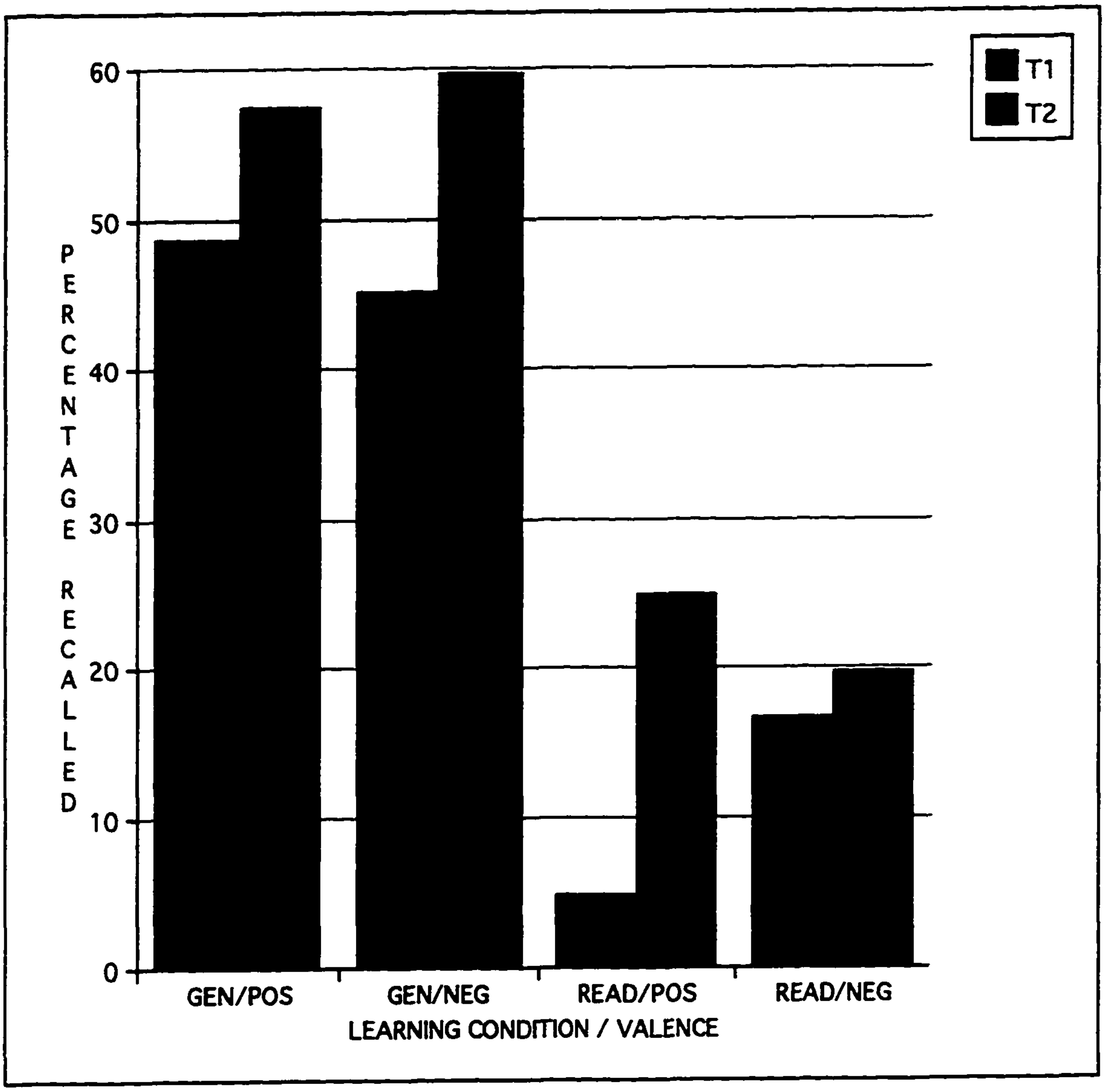

Figure 18. Percentage of sentences recalled in each condition by patients with (T1) and without (T2) temporal lobe damage.

Gen = generate; Pos = positive; Neg = negative and temporal lobe involvement. However, there was a trend for the three way interaction between valence, temporal lobe involvement, and condition, F (1,31) = 3.17, p = .085.

Related t-tests revealed that there was no valence effect in either learning condition, and that for both positive and negative material generated sentences were recalled more often than read sentences. Furthermore, in three of the four conditions involving both within-subject factors (i.e., generate/positive, generate/negative, read/negative) the difference in recall scores between the two patient sub-groups was not significant. As observed, only in the read/positive condition was the performance of patients with temporal lobe damage (mean = 5.00) significantly worse than that of the patients without temporal lobe damage (mean = 25.00), t (1,33) = 12.57, p = .001. As the laterality of lesion variable was not significant, we can conclude that subjects with both right and left temporal lobe lesions exhibited poor performance in the read/positive condition.

Analysis of Gender. The mean sentence recall scores for males and females are presented in Table 13. Although females recalled more sentences than the males, this difference was not statistically significant. Furthermore, each gender exhibited the same effects displayed by the total sample on this task (i.e., a generation effect, but no emotionality effect). This was confirmed statistically by the lack of significant interactions involving the gender variable in the 2 (gender) x 2 (emotionality) x 2 (learning condition) mixed ANOVA applied to the data.

The mean sentence recall scores for brain-damaged males and females are presented in Table 14. Again, although the females recalled more sentences, the main effect of gender was not statistically significant. A 2 (laterality of lesion) x 2 (gender) x 2 (learning condition) x 2 (emotionality) ANOVA also revealed a significant gender x laterality interaction, F (1,35) = 4.00, p = .053. Post-hoc

Table 13.

Mean percent of sentences recalled by male and female subjects in the entire sample.

	Females (n=27)	Males (n=32)
Total Sentence Recall	41.51	35.99
Positive	43.52	34.77
Negative	39.82	38.67
Emotional	41.67	36.72
Neutral	41.20	34.38
Generate	62.98	53.78
Read	20.99	17.97
Generate / Emotional	62.50	53.91
Generate / Neutral	62.04	53.13
Read / Emotional	20.83	15.93
Read / Neutral	22.22	15.63

Table 14.

Mean percent of sentences recalled by brain-damaged male and female subjects.

	Females (n=16)	Males (n=23)
Total Sentence Recall	37.24	34.49
Positive	39.06	33.15
Negative	35.94	37.50
Emotional	37.50	35.33
Neutral	37.50	32.61
Generate	59.38	51.99
Read	16.67	16.30
Generate / Emotional	59.38	52.72
Generate / Neutral	57.81	51.09
Read / Emotional	15.63	17.94
Read / Neutral	20.31	14.13

analyses indicated that there were no gender differences in the recall of either LBD or RBD groups on this task, but that females with left-sided brain damage recalled fewer sentences than females with right brain damage, $t(15) = 5.27$, $p = .038$, whereas the two male brain-damaged groups performed similarly, $t(22) = .579$, $p = .455$.

In order to investigate possible interactions between gender and valence effects in sentence recall, two additional analyses were applied to the data. A 2 (gender: male, female) x 2 (learning condition: generate, read) x 2 (valence: positive, negative) ANOVA was applied to the data from the total sample and a 2 (gender) x 2 (laterality of lesion) x 2 (learning condition) x 2 (valence) mixed ANOVA was applied to the data from the patients only. Neither analysis revealed any main or interactive effects of either gender or valence factors (see Appendix M for details).

Correlational Analyses

Analysis of verbal fluency and memory.

Table 15 lists the Pearson's product moment correlations between the scores from the neuropsychological tasks assessing verbal fluency (FAS and Animal Naming) and memory (LM I, LM II, and MDRS-Mem) with an index of the generation effect from each of the experimental tasks (see Method section for this equation). As seen in this table, out of the 15 correlations none are significant. Therefore, performance on verbal fluency and memory tasks was not related to the effect of generation and thus we did not analyze this data any further.

Analysis of mood-dependent memory

Table 16 lists the computed correlation coefficients between measures of mood and overall performance, as well as the significance of these values. Also presented in Table 16 are correlations between measures of mood and measures

Table 15.

Correlations between measures of fluency and memory and an index of the effect of sentence generation.

	FAS	ANIMALS	LM II	LM 1	MDRS-MEM
Word Recall GQ	.17	.21	-.03	-.05	- .13
Word Recognition GQ	.06	.19	-.02	.11	-.04
Sentence Recall GQ	.13	-.12	-.04	-.11	.10

Note. Numbers in cells are Pearson product moment correlation values (r); *$p<.05$
GQ = materials remembered that were originally learned in generate condition minus the materials remembered that were originally learned in the read condition divided by the total correct responses.

Table 16.

Correlations between measures of mood and performance on experimental tasks.

	PANAS POS	PANAS NEG	BDI
Overall Word Recall	-.089	-.303*	-.154
Overall Recognition - Hits	.182	-.125	-.139
Overall Sentence Recall	-.021	.005	-.065
Recall - Positive Words	-.077		
Recognition - Positive Hits	.259*		
Recall of Positive Sentences	.045		
Recall - Negative Words		-.419**	-.210
Recognition - Neg Hits		-.082	-.134
Recall - Neg Sentences		.053	-.152

Note. Numbers in cells represent the Pearson product moment correlation (r); *=p<.05; **=p<.01; T = p<.10;

of memory for stimuli of matching valence type. Negative mood states as assessed by the PANAS correlated in a negative direction with overall word recall and with the recall of negative words. Negative mood states as assessed by the PANAS, were not, however, correlated with scores on either of the other two experimental tasks.

We can also see by examining this table, that positive mood states as assessed by the PANAS were correlated in a positive direction with recognition of positive words on the Word Recognition task, but not with the overall results on any task, or with the scores for positive material on either of word or sentence recall. Depressive symptomatology (as assessed by the BDI) did not correlate with overall performance on any of the experimental tasks, nor did it correlate with memory for negative words or negative sentences. Thus, memory on the experimental tasks was not related in any consistent way to mood at time of testing.

Analysis of Additional Subject Variables

The correlation matrix presented in Appendix O lists the values of Pearson's product moment correlation coefficients (r) between the measures of cognitive ability, mood, personality, demographic factors, and an index of each of the experimental effects on each of the retrieval tasks (See methods section for description of indices). Each value represents a measure of the relationship between two of the variables in the matrix.

An examination of this matrix reveals that the standardized measures of cognitive ability are highly inter-correlated, as are the demographic measures of education and occupation. However, the last six rows of the matrix are of greatest interest and indicate that there are few significant relationships between subject variables and experimental effects (5 out of a possible 66 correlations with EQ, and 1 out of a possible 66 correlations with GQ).

It is possible that these few relationships are meaningful. However, given the number of correlations obtained in this analysis, the significant correlations may have also been obtained by chance. Furthermore, some of the significant correlations using similar variables were in opposite directions. For example, the significant correlation between the personality measure of rigidity and an index of the emotionality effect was positive on the word recall task and negative on the sentence recall task. Besides rigidity, there was no other measure which correlated with an experimental effect on more than one task. Thus, although we planned to conduct a regression analysis using a sub-set of these variables, our failure to find consistent relationships between indices of the experimental effects and variables reflecting individual differences suggested that no further investigation of these latter variables was warranted.

Discussion

One of the primary goals of this study was to demonstrate that subjects with right hemisphere brain damage would fail to exhibit the enhancing effect of stimulus emotionality, as compared to normal control subjects and left hemisphere brain-damaged subjects, who were expected to demonstrate better memory for emotional words than non-emotional words. Such findings would have supported the theory that the right hemisphere is dominant for emotional processing. Our results did not support this theory. The three primary groups under investigation were affected by alterations in stimulus emotionality in much the same way. That is, all groups exhibited the emotionality effect (better memory for emotional words) in both the word recall and word recognition task and no emotionality effect was obtained by any of the groups on the sentence recall task.

Another goal of this study was to demonstrate that subjects with left brain damage and particular verbal deficits would fail to obtain the enhancing effect of sentence generation. Such findings would have supported theories emphasizing the importance of lexical activation, semantic memory, and the enhanced meaningfulness of generated material. Our results did not support these theories. We found that subjects exhibited increased memory performance when learning occurred in a generate condition, regardless of presence or laterality of brain damage, and regardless of functional impairments assumed to have impinged upon sentence generation in the study phase.

A third goal of this study was to examine whether the two memory-enhancing effects, one a manipulation of stimulus word type, the other a manipulation of learning condition, would interact in healthy and brain-damaged individuals. We found that the emotionality and sentence generation effects often interacted, and that this interaction was further influenced by subject and task variables. The interaction of these two effects may be described as a suppressive phenomenon. That is, the effect of sentence generation appears to suppress the effect of emotionality. Similarly, but to a lesser extent, the effect of stimulus emotionality suppresses the sentence generation effect. Interpretation of these interactions are discussed in detail following the separate discussions of each memory-enhancing phenomenon.

The Effect of Stimulus Emotionality

Discrepant with our predictions, the results did not provide evidence of right hemisphere dominance for emotional memory. The three primary groups exhibited the emotionality effect (better memory for emotional words) in both the word recall task and the word recognition task. There was no emotionality effect exhibited by any of these groups on the sentence recall task.

One possible explanation for the emotionality effects focuses on an intervening arousal mechanism between the emotional components of stimuli and their effect on memory. That is, emotional words may be more arousing than neutral words, and hence easier to recall or recognize in later testing situations. The findings of Strauss (1983) may be interpreted as supportive of an intervening mechanism of arousal. She found that emotional words were read both faster and more accurately than non-emotional words. In the analysis of false alarms (see Appendix Q) we also found an effect of emotionality which we similarly explained by arousability.

If we utilize this "intervening arousal theory" and if we analyze the differences in methodology in various studies, we may be able to explain some of the discrepancies in the literature concerning the effects of emotional stimuli on memory. For example, we found a general enhancing effect of emotionality, as others have (e.g., Ellis et al., 1971), but Ley and Bryden (1982) did not. If we look at design, we find that in our study, the items were presented in a "mixed" fashion. That is, both neutral and emotional stimuli were presented in the same list in random order. Likewise, in the study by Ellis et al. (1971), the emotional event was placed in the middle of the neutral events. In each of these cases, the emotional material was recalled better than the surrounding neutral material.

According to Bower's (1992) explanation, the emotional stimuli are more arousing and caused a "recycling" of the emotional information, at the exclusion of the material occurring before and after each arousing stimulus. Ley and Bryden (1982), however, used emotional and nonemotional stimuli in separate study lists and did not obtain an effect. Perhaps their design was counterproductive in terms of the arousal/memory relationship. When the list contained only emotional stimuli then the arousal level of the subject may have waned after a few words since there was nothing new and exciting about the stimuli. The subject learned to expect an emotional word and that is what occurred. Thus, the arousal component was removed and hence the facilitative effect of emotionality was lost. In the current study, however, the subject was constantly surprised by intervening emotional stimuli, and hence arousal levels may have waxed and waned throughout presentation of the list during the study and recognition segments. These proposed arousal differences may account for our significant findings.

Although we found an effect of emotionality, there were no two-way interactions involving laterality of brain injury. There are several other studies which have also failed to find lateralized differences in emotional behavior. For example, Gainotti, Caltagirone and Zoccolotti (1993) summarized a number of studies which found that brain- damaged subjects with lesions in *either* hemisphere exhibit deficits in emotional processing (e.g., Bradvick et al., 1990; Mammucari et al., 1988; Weddel, 1989). More in line with our results, however, are the studies which have found instances of no clear impairment in the processing of emotional verbal material in right brain-damaged patients in comparison to other groups (Blonder et al., 1991; Bowers et al., 1987; Cicone et al., 1980; Lalande, 1992; Ostrove et al., 1990). Our lack of a laterality effect is consistent with the interpretation that both hemispheres were relatively equally involved in processing the stimuli in this experiment.

However, in light of the dozens of studies which *have* found deficits and alterations in emotional processing in patients with right brain damage (see Introduction) we need to explore how these studies differ from the one described herein. First, we are studying *memory* for emotional material, as opposed to mere perception, comprehension, or categorization of emotional material. Thus, the additional memory component may induce alterations in brain activity which would obscure the laterality effect often obtained in studies of emotion. This was one of the motivating factors in examining the involvement of other anatomical sites which are notable for their involvement in memory, such as anterior regions (frontal lobes) and temporal lobes. In fact, the analysis of these factors was more revealing than the analyses pertaining only to laterality.

There were two patient subgroups which failed to exhibit the emotionality effect as consistently as the rest of the subjects. For patients with frontal lobe damage, regardless of hemisphere, the immediate recall of emotional and neutral words was equivalent. That this failure of the emotionality effect appeared in the immediate recall task parallels what we already know about the frontal lobe's role in the learning of new information. Previous research has demonstrated other factors during stimulus encoding which normal subjects automatically encode (e.g., location and time of learning) and which patients with frontal damage often do not (e.g., Squire, 1986). Thus, stimulus emotionality may be another one of such factors. This finding also parallels previous findings that patients with frontal lobe damage have decreased level of autonomic responsivity to emotional stimuli (e.g., Damasio et al., 1990).

On the word recognition task, patients with right hemisphere non-temporal lobe lesions also failed to exhibit an emotionality effect. Since these patients had brain lesions in such disparate areas, it is difficult to make inferences about specific locations of importance. Furthermore, these interactions between intrahemispheric lesion site and emotionality were each only found on one of the three tasks. Thus, the findings should be replicated before we place too much importance on their significance. However, since altered emotional behavioral response in humans and animals has been associated with damage to both the frontal lobes (Hornak et al., 1995) and the temporal lobes (Kentridge & Aggleton, 1990), and since both of these areas were associated with failure to benefit from stimulus emotionality, future studies on emotional memory may choose to concentrate more efforts on these two cortical sites.

Thus, one possible explanation for our failure to find support for the right hemisphere hypothesis is that the additional component of verbal memory altered the balance of lateralized demands on these tasks. However, there have been studies which *have* found laterality effects in the memory of emotional material in brain-damaged subjects (Borod et al., 1996; Cimino et al., 1991; Wapner et al., 1981; Wechsler, 1973). A careful investigation of these studies brings to light that the differential findings based on laterality in most of these studies (e.g., Wapner et al., 1981; Wechsler, 1973) are of a qualitative nature. Such studies demonstrate that individuals who have experienced right hemisphere brain damage recall emotional information in a *different* way than do healthy individuals and individuals with damage to the left hemisphere. The right brain-damaged patients in these studies were found to make more inferences to the self and make more distortions and confabulations of the material than their left brain-damaged and normal control counterparts. Responses that are different from other subjects should not be confused with a poorer level of performance. With this distinction in mind, our findings do concur with those obtained by Wechsler (1973), for example, since he, too, found no quantitative differences based on laterality.

In the remaining studies which found that right hemisphere patients displayed impaired performance on an emotional verbal memory task (Borod et al. 1996; Cimino et al., 1991), it was the intensity of emotion that was measured, which is more quantitative. However, the verbal emotional material that was used in these studies was of a much lengthier and more complex nature than the materials employed herein. Thus, other deficits associated with right brain damage, such as comprehension of the pragmatic aspects of language (Foldi et al., 1983) and logical reasoning (Joanette, 1986), may have contributed to the results obtained in such studies, obscuring the notion of "pure" deficits in memory for linguistic emotional material. For example, in the Wechsler (1973) study, there was no method for distinguishing comprehension processes from memory processes. Since complex verbal material was used, this is a major issue. For example, it has been suggested that the defect found by Wechsler may have actually been in the comprehension of emotionally-laden propositional language rather than in memory for emotional material (Heilman, Watson, & Bowers, 1983). Because we used discrete bits of verbal material, our results are not as confounded with comprehension of material. Finally, we have measured accuracy of response, while in the studies of Borod et al. (1996) and Cimino et al. (1991) there was no way of measuring accuracy, since the material was from the subjects' personal histories.

The discrepancy between our findings and those from prior studies may also be related to another methodological issue. Previously we discussed the "pure" lists utilized by Ley and Bryden where emotional and non-emotional stimuli were presented separately. Likewise, in the Wechsler study, the "emotional story" was presented separately from the "non-emotional story". By contrast, in our study, the emotional and non-emotional words were presented together in "mixed" lists. Although such a design may have been beneficial in eliciting an emotionality effect, this type of presentation may have hampered laterality effects. That is, if emotional stimuli engage the right hemisphere preferentially, then a more continuous presentation of such stimuli would better elicit laterality effects. When a list of stimuli constantly alternates between emotional and non-emotional stimuli, as ours did, it may not be utilitarian for the right hemisphere to be preferentially engaged.

Whether or not any of these differences can explain the contradictory findings obtained is a topic for future research to untangle. If the findings of the current study are replicable, they will indicate that regardless of other emotional deficits which may plague the patient with right hemisphere stroke, the emotionality of single words remains salient and useful in the enhancement of memory.

Thus far our discussion has focused on the results pertaining to the right brain-damaged patients. An analysis of the memory performance of the left brain-damaged patients is also in order since previous research has shown that on language tasks, patients with left hemisphere lesions often exhibit facilitative effects of emotional conditions above and beyond that demonstrated by normal controls (Bloom et al., 1992; Bloom et al., 1993). There have been other studies, however, which have not found a facilitative effect of emotionality in left brain-damaged patients (Borod, Andelman, et al., 1992; Feyereisen & Seron, 1982). We found that memory for verbal material *was* facilitated by the emotionality of the target words in patients with left hemisphere damage, however,no more so than in control subjects.

Thus, our results are not totally discrepant with that of prior studies. The differences that were obtained between our findings and that of others may be explained by the differences between these studies. As stated above, although we used verbal tasks, the focus was on memory, rather than comprehension or expression of the material. Also, most of the left brain-damaged patients in prior studies could be classified as frankly aphasic, whereas our patients had only mild language disturbances. We did not use severely aphasic patients because they would have been unable to perform all of the necessary tasks involved in this experiment. As an important aside, we should mention that the left hemisphere patients in this study were especially difficult to recruit due to the exclusion of individuals with severe aphasia. Thus, the subjects herein are not representative of the average patient with left brain damage, but rather these subjects are among the rare patients with relatively intact language functions subsequent to left-hemisphere cortical stroke.

However, although our patients did not have frank aphasia, many of them did have language disturbances which were noticeable during the testing session. Thus, the findings from our left brain-damaged patients may have been obscured by combining individuals with and without language disorders. Based on the literature pertaining to aphasia and emotion, it is possible that the patients with language impairments in the current study were more affected by stimulus emotionality than the patients without language impairments. This possibility was investigated by comparing the performance of left brain-damaged patients with (n=13) and without (n=7) language disturbances (for more detail on these patients see Table 4).

A 2 (group: language disturbed, non-language disturbed) x 2 (stimulus type:

emotional, neutral) x 2 (learning condition: read, generate) mixed ANOVA was conducted on the data from the left brain-damaged patients for each task. On the free recall task, the only new finding was a trend for a two-way interaction between group and stimulus type, $F(1,18) = 3.13$; $p = .094$, indicating that the group *without* language disturbances was more influenced by stimulus emotionality than the group with language disturbances (for means see Appendix P). In fact, related t-tests revealed that only the group with normal language functions demonstrated enhancing effects of emotionality. Also, on the recognition task, we found a significant three-way interaction between group, stimulus type and learning condition, $F(1, 18) = 7.98$, $p = .011$. As in previous analyses, related t-tests indicated that in the Generate condition there was no effect of emotionality, and in the Read condition both groups recognized significantly more emotional than neutral words. However, the difference between emotional and neutral word recognition was larger in patients with normal language than in the patients with language impairments. Thus, as with word recall, the interaction indicates that the group *without* language disturbances were more affected by stimulus emotionality than the group with language problems. Finally, on the sentence recall task, there was again an interaction between group and stimulus type, $F(1,18) = 6.07$, $p = .024$. However, in this instance, the patients *with* language disorders recalled more sentences associated with emotional than neutral words, whereas the group without such disorders recalled more sentences associated with neutral than emotional words. However, related t-tests conducted with each group revealed that neither of these differences was significant and the interaction then indicates that stimulus emotionality affected the groups in opposite directions.

Thus, in the two tasks assessing memory for words, we found results which were discrepant with our expectations based on prior research with aphasics. In the recall of sentences, however, the group with language disturbances showed some facilitation in performance with emotional stimuli whereas non-language impaired patients with left hemisphere lesions did not. Sentence recall may require more language processing than word recall or recognition, and thus may explain why the findings in this task were more similar to the findings from previous aphasia studies. In general, the discrepancies in the obtained effect of emotionality found in different studies with left and right brain-damaged patients remains an intruiging problem which future research may clarify. Our findings do indicate that intrahemispheric sites, such as frontal and temporal regions, may be more important than interhemispheric location of lesion, at least in terms of memory for verbal emotional material.

Since the right hemisphere theory is often pitted against the valence theory of emotion, it is also important to highlight our findings concerning memory differences for positive and negative materials. On two of the three tasks (word and sentence recall), there were no main effects of valence and no two-way interactions involving valence and group, or valence and learning condition. Positive and negative materials were recalled at similar rates. Although there were two instances of three-way interactions on these tasks, neither interaction involves the laterality factor, and thus there was no support from these two tasks for a valence theory of emotional processing.

On the word recall task, the patients with frontal lobe involvement recalled more positive than negative words in the generate condition, and more negative than positive words in the read condition. The patients without frontal damage displayed the opposite pattern of performance, with more negative than positive material recalled in the generate condition and more positive than negative material in the read condition. Thus, recall of emotional words by brain-damaged patients was influenced by a combination of three factors: lesion caudality, valence of stimuli and encoding condition.

On the sentence recall task, the only interaction involving the valence factor was the three-way interaction between temporal lobe involvement, learning condition, and valence. However, post-hoc tests revealed that there were no differences in the recall of positive and negative sentences, only that in the read/positive condition, subjects with temporal lobe damage recalled many fewer sentences than their patient counterparts with no temporal lobe damage. In fact, subjects with temporal lobe lesions recalled practically no positive, read sentences.

On the recognition task, by contrast, there were performance differences based on valence. In the recognition of previously seen stimuli (hits), positive material was recognized at a higher rate than negative material. Furthermore, in many subjects, positive words were also associated with more false alarms (see Appendix Q) than negative words. These main effects of valence on the recognition task seem to parallel the effects of emotionality and may be similarly interpreted. That is, it is possible that positive stimuli may induce higher levels of arousal than negative stimuli, making it easier to recall and recognize positive words. The few studies of memory for emotional words that have separated material according to valence have also found that positive stimuli were remembered better than negative stimuli (Ali & Cimino, 1996; Amster, 1964; Winnick & Archer, 1974). In further support of an arousal interpretation, and as reported by Vanderploeg, Brown, & Marsh (1987), studies have found that positive words elicit larger ERP (event-related potential) amplitudes than negative words (e.g., Begleiter, Porjesz, & Garozzo, 1979; Chapman, McCrary, Chapman & Martin, 1980). Positive words have also been found to be read more accurately and recognized faster than negative words (Strauss, 1983).

Isen (1990) has put forth another idea concerning the valence of emotional material that offers a different interpretation of these results. Isen postulates that there is a rich neural connectivity for positive stimuli, whereas for negative and neutral words there may be distinct connections to fewer circuits. In support of this she cites Cramer (1968) who reviewed several studies which found that the pool of associates to positive words is larger than that for other words. This richer connectivity for positive words may lead to better memory for such words due to the increase in the number of associations that can serve as retrieval cues (Isen, 1985). This is similar to the idea presented in the introduction of this paper concerning the meaningfulness of emotional stimuli. Isen is proposing that positive material is more meaningful than negative material and this meaningfulness is responsible for the memory facilitation effects associated with positive material.

Although we began this discussion by remarking that the three primary groups under investigation all exhibited the memory-enhancing effect of emotionality, this is not an adequate picture of our findings since there were interactions between the factors of stimulus type and encoding condition, which served to suppress the emotionality effect differentially across subjects and across tasks. In the next section, we will discuss our findings related to the effect of sentence generation, and then conclude with a discussion of how the two experimental manipulations (stimulus type and learning condition) interacted and how this interaction was further complicated by subject variables.

<u>The effect of sentence generation</u>

We expected the processes involved in generating sentences to be related to the effect of generation upon later memory for the stimulus words. More specifically, we expected verbal fluency and memory abilities to relate in a meaningful way with the memory effects of sentence generation. Since we also expected our group with left brain damage to exhibit impairments in fluency and memory, we therefore predicted a failure or dampening of the effect of sentence generation in patients with left brain damage compared to that obtained in healthy individuals and individuals with right brain damage. Our predictions were not met. Results of neuropsychological tests indicated that left brain-damaged subjects did exhibit overall impairments in memory and both left and right brain-damaged subjects were quite impaired for verbal fluency. Yet the the three primary groups, across all tasks, exhibited a memory-enhancing effect of sentence generation.

These findings are in concurrence with those of Grix (1992) who found memory-enhancing effects of generating sentences in an explicit memory task using normal subjects. In her experiments, there was better memory for target words when the contextual sentences were generated rather than when they were read. We extend these findings by providing evidence that the effects of sentence generation can be dissociated from the underlying processes involved in producing the sentences since the memory-enhancing effects were obtained in brain-damaged subjects with less than optimal memory and fluency abilities. Further evidence for the dissociation between functional impairments and the effect of self-generation comes from the results of our correlational analyses. Our failure to obtain significant correlations between measures of verbal memory and verbal fluency with indices of the generation effect (i.e., the difference between words retrieved in the two learning conditions) does not confirm our predictions about the relevance of such processes in the effects of generation.

These findings argue against the necessity of a quality response or a rich semantic base of knowledge in order to obtain an effect of generation. These findings are not necessarily in contradiction to those found in studies of patients with Alzheimer's disease (Malcolm et al., 1989; Mitchell et al., 1986) because the memory capacities of our subjects most likely differ in quality, as well as quantity, from those of the Alzheimer's patients in the former studies. Thus, although the memory capacity of the left brain-damaged subjects herein was poor in comparison to normal controls, it may have been adequate enough to be activated and participate in the integration of functional stimulus-context units. The replicated finding that generation effects are unobtainable in Alzheimer's patients, therefore, may represent a lower limit of the rule that, in general, there is a dissociation between memory capacity and ability to benefit from generation conditions.

Thus, no support was found for explanatory theories emphasizing differences in meaningfulness via the formation of target-context connections in memory or for theories emphasizing differences in effort required in the two encoding conditions. Left brain-damaged subjects with both linguistic and memory deficits had a more difficult time and expended more energy in generating sentences than other subjects, but they did not enjoy a corresponding greater or smaller effect of learning under such conditions than did normals.

This may be the result of the unanticipated factor of reading impairment. That is, although the left brain-damaged patients had a more difficult time generating, as compared to normals, they also were observed to have a more difficult time reading in comparison to the other two groups of subjects. Thus, the differential increase in effort that was expected to influence the left brain-damaged subjects in the generate condition, was also found in the read condition, thereby cancelling any effect of language impairment on the pattern of performance in the left brain-damaged patients.

Thus, our group comparison of the generation effect does not support the theories based on effort and arousal, but it does not refute them either. As mentioned in the introduction to this study, we can dissociate the concepts of effort and arousal. That is, regardless of the effort that may have been expended in the two procedures, subjects may have been in a more aroused state while generating as compared to reading. Thus, differences in the size of the generation effect that were found in some of the analyses of patient sub-groups (e.g., comparisons across caudality of lesion and comparisons across gender) may be due to the differential ability of these subjects to be aroused by the encoding instructions. Unfortunately, since we provided no measure of arousal in this study, conclusions related to arousal are based only on inference at this point.

There was evidence, however, that the *robustness* of the generation effect differed in the brain-damaged subjects, despite the fact that measures of specific impairments were not related to the magnitude of this effect. For example, in the analysis of valence effects in free recall, when only emotional words were analyzed, we found that brain-damaged subjects exhibited generation effects that were smaller in size than those found in normal control subjects. In further analyses with the brain-damaged patients alone, generation did not exert an effect on the free recall of emotional material. It is interesting that these findings only occurred on the free recall task, since there are similar limitations of word generation effects.

In our efforts to explore other variables that may interfere or interact with the effect of sentence generation, we did obtain some two-way interactions between learning condition and subject variables, which indicated differences in size of generation effect. For example, in the word recall task, although both males and females recalled more words that had been originally learned in the generate condition, this effect tended to be larger for the female subjects. This interaction with gender was found in the analysis of the entire sample and when the brain-damaged subjects were analyzed separately. A similar interaction occurred for patients distinguished by the caudality of their lesions. Although all patients recognized more words that were learned in a generate condition, the patients with lesions circumscribed to posterior regions were less affected by encoding manipulation than were their counterparts with frontal lobe damage. Thus, we found that subject variables such as gender and caudality of brain lesion can affect the *strength* of the sentence generation effect.

Our three-way interactions between patient sub-groups, learning condition, and emotionality may be similar in nature to findings in a previous study where group differences in a word generation effect were obtained between those with and without depressed mood and resourcefulness (Schefft & Biederman, 1990). Schefft and Biederman (1990) found that subjects who were depressed obtained effects of generation that were smaller in size than those who were not depressed. However, another subject variable, resourcefulness, was able to counteract the effect of depression. Hence, subjects with depressed mood, but high scores on a measure of resourcefulness, were able to benefit normally from instructions to generate. This is another indication that particular subject variables may alter the effects of instructions to generate. It is possible that the factor of resourcefulness is related to arousability (i.e., how well individuals can motivate themselves in certain situations). If this is the case, we might then say that it is a factor that can outweigh the effects of other internal processes (e.g., depression) that may otherwise hamper performance. Likewise, in the current study, we may say that the arousability of the brain-damaged patients may have outweighed the effects of their specific impairments.

Furthermore, our finding of an interaction with stimulus type may be similar in nature to the finding in another study that found generation effects were stronger with unfamiliar words than with familiar words (Peynircioglu & Mungan,1993). In both our study and in the Peynircioglu and Mungan study (1993), it was the unexpected stimulus type (i.e., neutral words and unfamiliar words) that enjoyed a greater benefit of generation than the stimulus type usually noted for memory enhancement (i.e., emotional words and familiar words).

Because we obtained generation effects in both memory for words and sentences, we may ask whether the actual information from the sentence was being utilized during the retrieval tasks for target words, or if the results from these tasks are primarily or solely based on differences in factors such as arousal which occurred during the encoding conditions. Either way, whatever is responsible for the increase in words recalled from generated sentences is likely to also be responsible for the increase in recall of the generated sentences themselves. Thus, some may view the results of the sentence recall task as inherently confounded with the results of the word tasks and may wonder, therefore, why we included the sentence recall task.

The two reasons for sentence recall inclusion are related to the limitations of the word generation effect reviewed previously. That is, most research has indicated that in word generation experiments it is the response, and not the stimulus, that benefits memory performance (Slamecka & Graf, 1978), although there are rare exceptions to that rule. Thus, at the outset, it was unknown whether or not the generation effect would be obtained on the word recall task, since these words were the stimulus cues, not the generated response. One of the reasons for including the sentence recall task, then, was to provide an opportunity for finding generation effects in brain-damaged patients, even if the effect failed to extend to the single-word stimulus cues.

The second reason for inclusion of this task was that most researchers (e.g., Slamecka & Graf, 1987), but not all (e.g., Buyer & Dominowski, 1989) have only been able to demonstrate an effect of generation for single words. We reasoned, therefore, that even though sentences were the generated responses, it may be hard to obtain an effect in this task since the sentences may have been too lengthy and difficult to remember, especially after a 20-minute delay. Thus, we were also interested in testing the limitations of the generation effect for length of to-be-remembered material. Our findings did indicate that the sentence recall task was very difficult, but for many subjects, it was no more difficult than the word recall task. Thus, the information that we gain from the findings on each task is different and useful.

Finally, we must point out that simply because subjects remembered certain types of words on the word recall task doesn't necessarily dictate that their contextual sentences will be recalled, and thus, results on the sentence recall task should not be viewed as confounded by the results of the word recall task. This is demonstrated by the fact that the emotionality effect was not obtained on sentence recall, even though it was found on the other two tasks. Thus, even though more emotional words were recalled, when some of those same words were later given as cues, the sentences related to those words were not recalled at a higher rate than sentences related to other (neutral) words.

In comparison to the word generation effect, the sentence generation effect appears to be a more robust phenomenon. Despite the interactions described above concerning the magnitude of the effect in some subjects in certain tasks, differences in performance based on encoding condition, were obtained across all tasks, including free recall, recognition, and cued recall when both emotional and neutral stimuli were included in analysis of performance. As the effect did not dissociate across task or group, we cannot infer underlying processes of the effect from task or group comparisons. However, we can point out that limitations sometimes found in studies of word generation, based on design procedures in the study phase and retrieval task type, did not extend to the sentence generation effect obtained herein. For example, the word generation effect is often only obtainable in a within-list (or mixed list) design (e.g., Begg & Snider, 1987; Hirshman & Bjork, 1988), and this is especially the case for free recall procedures where reverse generation effects are sometimes obtained with between-list (pure list) designs (Nairne, et al. 1991; Schmidt & Cherry, 1989). We utilized "pure lists" in a between-block design paired with free recall procedures, and yet most groups still benefited from instructions to generate a sentence. The only limitation of this effect was in the free recall task when analyzing valence of emotional stimuli in brain-damaged patients.

Interaction Effects

Our third and final goal of this study was to determine whether or not the emotionality of stimuli would impinge on the effect of sentence generation, and conversely, whether or not different encoding conditions would influence the effect of emotionality. In fact, there were several instances where the manipulation of these two variables elicited interactive effects. The interactions between stimulus type and encoding procedure are considered suppressive since alterations in one appear to weaken the effect of the other.

For example, the effect of altering stimulus type, from neutral to emotional, was stronger when instructions were to read than when the subject were to engage in the process of generating. The effect of altering encoding instructions from reading to generating was also suppressed when stimulus type was manipulated, such that the effect of generating was somewhat stronger for neutral material than for emotional material.

These suppressive effects were found to be stronger in the brain-damaged subjects in two respects. First, with brain-damaged subjects the suppression occurred across two tasks (free recall and recognition), whereas interactions between stimulus type and encoding procedure occurred in normals only on the recognition task. Second, on the recognition task, instructions to generate completely obliterated the effect of emotionality (stimulus type) for brain-damaged subjects, but only weakened the effect of emotionality in normals. There are several possible interpretations of these interactive effects, which include speculation as to why they would be stronger in brain-damaged patients. We will offer three suggestions and conclude that only one of these holds up to scrutiny.

Emotional Concordance. Perhaps for the normal control subjects, the original emotional appraisal of the word was more concordant with the intended (or pre-rated) valence of the stimulus, whereas the brain-damaged subjects may not have appraised the emotional stimulus "correctly" to begin with. Alternatively, all groups may have appraised the stimuli similarly, but the normal controls may have been better at forming sentences which were more concordant with their initial emotional appraisal of the word. Finally, the groups may all have appraised the stimuli appropriately and created the same proportion of discordant sentences, but the brain-damaged subjects may have been more influenced than the normal controls by these emotionally discordant generated sentences. As main effects of emotionality were obtained for most of the brain-damaged patients, we can assume that the initial appraisal of the word was similar to that of the normal controls. Thus, here we will discuss the possibilities based on the emotional concordance between the target words and sentences in the two learning conditions.

By reviewing these procedures, we can try to understand the effect that these later semantic elaborations (the contextual sentences) may have had on emotional memory. In the read condition, the emotionality of a word was re-emphasized by a subsequent emotionally concordant sentence. This may have enhanced the utility of the emotional component of the word and thus enhanced the impact of emotionality upon memory. In the generate condition, the subsequent sentence was left up to greater and more diverse interpretation by the subject. Thus, we are uncertain as to whether or not the emotional component of the word was maintained in the sentence and therefore emphasized by the sentence, or whether the valence was altered by the subject. Thus, a word pre-rated as neutral, like "hotter", may have attained greater emotional status via the generated sentence: "I love it when it gets hotter outside". Emotionally discordant sentences may help to explain the failure for emotionality to exert an effect in the generate condition.

This possibility was investigated by having independent raters rate the generated sentences for how concordant they were with the intended valence of the stimulus word (see Appendix J). We found that the ratings were very similar across groups (NC mean = 78.97; RBD mean = 79.47; LBD mean = 81.75). A one-way ANOVA confirmed that the difference between these scores was not significant, $F(2,57) = .58$, $p = .562$. These concordance ratings were also included as a factor in the correlation matrix presented in Appendix O. By viewing this matrix we see that the emotional concordance of generated sentences does not appear to be related to either of the memory-enhancing effects on the three tasks, and thus, it is not likely to play a major role in the interaction of these effects either.

However, when correlational tests were performed separately on each group for each task, differences emerged in word recall. In the normal control and right brain-damaged subjects, there was no correlation between concordance ratings and an index of the emotionality effect (NC: $r = -.13$, $p = .157$; RBD: $r = .32$, $p = .163$), although in the left brain-damaged group this correlation was significant ($r = .48$; $p = .052$). Thus, in the former two groups, the generation of sentences which are concordant in valence with the stimulus word does not appear to be related to the emotionality effect. However, in left brain-damaged patients there is some evidence that the emotionality effect is related to the difference in emotional concordance between stimuli and sentences. Thus, for the left brain-damaged patients only, the emotionality of the generated sentence, or lack thereof, may help to explain the the failure for emotionality to enhance memory in the generate condition.

This issue should be investigated further in the future. The concordance ratings were only analyzed across the three major groups (NC, RBD, LBD). It is possible that analyzing the concordance ratings across a different subject variable (e.g., gender or intrahemispheric lesion site) may have yielded even more information and could possibly explain some of the two- and three-way interactions involving these variables. Additionally, we lumped all of our words together in our analysis of concordance. It is possible to break concordance ratings down by valence type. In this way we could determine in which *direction* words were being altered. For instance, it is possible that the discordant sentences in the normal control group were due to subjects inserting neutral words into emotional sentences. The discordant sentences of the brain-damaged subjects, on the other hand, may have been due to emotional words being inserted into neutral sentences. These additional analyses of the concordance factor were beyond the scope of this project.

A more skeptical and extreme extension of the concordance hypothesis is that the *only* reason we found emotionality effects was due to the read condition, where subjects may have been alerted to the emotional component of a word, since it was emphasized in the subsequent sentence. If this were the case, it would help to explain why our results differ from those of Ley and Bryden (1982), who found no emotionality effect in memory for single words. We conducted a preliminary test on a subset of the subjects to look into this possibility. The last 17 subjects tested (13 LBD, 2 RBD,2 NC) were given a second word recall task after completing the entire protocol. The words were presented in the same blocked format, but without accompanying sentences. Thus, subjects read words one after the other, and were then asked for a free recall. A related t-test on these data was conducted testing the difference in word recall for emotional and neutral words. As in the original design, there was a significant effect of emotionality ($p=.025$). Thus, we can conclude that subsequent reading of emotionally concordant sentences does not account for emotionality effects. Presentation of these words with no context still elicited better recall for emotional words.

Task Difficulty. The second possible explanation for the interaction between learning condition and emotionality is based on task difficulty. When a task is difficult, emotional information may be useful in raising the accessibility of a word over a certain threshold. However, when a task is easy, emotional information may not be "necessary" in retrieving material learned in the past. That is, since retrieving material that was learned in a generate condition is relatively easy, perhaps the utility of the emotional component decreases. Retrieving material that was learned in a read condition, however is more difficult and hence, the utility of the emotional component may increase. This may be related to the order in which different features of encoding condition come into play at test time. If we use the terminology of Morton (1979), emotionality may be just one of several pieces of "evidence" or features that can stimulate a word from one's verbal lexicon. According to an explanation based on task difficulty, emotionality would be a later feature on the "list" of variables that could induce a word to be accessed.

Although this theory is plausible and may partially account for the results, an argument against this explanation is that even on the "easiest" task (recognition), accuracy in the generate condition ranged from 80-85%, and, therefore, there was still room for improvement in memory performance. Results of the sentence recall task also provide evidence against this interpretation. In this situation, the task was very difficult, yet stimulus emotionality had no impact upon the results. Since the large majority of the sentences recalled were generated, it is more likely that there was a specific deleterious effect of generation upon the effect of emotionality. That is, despite the enhancement that generation induces in later memory for target words, our findings demonstrate that learning in a generate condition can also diminish or expunge the enhancing effects of stimulus emotionality in female subjects and in some brain-damaged patients. There are other instances in the literature where generation has served to eliminate strong effects upon memory, such as serial order (Nairne et al., 1991).

Arousability. The third possible explanation for the emotionality x learning condition interaction is based on concepts of levels of arousability and divided attention. The concept of arousal was previously introduced in regard to both effects of emotionality and effects of sentence generation. Arousal was also introduced early on when discussing factors possibly affecting the general emotion/cognition relationship. Although there is no evidence that the same mechanism underlies these two effects on memory, arousal is a useful concept in understanding both the main effects and interactive effects in our results.

In this study, we found that emotional and/or generated words were easier to remember. If we pair this with the knowledge that arousing words are also easier to remember (Schonpflug & Beike, 1964; Schurer-Necker, 1984), we see that it is possible that generated or emotional words are easier to remember because they are both more arousing. This may be proven empirically by measuring physiological levels of arousal during the presentation of such words.

If both the emotionality and sentence generation effects are mediated by an arousal mechanism, then it is possible that the interactions between these effects are a result of an optimum or "maximum arousal level" that is advantageous in memory performance. Thus, if generation has already raised arousal to this point, the emotional component of the stimuli cannot raise it any higher. Additionally, if we presume that reading does not raise the arousal level significantly, then there is room for the arousal level to be raised by the emotional components of the stimuli.

For example, on the word recall task, there was a three-way interaction among gender, learning condition, and emotionality in brain-damaged subjects. Although we frequently found that the emotionality effect failed in the generate condition, when the groups were separated by gender in word recall, this only occurred for females. For males, the emotional components of stimuli continued to have an enhancing effect on memory. For females, generation alone may have raised arousal levels to the point that subjects performed at the peak of their potential in that situation. For males, being in the generate condition may not have raised arousal to the point that maximum performance was achieved. Therefore, when a word also contained emotional components, there was room for the arousal level to be raised and for enhancing effects based on emotionality to occur. Since this specific interaction only occurred on one of the tasks, it should be investigated further before making any generalizations.

Another way to utilize an arousal interpretation is to view the interaction effects as suppressive phenomena. Thus, instructions to generate may have *suppressed* the memory-enhancing effects of emotionality in the patients. The types of patients found to be susceptible to suppressive effects of generation include females, patients with posterior lesions, and patients with temporal lobe lesions. Although patients with frontal lobe damage also did not benefit from the emotionality of a stimulus in word recall, we view this as a separate phenomenon since, on this task, they did not exhibit emotionality effects in either encoding condition and actually recalled more neutral than emotional items in the generate condition.

This suppression of the effect of emotionality or this context-dependent emotionality effect is more evident in word recognition where it occurred not only across all patient groups, but in the analysis of the total sample, as well. Thus, subjects with all sorts of focal brain damage and both males and females, displayed emotionality effects on a recognition task when they had learned the material in the read condition, but not in the generate condition.

In addition, because these effects are two-way, we see that instructions to generate a sentence also show a more enhancing effect with neutral words than with emotional words. The difference in the case of the sentence generation effect, however, is that in most cases, the effects of encoding are still observable in emotional material, albeit at a lower level. By contrast, the effect of emotionality is often completely abolished in the generate condition. Thus, even though the effect of generation may be dampened by the competing factor of stimulus emotionality, its effect is usually maintained.

Suppression effects are often explained by the concept of divided attention, which is defined as the ability to process relevant information simultaneously (van der Meere & Sergeant, 1987). Thus, the interactive effects obtained herein may be interpreted as resulting from competing demands on the subject to attend to two salient features of his/her environment simultaneously. Accordingly, we may say that normal control subjects were better able to simultaneously attend to both the affective characteristic of the stimulus and the instructional demand than were brain-damaged subjects. Likewise, some of the three-way interactions among subject variable, stimulus type, and encoding condition may be explained by differences between subjects in tendency to attend to a particular feature of the environment (either stimulus type *or* task instruction) when faced with a situation where both features are salient.

Finally, it must be noted that not all of the higher-order interactions found herein can be attributed to suppressive effects of one salient feature of the environment upon another, since some of the three-way interactions indicated that performance differences between groups were most obvious in read/neutral conditions. However, a level-of-arousability interpretation may still explain the results. For example , there was a marked difference between the right brain-damaged patients with and without temporal lobe impairment in the read/neutral condition. This may simply reflect differences in baseline memory abilities which are more noticeable in conditions that do *not* induce arousal. Since these performance differences in memory were less apparent when other (arousing) variables (e.g., emotional stimuli or instructions to generate) were present, this may indicate an inability on the part of the patients with right temporal lobe lesions to use internal methods of raising arousal level to improve memory. A lower baseline level of arousal and/or a deficit in internally induced arousability may be responsible for the poor performance seen in the read/neutral condition. From a clinical viewpoint, the improvement in memory performance induced by changes in external features of the environment is encouraging since it indicates the ability of these patients to use external memory aids to improve functional performance.

Contributions to emotion/cognition theories

Our finding, in several circumstances, of an interaction between learning condition and emotionality warrants a discussion about how this information contributes to the general emotion/cognition equation. The way in which these variables interacted does not fit in with the author's inclination toward the affective primacy theories. In the milder version of such theories, processing emotionality is automatic and occurs before most other cognitive activity. In the more stringent versions (Wundt, 1907; Zajonc, 1980), emotional components of behavior are independent of cognitive components. Our findings cannot support or refute the time element involved in processing emotionality. Thus, the emotional component of a stimulus may have been immediately and automatically encoded when a word was presented in isolation at study, but, the saliency of this feature was then altered (or suppressed) by the subsequent task demands. Thus, the milder version of this theory has not been disproved.

However, our findings are at odds with the stricter view that emotional processing occurs separately from cognitive processing. The impact of stimulus emotionality was clearly affected by the semantic "milieu" in which the stimuli were presented. These findings are in clear contrast to those of Bock (1986) and of Bock and Klinger (1986), who were unable to suppress the emotionality effect in normals by varying task conditions in two well-designed studies. They interpreted their lack of task/emotionality interactions as evidence that emotionality effects are robust, basic and independent of higher-order cognitive processes. By contrast, the emotionality effect found herein was dependent on both the input (learning condition) and output (task) conditions, as well as dependent upon subject variables (e.g., gender and certain types of brain damage). The reason for the discrepancy between our results and the results of Bock and colleagues is unclear. However, there have been other studies with findings that are more similar to ours, where the effect of emotionality was influenced by cognitive task demands (e.g., Amster, 1964; Heuer & Reisberg, 1990).

Thus, with the limited information we have available to support one of the existing theories of the emotion/cognition relationship, we conclude that our data best supports simultaneous processing theories (e.g., Lewis et al., 1984), where cognitive and emotional processes are interwoven. In the future, designs can be implemented so as to better answer the question of when (i.e., the order in which) different features of a stimulus are processed. For the present, we can state that emotional and cognitive processes interact in their effect upon memory and that cognitive task demands can be more effective than emotionality of material.

Conclusions

The findings from this study suggest that normal enhancement of memory, induced through alterations in stimulus type (from neutral to emotional), and alterations in encoding procedures (from reading a contextual sentence to generating a contextual sentence), can be obtained in patients with documented cortical brain damage, although there are contributing influences of subject variables such as gender and lesion site. Basic functional abilities, however, do not appear to influence the expression of these effects nor do they relate to the strength of these effects.

We can state with confidence that the generation effect is quite robust and can be found across several tasks (free recall, cued recall, and recognition), with different types of verbal material (words and sentences), in emotional (positive or negative) and neutral stimuli, in different types of subjects (normal healthy adults and adults with cortical brain damage), and in both genders. The only limitation we found was that generating did not improve memory in male brain-damaged subjects for emotional stimuli on a free recall task. And on a recognition task, for all groups, the generation effect was stronger for neutral material than for emotional material.

The emotionality effect, however, is not as robust. It did not occur with sentences in a cued recall format; it often did not occur when words were learned in a self-generate condition; its effects were often stronger in males than females; and the performance of certain patient sub-groups was inconsistently affected by stimulus emotionality. Valence effects were even less robust and only operative on the recognition task, where positive material was associated with higher rates of recognition than negative stimuli. Furthermore, there were unexpected effects of emotionality and valence in the rate of false alarms. That is, when task requirements were to reject previously unseen stimuli, emotional words were associated with a higher rate of commission errors than neutral words, and positive words were often associated with a higher rate of commission errors than negative words .

Although we obtained interesting and significant main and interaction effects, none of our main a priori hypotheses were confirmed. Neither fluency difficulties nor memory impairment were related to the generation effect, and the performance of patients with left brain damage, unexpectedly, was as affected by self-generation procedures as the normals and right brain-damaged patients. Furthermore, the group with right-hemisphere damage exhibited improvements in memory in response to stimulus emotionality, as did normal controls and left brain-damaged subjects. In line with other researchers we may conclude that stimuli such as facial expressions may be more powerful conveyors of emotional meaning than verbal semantics (e.g., Vanderploeg et al., 1987), and as such, verbal emotional stimuli may be less consistent in eliciting right hemisphere activation.

In our speculations about the mechanism of action underlying these effects, our results best support the notion of arousal as an important intervening variable in both the main effects obtained and in the interaction between these effects. Thus, we propose that most of the brain-damaged subjects who participated in this study had relatively normal levels of arousability, allowing them to benefit from the manipulations involved, despite their functional impairments.

Future Directions

There are some improvements which could be made in the design and implementation of this type of study. There are also several directions which future studies can take in order to extend this line of research. In closing, we make some of these suggestions below.

Improvements of our study. In this study there were differences between the encoding conditions in both *what* was formed (the product) and *how* it was formed (the process). Only one of these differences, the process, was investigated in this study. In the future, studies should either include qualitative analysis of the generated sentences (e.g., for syntax or emotional concordance) or alter instructions to produce sentences which are more similar to the read sentences.

Our study may also have benefited from a stricter separation of perception and comprehension of the stimuli from memory for the stimuli. Since our material was discrete and well-defined (i.e., testing memory for single words), the demands on comprehension were far less than those called for in a story recall paradigm. However, if future investigators can somehow further separate the process of perception or basic appraisal from memory, more clarity may be added to the emotion/memory equation. One method may be for subjects to rate words for emotionality and compare this to the results from the memory portion of the study.

Future studies should also be conducted in a careful manner with regard to specifying brain damage. Most brain-damaged subjects have had imaging scans, and it is important to put this information to use, as we did, in the division and analysis of subjects. However, we relied only on verbal summaries of the imaging scans and therefore, our knowledge of specific location and subcortical involvement was limited. In the future, a more thorough investigation of the imaging scans themselves would contribute additional neuroanatomical information. Furthermore, a "size of lesion" variable would enhance methodology in studies of this type.

Extensions of our study. The effect of learning condition on memory in brain-damaged samples is encouraging in a clinical sense, and future studies should explore this sentence generation effect with other brain-damaged samples to determine its boundaries. It is of particular interest, for example, that subjects with right temporal lobe lesions recognized only 50% of the words that were originally studied when encoding instructions were merely to read, but they recognized 80% of the words when encoding instructions included generate procedures. In both statistical and clinical terms, this difference is very significant. These findings, therefore, warrant experimentation and implementation of generation techniques in the cognitive rehabilitation of patients with specific memory deficits.

Because we did not exclude patients with post-stroke depressive symptomatology, there were patients with various degrees of depression. There was no significant difference in the number of such individuals in each group, and no significant correlation between mood and memory at the time of testing. As some of the individuals were on anti-depressant medication, a future comparison of the performance of patients with and without post-stroke depression may yield interesting results. Once again, if individuals had also rated the words on a pleasantness or valence scale, this information would have also been interesting in the comparison of depressed and non-depressed patients.

Furthermore, although we erred on the side of caution in deciding not to further examine the significant correlations found in the correlation matrix in Appendix O, one of the relationships (between EQ on the sentence recall task and months post onset) may be worthy of further analysis. Out of curiosity we did another analysis of the sentence recall task with the total patient sample while controlling for months post onset (by using it as a covariate in the ANOVA). In doing so, the effect of emotionality became significant, where it had not been so in any other analysis. It is possible that as time since onset increases, some patients increase their reliance on the emotional components of complex stimuli in a compensatory fashion. However, when separate correlational matrices for each of the three groups were reviewed, the relationship between months post onset and EQ on sentence recall was only significant in the left brain-damaged group. Thus, it is possible that during the course of recovery, the effect of emotionality in complex verbal stimuli is more important after left brain damage.

Because the current experimental design and procedures were useful in uncovering main and interactive effects of both emotionality and generation on memory performance, it is recommended that this paradigm be used in future research of this type. Alternatively, or in addition, a between-list design for the emotionality variable may also be useful, with separate lists containing only words of a particular valence type. This may serve to alter the emotionality effect or elicit a laterality effect for reasons described above.

Another way to extend these findings is by adding to the length and complexity of the verbal stimuli by using sentences and paragraphs in a similar paradigm. There would be great difficulty, however, in controlling for confounding factors of imagery, familiarity, comprehension, etc. It is our prediction, based on the current findings, that if these factors could be controlled, such a study would yield similar results. That is, both emotionality and generation effects would occur, but generation effects would often suppress emotionality effects, and higher-order interactions with subject variables would ensue. Such a study would be very interesting since the task would be much closer to the day-to-day memory demands that individuals encounter.

In the current study, words also varied by syntactic category (nouns, verbs, and adjectives) and imaginability (abstract, moderately concrete, and highly concrete). Although this data was collected, analysis of these variables and how they interacted with each of the main effects under investigation was beyond the scope of this study. However, in the future, we may opt to extend our findings by investigating how these other variables, which may also influence memory, are related to each other and to the emotionality and generation effects.

It is also advisable that manipulations or measures of arousal be examined to investigate the contribution of arousal in the memory-enhancing effects obtained herein. There are several ways this may be accomplished using the current paradigm: 1) Normal subjects may be tested under high and low arousal conditions; 2) subject groups with known differences in arousability may be studied (e.g., introverts vs. extroverts); or 3) different measures of autonomic arousal (e.g., heart rate, galvanic skin response) or functional imaging measures of arousal (e.g., PET) may be taken during learning and retrieval phases. Furthermore, in the current study, response time on the recognition task was measured and its analysis may yield valuable information pertaining to aroual.

Finally, since we did not uncover any cortical lesion site that was consistently associated with an obliteration of either of these effects, the next logical step would be to examine subjects with subcortical damage in our search for brain structures, systems, and processes which are critical to these enhancing effects on memory. In particular, brain-damaged patients with subcortical lesions in areas associated with arousal would be most interesting to study.

Appendix A

Initial Screening

Subject Name________________ Phone Number_______________
Address__________________________ D.O.B.________
__________________________ Contact_______________

Age___ Gender____ Date of Stroke_______
Admitting Hospital________________ Date of Appt________
Length of Stay_____________ Time since onset______

Did you go to another facility for rehabilitation?__________________
Length of rehab__________Any CT scans or MRIs done there?_____

Language
English as first language? yes___ no___
If no, when did you learn English?____________________

Handedness
Before your stroke were you clearly :Rt. handed___Left Handed___Ambidex___
Now? Rt. handed___Left Handed___Ambidex___
Administer Handedness Questionnaire. Score____

Neurologic History
Besides the stroke do you have a hx of any other neurological illnesses or problems?________
If yes, please explain________________________________
Do you have any other medical problems? _____If yes, please explain______________________
Have you ever hit your head or been in an accident where you lost consciousness?_______
If yes, please explain___________________
If so, which hospital were you admitted to?____________Were you given an MRI or CT scan?____
Were you ever hospitalized for any other reason?______If yes, please explain__________________
Have you ever had a seizure?_____If yes, how many and when?________
Who is your primary doctor right now?_________________

Disabilities
Were your language skills affected by the stroke?________________________
Fluency__________________Comprehension____________________

Did you have any loss of movement in your face, arms or legs due to the stroke?______________
If so which side was affected?___Left side of body___Right side of body
Is movement in these areas still a problem?___________________

Did you have any sensory loss in your face, arms or legs due to the stroke?___________________
If so which side was affected?___Left side of body___Right side of body
Does the sensory loss remain?______________________________
Did/do you have any visual problems or neglect due to the stroke?__________
Education
How far did you go in school?_______________________________

Do you have any type of learning disability or any problems in reading, writing, spelling or arithmetic?____

Psych History

Have your ever been to a counselor, social worker, psychologist, or psychiatrist?_____
If yes, was it before or after the stroke___________
What was (or is) the general nature of the visit?________________

Did you ever experience a period of depression before the stroke?____
If yes, please explain____
Were you ever on medication or hospitalized for the depression?______

Did you ever experience a period of depression after the stroke?____
If yes, please explain____
Were you ever on medication or hospitalized for the depression?______

Would you consider yourself currently depressed?_______If yes, please explain____
Does your mood ever interfere with your daily functioning?__________

Occupation

Are you currently working?yes___no___
If yes, what is your job title?_____________________
How long have you worked at this job?________________
Was there any other job that you worked at for a long time?_________

How is your hearing?
How is your vision? Do you use glasses for reading? (Please bring)

Medication

Are you currently taking any prescription medication?_______
If yes, please name and explain_______________________________
____
How long have you been on these medications?________________
____
Have you ever taken medication like tranquilizers, antidepressants, sleeping pills, or stimulants?______
If yes, please name and explain_______________________________
How long did the drug usage last?____________________________

Drug and Alcohol Use

Have you ever used recreational drugs, for example, marijuana, cocaine, heroine, etc.?______
If yes, please name and explain_______________________________
How long did the drug usage last?____________________________

How frequently do you have an alcoholic beverage?______________
Did you ever drink more frequently?__________________________
If yes, did drinking ever interfere with your daily activities?______________

Subject passed screening? yes_______ no_______
If yes, obtain consent for medical records. Consent obtained_____
Records obtained: ______

Appendix B

Handedness Questionnaire

(Before your stroke...)	Right	Left	Either
1) With which hand would you throw a ball to hit a target?	___	___	___
2) With which hand would you draw?	___	___	___
3) With which hand would you use an eraser?	___	___	___
4) With which hand would you remove the top card when dealing?	___	___	___
5) With which foot would you kick a ball?	___	___	___
6) With which foot would you pick up a pebble with your toes?	___	___	___
7) With which foot would you step up onto a chair with first?	___	___	___
8) With which foot would you stamp out a cigarette?	___	___	___
9) Which eye would you use to peep through a keyhole?	___	___	___
10) Which eye would you use to look into a dark bottle to see how full it is?	___	___	___
11) Which eye would you use to sight down a rifle?	___	___	___
12) Which eye would you use to look through a telescope?	___	___	___
Total	___ /12	___ /12	___ /12

Note: Subjects who answered "left hand" or "either" to more than one of the first four questions were excluded. Subjects were also excluded if they answered "right" a total of less than 9 times for the entire questionnaire.

Appendix C

96 Stimulus Words

amuse	author	banker	beauty	bitter	blind
brutal	cancer	cause	cheat	cheerful	combine
contract	country	cowardly	cruel	dance	degraded
despise	destroyed	dream	failing	fantasy	feels
fraud	freeze	generous	gentle	greedy	guilt
happy	hates	honesty	hotter	imitate	innate
insult	laugh	lighter	literal	loves	music
naval	nicely	obedient	obese	owner	passion
peaceful	peddle	perjury	petting	playing	point
pollution	pretty	prevalent	projector	rejected	retain
sailing	salty	science	scorched	sever	shoot
shown	sighed	skiing	slavery	smile	softly
spray	square	straight	suffocate	sunset	swallow
sweet	swimming	theme	throw	tragedy	traitor
tranquil	travel	trend	truth	unjust	washes
wreck					

Appendix D

Word Characteristics

List A

	Pleasantness	Concreteness	Word Length	Familiarity
author	4.12	4.75	6	6.43
bitter	2.31	4.05	6	6.16
cheat	2.29	3.25	5	6.23
cheerful	5.90	3.58	8	6.15
combine	3.97	3.98	7	5.67
country	5.54	4.54	7	6.57
cowardly	2.40	2.41	8	5.87
dance	5.51	5.51	5	6.24
despise	2.34	3.10	7	5.43
destroyed	2.43	3.63	9	6.25
feels	5.52	3.20	5	6.62
freeze	3.89	4.76	6	6.37
generous	5.90	2.56	8	6.12
greedy	1.88	3.56	6	5.94
guilt	2.43	2.95	5	6.33
honesty	5.95	2.74	7	6.52
hotter	3.78	4.29	6	5.79
innate	4.03	3.04	6	5.25
laugh	6.00	4.29	5	6.68
loves	6.07	3.55	5	6.71
manner	4.23	2.93	6	6.20
misery	2.04	3.24	6	5.89
murder	1.75	4.68	6	6.08
music	6.22	5.15	5	6.77
nicely	5.50	2.75	6	6.31
obese	2.52	4.88	5	4.98
owner	4.07	4.09	5	6.26
passion	5.85	3.53	7	5.71
peaceful	5.79	3.56	8	6.34
peddle	4.02	4.78	6	5.75
prevalent	4.13	2.51	9	4.92
projector	3.82	5.44	9	5.51
rejected	2.21	2.82	8	5.97
retain	3.85	3.04	6	5.81
salty	3.84	4.86	5	6.05
sever	2.50	4.00	5	5.03
shown	4.15	3.11	5	5.93
skiing	5.85	5.86	6	6.25
slavery	1.87	3.89	7	5.86
smile	6.23	5.19	5	6.41
softly	6.00	3.59	6	6.98
spray	4.00	4.81	5	6.05
straight	4.13	4.00	8	6.33
suffocate	1.81	3.87	9	5.48
traitor	2.40	4.63	7	5.36
trend	3.85	3.24	5	5.77
truth	5.66	2.72	5	6.31
wreck	2.28	4.88	5	6.24

	Pleasantness	Concreteness	Word Length	Familiarity
Mean	**4.02**	**3.85**	**6.30**	**6.03**
S.D.	**1.51**	**0.9**	**1.3**	**0.47**

Appendix D. (cont.)

List B

	Pleasantness	Concreteness	Word Length	Familiarity
amuse	5.55	3.17	5	5.60
banker	3.84	5.16	6	6.03
beauty	6.07	3.34	6	6.52
blind	2.47	4.39	5	6.05
brutal	2.46	3.98	6	5.48
cancer	1.73	6.11	6	6.10
cause	3.94	2.90	5	6.07
contract	3.78	4.50	8	5.79
cruel	2.06	3.63	5	5.95
degraded	2.30	2.58	8	5.70
dream	5.60	4.34	5	6.25
failing	2.15	2.93	7	5.85
fantasy	5.82	3.17	7	6.37
fraud	2.23	2.72	5	5.53
gentle	5.76	3.18	6	6.36
happy	6.10	3.51	5	6.84
hates	2.06	3.91	5	6.29
imitate	3.85	3.44	7	5.78
insult	2.38	3.71	6	6.26
lighter	4.21	3.96	7	6.20
literal	3.81	2.91	7	5.42
lying	2.48	2.48	5	6.17
mother	5.84	5.47	6	6.85
naval	3.95	5.15	5	5.50
obedient	4.10	3.13	8	5.70
perjury	2.22	3.30	7	5.13
petting	5.60	5.56	7	6.41
playing	5.60	3.75	7	6.32
point	3.94	4.60	5	6.12
pollution	2.17	5.15	9	6.30
pretty	5.73	3.37	6	6.25
sailing	5.79	5.63	7	5.78
science	4.18	4.14	7	6.42
scorched	2.38	4.72	8	5.48
shoot	2.39	4.63	5	6.05
sighed	4.03	3.21	6	5.51
square	3.79	5.15	6	6.25
sunset	6.04	5.12	6	6.25
swallow	4.12	5.02	7	6.36
sweet	5.55	4.59	5	6.15
swimming	5.77	5.44	8	6.34
theme	3.75	3.32	5	5.98
throw	4.05	4.11	5	6.08
tragedy	2.30	3.53	7	5.86
tranquil	5.77	3.30	8	5.53
travel	5.73	3.98	6	6.24
unjust	2.28	2.40	6	5.78
washes	4.07	4.20	5	6.59

	Pleasantness	Concreteness	Word Length	Familiarity
MEAN	**3.96**	**4.02**	**6.26**	**6.05**
S.D.	**1.46**	**0.95**	**1.12**	**0.38**

Appendix D (cont.)

Comparison of stimulus characteristics between List A and List B.

Stimulus Characteristic	t	df	p
Pleasantness	0.08	47	.938
Concreteness	0.92	47	.361
Length	0.27	47	.790
Familiarity	0.01	47	.991

Appendix E

Word Characteristics by Block

List A

Block 1	Pleasantness	Concreteness	Word Length	Familiarity
skiing	5.85	5.86	6	6.25
obese	2.52	4.88	5	4.98
combine	3.97	3.98	7	5.67
country	5.54	4.54	7	6.57
rejected	2.21	2.82	8	5.97
freeze	3.89	4.76	6	6.37
laugh	6.00	4.29	5	6.68
guilt	2.43	2.95	5	6.33
trend	3.85	3.24	5	5.77
generous	5.90	2.56	8	6.12
slavery	1.87	3.89	7	5.86
hotter	3.78	4.29	6	5.79
Mean	**4.00**	**3.98**	**6.27**	**6.05**
S.D.	**1.53**	**0.97**	**1.14**	**0.46**

Block 2	Pleasantness	Concreteness	Word Length	Familiarity
wreck	2.28	4.88	5	6.24
prevalent	4.13	2.51	9	4.92
peaceful	5.79	3.56	8	6.34
suffocate	1.81	3.87	9	5.48
salty	3.84	4.86	5	6.05
truth	5.66	2.72	5	6.31
sever	2.50	4.00	5	5.03
manner	4.23	2.93	6	6.20
honesty	5.95	2.74	7	6.52
despise	2.34	3.10	7	5.43
spray	4.00	4.81	5	6.05
softly	6.00	3.59	6	6.98
Mean	**3.87**	**3.63**	**6.45**	**5.87**
S.D.	**1.55**	**0.87**	**1.56**	**0.62**

Block 3	Pleasantness	Concreteness	Word Length	Familiarity
shown	4.15	3.11	5	5.93
destroyed	2.43	3.63	9	6.25
music	6.22	5.15	5	6.77
innate	4.03	3.04	6	5.25
misery	2.04	3.24	6	5.89
smile	6.23	5.19	5	6.41
peddle	4.02	4.78	6	5.75
murder	1.75	4.68	6	6.08
loves	6.07	3.55	5	6.71
owner	4.07	4.09	5	6.26
bitter	2.31	4.05	6	6.16
cheerful	5.90	3.58	8	6.15
Mean	**3.94**	**4.05**	**5.82**	**6.13**
S.D.	**1.7**	**0.78**	**1.28**	**0.41**

Block 4	Pleasantness	Concreteness	Word Length	Familiarity
straight	4.13	4.00	8	6.33
feels	5.52	3.20	5	6.62
greedy	1.88	3.56	6	5.94
retain	3.85	3.04	6	5.81
dance	5.51	5.51	5	6.24
cheat	2.29	3.25	5	6.23
author	4.12	4.75	6	6.43
passion	5.85	3.53	7	5.71
traitor	2.40	4.63	7	5.36
projector	3.82	5.44	9	5.51
nicely	5.50	2.75	6	6.31
cowardly	2.40	2.41	8	5.87
Mean	**4.08**	**3.97**	**6.36**	**6.04**
S.D.	**1.44**	**1.03**	**1.31**	**0.39**

Appendix E (cont.)

List B

	Pleasantness	Concreteness	Word Length	Familiarity
Block 1				
swimming	5.77	5.44	8	6.34
brutal	2.46	3.98	6	5.48
point	3.94	4.60	5	6.12
tranquil	5.77	3.30	8	5.53
perjury	2.22	3.30	7	5.13
square	3.79	5.15	6	6.25
sunset	6.04	5.12	6	6.25
tragedy	2.30	3.53	7	5.86
swallow	4.12	5.02	7	6.36
travel	5.73	3.98	6	6.24
degraded	2.30	2.58	8	5.70
theme	3.75	3.32	5	5.98
Mean	**4.04**	**4.18**	**6.73**	**5.93**
S.D.	**1.5**	**0.93**	**1.08**	**0.39**
Block 2				
shoot	2.39	4.63	5	6.05
washes	4.07	4.20	5	6.59
fantasy	5.82	3.17	7	6.37
scorched	2.38	4.72	8	5.48
obedient	4.10	3.13	8	5.70
pretty	5.73	3.37	6	6.25
insult	2.38	3.71	6	6.26
cause	3.94	2.90	5	6.07
beauty	6.07	3.34	6	6.52
failing	2.15	2.93	7	5.85
naval	3.95	5.15	5	5.50
sweet	5.55	4.59	5	6.15
Mean	**3.91**	**3.75**	**6.18**	**6.06**
S.D.	**1.48**	**0.79**	**1.17**	**0.39**

	Pleasantness	Concreteness	Word Length	Familiarity
Block 3				
sighed	4.03	3.21	6	5.51
pollution	2.17	5.15	9	6.30
mother	5.84	5.47	6	6.85
throw	4.05	4.11	5	6.08
blind	2.47	4.39	5	6.05
playing	5.60	3.75	7	6.32
literal	3.81	2.91	7	5.42
fraud	2.23	2.72	5	5.53
happy	6.10	3.51	5	6.84
science	4.18	4.14	7	6.42
hates	2.06	3.91	5	6.29
sailing	5.79	5.63	7	5.78
Mean	**3.87**	**3.93**	**6.09**	**6.15**
S.D.	**1.54**	**0.95**	**1.26**	**0.48**
Block 4				
banker	3.84	5.16	6	6.03
amuse	5.55	3.17	5	5.60
cruel	2.06	3.63	5	5.95
lighter	4.21	3.96	7	6.20
petting	5.60	5.56	7	6.41
cancer	1.73	6.11	6	6.10
contract	3.78	4.50	8	5.79
gentle	5.76	3.18	6	6.36
lying	2.48	2.48	5	6.17
imitate	3.85	3.44	7	5.78
dream	5.60	4.34	5	6.25
unjust	2.28	2.40	6	5.78
Mean	**4.04**	**4.14**	**6.09**	**6.06**
S.D.	**1.58**	**1.17**	**1.04**	**0.27**

Appendix E (cont.)

Comparison of stimulus characteristics between four blocks of List A.

Stimulus Characteristic	F	df	p
Pleasantness	0.03	(3,44)	.995
Concreteness	0.45	(3,44)	.716
Length	0.33	(3,44)	.805
Familiarity	0.26	(3,44)	.853

Comparison of stimulus characteristics between four blocks of List B.

Stimulus Characteristic	F	df	p
Pleasantness	0.02	(3,44)	.995
Concreteness	0.21	(3,44)	.888
Length	0.54	(3,44)	.660
Familiarity	0.46	(3,44)	.712

Appendix F

Sentences

List A

Block 1

1) **skiing**
We enjoy skiing at the resort on our family vacations.
2) **obese**
Unfortunately, she will become obese if she continues eating such fattening foods.
3) **combine**
I want to combine all of my thoughts into one essay to be published.
4) **country**
Many citizens believe that America is the greatest country in the world.
5) **rejected**
It feels terrible to be rejected by your peers.
6) **freeze**
Water will freeze when the temperature falls below a certain point.
7) **laugh**
I know they will laugh at all the great jokes he will tell tonight.
8) **guilt**
He felt tremendous guilt after sending the wrong man to jail.
9) **trend**
The trend this year is toward longer skirts and shorter hair.
10) **generous**
Her generous nature brought the woman many friends.
11) **slavery**
It is hard for free people to imagine the anger and humiliation brought about by slavery.
12) **hotter**
The humidity level makes it feel even hotter outside.

Block 2

1) **wreck**
You will wreck the car if you keep driving so carelessly.
2) **prevalent**
Care-free attitudes are prevalent during the teenage years.
3) **peaceful**
Growing up on my grandmother's farm was a very peaceful experience.
4) **suffocate**
He will suffocate her with his pillow in the middle of the night.
5) **salty**
Some people like salty foods and some people don't.
6) **truth**
Telling the truth is one of the virtues that all men should strive for.

7) **sever**
I would like to sever all ties with my ex-spouse, but it is a difficult task.
8) **manner**
His manner of speech revealed his country of origin.
9) **honesty**
It was his honesty that attracted her to her husband.
10) **despise**
When he grows up he will despise his father for abusing him as a child.
11) **spray**
I spray the fertilizer on my lawn every year about this time.
12) **softly**
He touched her softly and tenderly because he adored her.

Block 3

1) **shown**
She was shown a picture of the building and was asked to draw it.
2) **destroyed**
He destroyed his enemies one by one until there was no one left to stop him.
3) **music**
The girls loved listening to their favorite music on the radio.
4) **innate**
Some believe it is solely our innate nature that determines what kind of life we will have.
5) **misery**
Her memories of the concentration camp will bring her misery for as long as she lives.
6) **smile**
The little boy liked to smile all the time.
7) **peddle**
The boy will peddle his bicycle down the street to the grocery store.
8) **murder**
After witnessing the murder of his father the little boy had angry outbursts everyday.
9) **loves**
She loves him more than she thought was possible.
10) **owner**
The owner of the car was a man in his forties with light brown hair.
11) **bitter**
The medicine was so bitter that she even disliked the thought of it.
12) **cheerful**
Everyone liked the teacher because she was so cheerful.

Block 4

1) **straight**
If you continue to drive straight through the town you will reach its border.
2) **feels**

It feels good to have your back massaged after exercising at the health club.

3) **greedy**
The man was such a greedy person that it led him to a life of crime and deceit.

4) **retain**
One must retain a certain amount of information in order to pass the exam.

5) **dance**
I want to dance with the most popular person at the party.

6) **cheat**
I was warned that if I cheat on the test I will suffer harsh consequences.

7) **author**
The author of the book returned and began to write again.

8) **passion**
They were each filled with passion on the first night of their honeymoon.

9) **traitor**
When they discovered he was a traitor his bunkmates wouldn't even look at him.

10) **projector**
Please bring the movie projector to the office for its storage.

11) **nicely**
The little girls played nicely with their new dolls.

12) **cowardly**
The bully acted cowardly in the face of real danger.

List B

Block 1

1) **swimming**
We enjoy swimming in the lake on our family vacations.

2) **brutal**
My uncle suffered a brutal attack in the subway.

3) **point**
Babies usually learn to point before they can way words.

4) **tranquil**
It feels so tranquil to lie on a quiet beach and hear only the waves roll in.

5) **perjury**
The corrupt man lied on the stand even though he knew he was committing perjury.

6) **square**
Square tiles are used in most bathrooms today.

7) **sunset**
We strolled along the beach hand in hand watching the sunset.

8) **tragedy**
It was a tragedy that her home was destroyed in the earthquake.

9) **swallow**
Please chew all your food before you swallow it.

10) **travel**
She wished to travel all over the world with her boyfriend.

11) **degraded**

I feel so degraded when someone gossips about me behind my back.
12) **theme**
We studied the major theme of the novel before taking the test.

Block 2

1) **shoot**
During the war I had to shoot many men.
2) **washes**
He washes and dries the dishes after every meal.
3) **fantasy**
His fantasy was to meet a beautiful princess and live happily ever after.
4) **scorched**
The woman was scorched in the fire because they could not save her in time.
5) **obedient**
He was an obedient dog who obeyed all of his master's commands.
6) **pretty**
She is so pretty that all the boys stared at her.
7) **insult**
How dare you insult me when you speak about my family in such negative terms!
8) **cause**
There is a cause for everything that happens, but we may never know what it is.
9) **beauty**
The beauty of a sleeping baby is something almost everyone can appreciate.
10) **failing**
No matter how hard he tried he was failing in all of his studies.
11) **naval**
He was assigned to the naval division as soon as he arrived.
12) **sweet**
Many people love candy because it tastes so sweet.

Block 3

1) **sighed**
I came home, sat down on the couch and sighed .
2) **pollution**
Pollution is one of the worst downfalls man has brought upon himself.
3) **mother**
My mother is the most beautiful woman in the world.
4) **throw**
I will throw the laundry into the appropriate bin.
5) **blind**
Due to his difficult birth the child was born blind.
6) **playing**
The little girls were playing with the new dolls all day.
7) **literal**
She took the literal meaning of the words and wrote them down.
8) **fraud**
He committed fraud and was not allowed to do any more business.

9) **happy**
Being with her grandchildren made the woman so happy.
10) **science**
There are many TV shows based on science today
11) **hates**
He hates his boss so much that work became like torture for him.
12) **sailing**
When we were first married, we went sailing whenever we had the chance.

Block 4

1) **banker**
My neighbor is a banker in a nearby town.
2) **amuse**
I will try to amuse you with all of my new tricks.
3) **cruel**
He was so cruel to animals that even his friends were horrified.
4) **lighter**
Please pick up the lighter box and bring it to the office
5) **petting**
She likes petting the cat, especially when he cuddles up against her and purrs.
6) **cancer**
Grandfather was diagnosed with cancer and suffered in pain before finally dying.
7) **contract**
We signed the business contract yesterday afternoon.
8) **gentle**
He had such a gentle touch that she was quite attracted to him.
9) **lying**
She found out the hard way that you can lose your friends by lying to them.
10) **imitate**
It is natural for children to imitate their older siblings.
11) **dream**
It was the most fantastic dream I have ever had.
12) **unjust**
It was simply unjust that the man who raped her was not given any jail time.
11) **degraded**
I feel so degraded when someone gossips about me behind my back.
12) **theme**
We studied the major theme of the novel before taking the test.

Appendix G

Instructions for Study and Word Recall

INSTRUCTIONS WHEN THE READ CONDITION IS FIRST

Block 1

On the screen a word will appear. Please read the word out loud and then you will read aloud a sentence that appears on the screen. You must simply read the words and sentences as they appear until the screen is blank. At that time the examiner will ask you to try to remember all of the individual words you saw on the screen. Do you have any questions?

Block 2

Now we're going to do the same thing again with new words. Are you ready?

Block 3

This time we're going to do something a little different. You will still be reading words out loud but each time after they appear, you will be making up a sentence using that word and saying the sentence out loud. Again, after all the words have been read, the screen will be blank and the examiner will ask you to recall as many individual words as you can.

Block 4

OK, this is the last time. You're going to read words and make up sentences once more. Are you ready?

Appendix G (cont.)

INSTRUCTIONS WHEN THE GENERATE CONDITION IS FIRST

Block 1

On the screen a word will appear. Please read the word out loud and then make up a sentence using that word. Say the sentence out loud and then you will see another word appear. You will continue to read words and create sentences until the screen is blank. At that time I will ask you to try to remember all of the individual words you saw on the screen. Do you have any questions?

Block 2

Now we're going to do the same thing again with new words. Are you ready?

Block 3

This time we're going to do something a little different. After you read the word, a sentence will appear on the screen. You must simply read the words and sentences as they appear until the screen is blank. Again at that time I will ask you to recall as many individual words as you can.

Block 4

OK, this is the last time. You're going to read words and sentences once more. Are you ready?

Appendix H

Instructions for Sentence Recall

On the screen more words will appear. First read the word out loud. Then try to remember the sentence that went with the word. If you cannot remember the whole sentence try to remember part of the sentence or any idea from the sentence. Some of the sentences will be those that you made up. Others will be those you read from the computer screen. Please tell the examiner whatever you can recall. If you do not remember the word or the sentence that went with the word simply indicate this as well.

Appendix I

Coding of Stimulus Words

Key to Codes:	Valence	Concreteness	Pt. of Speech
	2=positive	2=concrete	2=noun
	1=negative	1=mid	1=verb
	0=neutral	0=abstract	0=adjective

List A

	Valence	Concreteness	Pt. of Speech
author	0	2	2
bitter	1	2	0
cheat	1	0	1
cheerful	2	2	0
combine	0	1	1
country	2	2	2
cowardly	1	0	0
dance	2	2	1
despise	1	0	1
destroyed	1	1	1
feels	2	0	1
freeze	0	2	1
generous	2	0	0
greedy	1	1	0
guilt	1	0	2
honesty	2	0	2
hotter	0	2	0
innate	0	0	0
laugh	2	1	1
loves	2	0	1
manner	0	0	2
misery	1	0	2
murder	1	2	2
music	2	2	2
nicely	2	0	0
obese	1	2	0
owner	0	1	2
passion	2	1	2
peaceful	2	1	0
peddle	0	2	1
prevalent	0	0	0
projector	0	2	2
rejected	1	0	0
retain	0	0	1
salty	0	2	0
sever	1	2	1
shown	0	0	1
skiing	2	2	1
slavery	1	1	2
smile	2	1	1
softly	2	2	0
spray	0	1	1
straight	0	1	0
suffocate	1	1	1
traitor	1	2	2
trend	0	0	2
truth	2	0	2
wreck	1	2	1

List B

	Valence	Concreteness	Pt. of Speech
amuse	2	0	1
banker	0	2	2
beauty	2	0	2
blind	1	2	0
brutal	1	2	0
cancer	1	2	2
cause	0	0	2
contract	0	2	2
cruel	1	1	0
degraded	1	0	0
dream	2	1	2
failing	1	0	1
fantasy	2	0	2
fraud	1	0	2
gentle	2	0	0
happy	2	2	0
hates	1	1	1
imitate	0	0	1
insult	1	1	1
lighter	0	1	0
literal	0	0	0
lying	1	0	1
mother	2	2	2
naval	0	2	0
obedient	0	0	0
perjury	1	0	2
petting	2	2	1
playing	2	0	1
point	0	2	1
pollution	1	2	2
pretty	2	1	0
sailing	2	2	1
science	0	1	2
scorched	1	2	1
shoot	1	2	1
sighed	0	0	1
square	0	2	0
sunset	2	2	2
swallow	0	2	1
sweet	2	2	0
swimming	2	1	1
theme	0	0	2
throw	0	1	1
tragedy	1	1	2
tranquil	2	0	0
travel	2	1	1
unjust	1	0	0
washes	0	1	1

Appendix J

Concordance Ratings

A three-point concordance scale was created (see below) and two independent raters rated the sentences according to how well subjects maintained the intended valence of the word. A third rater participated only when a discrepancy occurred, which was approximately one-fourth of the time. The raters were female, Caucasian, right-handed, and naive about the identity of the subjects; the raters had an average age of 58.

Basically, if the overall valence of the sentence matched the intended valence of the stimulus word, the subject received full concordance credit. If the valence of the sentence varied by one point (either from neutral to one of the emotional extremes or from one of the emotional extremes to neutral), the sentence received partial concordance credit. Discordance was indicated, and no credit was awarded, if the valence of the generated sentence was the opposite of the intended valence of the stimulus word. A final concordance score was calculated by summing the individual concordance ratings and dividing by twice the total number of generated sentences (since each sentence could receive a score of 2). See scoring example below.

Appendix J (cont.)

Concordance Scale

Valence of Target Word	Valence of Generated Sentence	Score
positive	positive	2
negative	negative	2
neutral	neutral	2
positive	neutral	1
negative	neutral	1
neutral	positive	1
neutral	negative	1
positive	negative	0
negative	positive	0

Example of scoring a sentence for emotional concordance:

The word "mother" was rated and selected as a positive word. If the subject created the sentence "I hate my mother", the sentence would be rated as negative, and no concordance credit (0) for the sentence would be given. If the subject created the sentence "My mother is at the store", the sentence would be rated as neutral, and partial concordance credit (1) would be given. If the subject created the sentence, "My mother was wonderful, I'll remember her always", the sentence would be rated as positive and full concordance credit (2) would be awarded.

Example of deriving a total score for Subject "A":

There were 24 sentences to be generated by each subject. If subject A generated all 24 sentences, the total possible score for A would be 48, since each sentence can receive up to two points. Thus, if the sum of A's concordance ratings was 30, then A's overall concordance score would be 30/48 or 62.5%.

Appendix K

An attempt to cluster subjects with aberrant emotionality effects

Although there were several interesting findings when the data were examined via the conventional, statistical approach, I was not fully satisfied. Therefore, the following case-by-case investigation of the data was undertaken. The results found herein are in no way opposed to the findings using the statistical approach. In fact, the following information should be viewed as more of a description of those subjects with aberrant effects of emotionality on memory performance. My aim was to find commonalities in these types of subjects.

Word Recall Task. When individual scores were examined and subjects were separated by the criteria of either displaying the emotionality effect (emotional words recalled at a higher rate than neutral words: E>N) or not (those who recalled emotional words at an equal or lower rate than nonemotional words: N>E) the results are quite interesting. If only the brain-damaged patients (BDs) are considered, the number of subjects who displayed the emotionality effect was 27 and those who did not show this effect numbered 13 (see Table K.1). In comparing these two groups, we found no difference in months-post-onset, age or race. Trends were found between the groups on education ($F = 3.86$; df = 1,38; $p = .057$) and occupation ($F = 3.15$; df = 1,38; $p = .084$) with those displaying the emotionality effect possessing both higher education and occupation. The only highly significant difference between the groups was on gender ($F = 11.57$; df = 1,33; $p = .002$).

Figure K.1 depicts the differences in gender between the two groups. The E>N group was 25.93% female (n=7) and 74.07% male (n=20; see pie chart on left). By contrast, the N>or=E group was 76.92% female (n=10) and 23.08% male (n=3; see pie chart on right). Another way to state these differences is to say that of all the brain-damaged males, 86.96% of them displayed the emotionality effect and 13.04% did not (see Figure K.2). Of all the brain-damaged females, 41.18% of them showed the emotionality effect and 58.82% did not. Either way it is obvious that the males displayed the emotionality effect much more often than the females.

Occupation was correlated with both gender and education, and is most likely a result of these two factors. Occupation is therefore not very useful as a distinct factor in discussing results. Education, however, is not correlated with gender, and therefore it may be useful to ponder over why those who displayed the emotionality effect were also higher in education (mean = 15.00 years) than those who did not (mean = 13.23 years). Perhaps those who are more educated have learned to pay attention to the more memory-enhancing aspects of stimuli, such as emotionality. Or, it is possible that those individuals who pay more attention to memory-enhancing components of stimuli, opt for more education because they perform better in school.

The stroke symptomatology in the brain-damaged subjects was also reviewed. The groups (E>N and N>E) were similar in presence of hemiplegia, facial paralysis, seizures, visual disturbances, language disturbances, and depression. The only symptom which was much more frequent in the N>E group was sensory loss. Out of the 13 brain damaged subjects in this group, 10 (76.92%) had symptoms of sensory loss accompanying their stroke. Out of the 27 brain damaged subjects in the E>N group, 11 (40.74%) had a history of stroke-related sensory impairments. Perhaps the cortical systems that were damaged causing the sensory loss (or impaired perception of physical stimuli) are the same ones involved in the perception of the emotional quality of stimuli. This is certainly an issue that should be explored in the future.

It is useful to know that gender differences remain when the control subjects were added to this picture (see Table K.2). With the inclusion of the NCs, the E>N group (n = 44) still has a much higher male representation (males: 63.64%; females: 36.36%) and the N>E group (n=16) still has a much higher female representation (females: 75%; males: 25%). Furthermore, with the NCs included, the differences between the groups who did and did not display the emotionality effect were the same in terms of age, race, education and occupation.

Word Recognition Task. When the data from hits on the word recognition task was analyzed on a case-by case basis for the whole sample, and similarly divided into those who did and did not display the emotionality effect, the comparisons were less revealing (see Table K.3). The group which does display the emotionality effect is higher on education and occupation, however these differences are not significant. Also, the groups do not differ in their gender distributions. The brain-damaged subjects within these groups are similar in months post onset, similar distributions of caudality, and similar distributions for those with and without temporal lobe damage. The only noticeable difference between the groups is the distribution of subcortical damage in the brain damaged subjects. In the group which displays the emotionality effect, only 10% of the brain damaged subjects have subcortical involvement. In the brain damaged subjects who displays a reverse emotionality effect, 50% have subcortical damage. It is quite possible that damage to these subcortical regions had a detrimental effect upon the recognition of emotional words.

In examining the false alarm data, there were 7 subjects who elicited more false alarms to neutral stimuli than to emotional stimuli (see Table K.4). By contrast, as described in Appendix Q, most subjects made more false alarms to emotional than to neutral stimuli. There were some interesting observations in looking at these 7 subjects. First, the group was approximately 86% female (n=6), 14% male (n=1).

Second, we noticed that 71% of the group (all female) also displayed a reversal of the expected emotionality effect in at least one other situation (word recall and/or the familiar portion of the recognition task). This led us to thinking about examining those subjects who consistently (across task) showed a reversal of the expected emotionality effect.

Subjects with reversal of the emotionality effect across task. Only two subjects displayed this aberrant behavior in all three of the possible situations in which it could be found on these tasks (word recall, recognition - hits, recognition - false alarms). The commonalities between two subjects were youth (ages 52 and 55), gender (female), and caudality (both were anterior/posterior). The differences between these subjects were MPO (51 v. 18), presence of subcortical damage (represented in one subject), occupation (5 v. 9), education (13 v. 16), race (one woman was black, the other white), and side of lesion (one was an RBD, one was an LBD). Thus, the commonalities of youth, gender and frontal damage exist between these two subjects.

There were 9 subjects who displayed a reversal in direction of the expected emotionality effect under two different task demands (see Table K.5). The following is a description of these subjects. 78% (n=7) of the group was female and 22% (n=2) of the group was male. 100% of them had brain damage. 78% (n=7) of them had left cortical brain damage and only 22% were RBDs. There were twice as many subjects with frontal damage (n=6), than with non-frontal damage only (n=3). There were nearly equal numbers of subjects with and without temporal lobe involvement. Two of the subjects had additional subcortical damage. This group appears to be somewhat younger than the overall sample, with 67% (n=6) under 60 years of age, as opposed to only 42% (n=17) under 60 years of age in the overall brain damaged sample. Put a different way, only 13% of brain-damaged subjects over 60 belong to this aberrant group, but 35% of brain-damaged subjects under 60 belong to the group. The most striking finding is that approximately 41% of all brain damaged female subjects belong to this group (7 out of 17) and consistently display a reversal of the "normative" direction of the emotionality effect. This is in distinction to only 9% of the brain damaged males belong to this group and consistently exhibit this aberrant behavior (2 out of 23).

Thus, in an attempt to find a common ground between subjects who consistently display aberrant emotionality effects, the qualities of youth, having left brain damage and being female are the three outstanding characteristics of this group and are perhaps worthy of further investigation. The previously discussed characteristics of education and sensory loss may also be potentially meaningful factors in the emotion/memory equation.

Alternative explanations for weaker emotionality effects in brain-damaged groups.

Although all three groups displayed the emotionality effect on two of the tasks, it was larger, although not significantly, in the NC group than it was in the two BD groups. Of equal interest was the finding that in the word recall task, the LBDs and RBDs recalled significantly less emotionally laden stimuli than the NCs, but they were similar in their recall of neutral stimuli. Additional evidence for a stronger emotionality effect in NCs was found in this case-by-case analysis where there were many more brain-damaged than control subjects who displayed atypical or aberrant behavior with respect to emotional material. We may characterize this as a mild to moderate impairment in emotional memory in many of the brain-damaged subjects.

There may be a common underlying mechanism for those with moderately impaired emotional memory. That is, these RBDs and LBDs may both have insidious (undetected) lesions in subcortical areas, e.g. thalamo-limbic projections.

When thalamo-limbic projections are damaged, conditioned emotional responses may be disrupted, even if all of the relevant cortical areas are intact (LeDoux, 1984). The neuroanatomical information we have on these patients is not specific enough in this regard. Thus, there is no way to determine if these projections were involved.

Alternatively, it is possible that there are different mechanisms underlying the same behavior of the two brain-lesioned groups. Although there were no lateralized differences in these impairments, there are many different parts of the brain which mediate different components of emotional behavior (Papez, 1937). Thus, those RBD patients who failed to display the emotionality effect may have done so because of lesions in cortical-subcortical connections, which lower the ANS response to emotional stimuli. Thus, the emotional stimuli may not have been responded to or "recorded" as such. There is evidence that the right hemisphere is more involved in changes in arousal than the left hemisphere (e.g., Heilman et al., 1978; and see Heller, 1993)

The LBD patients, on the other hand, may have registered the material as emotional during its presentation, but on a higher cognitive level may not have given precedence to this material in terms of its future importance. Thus, the signals may have entered the subcortical limbic system and may have been correctly evaluated as emotional, but when that information is projected back for LH-cortical interpretation, the LBDs may not have processed it in the most beneficial manner. In fact, in the case-by-case analysis, out of those subjects who consistently (across at least two different tasks) displayed atypical effects of emotional stimuli, 7 out of 9, or approximately 78% of them had left brain damage. Thus, emotional stimuli was not being used effectively by these patients.

The emotional deficit in RBDs may be conceived of as an input deficit, whereas the deficit in LBDs may be conceived of as an output deficit. The deficient RBDs may not even have the correct information, whereas the LBDs have the information but do not know what to do with it. This fits in very well with Gainotti's interpretation (1989) of the emotional reactions often seen after a stroke. The RBDs, he says, exhibit "indifference reactions" because they are not encoding emotional stimuli as such (i.e., they do not show the proper ANS responses to emotional stimuli). The LBDs exhibit "catastrophic reactions", he says, because they are encoding emotional stimuli as such, but they are not dealing with it normally.

Thus, the RBDs may have failed to show memory enhancement for emotional stimuli due to basic arousal deficits and the LBDs may have failed due to a later, more cognitively-based deficit in language and memory which impinged on decisions and interpretations about the significance of emotional stimuli in memory. This proposed dichotomy of underlying mechanisms may be tested empirically by measuring arousability. For this theory to be borne out, "abnormal arousability" would be demonstrated in those RBD subjects with impairments in emotional memory and "normal arousability" would be demonstrated in those LBDs with impaired emotional memory.

The dichotomy described above relates to Leventhal's (1984) distinction between levels of emotional processing. The RBDs performance may reflect difficulty at the "schematic level" which relies on subcortical circuits and structures, while the LBDs performance may reflect difficulty at the "conceptual level" of emotional processing which relies on cortical/cognitive appraisal.

Table K.1

Word Recall: Case-by-case analysis of brain damaged subjects.

Comparison of those who display the E.E. versus those who do not display the E.E.

	Group	Age	Gender	Race	Education	Occupation	MPO
E>N (27)	12 LBD, 15 RBD	66.00	20M 7F	5AA 22W	15.00	6.78	29.67
N>=E (13)	8 LBD, 5 RBD	63.08	3M 10F	4AA 9W	13.23	5.38	39.08

Table K.2

Word Recall: Case-by-case analysis of total sample.

Comparison of those who display the E.E. versus those who do not display the E.E.

	Group	Age	Gender	Race	Education	Occupation
E>N (44)	17NC, 12 LBD, 15 RBD	65.64	28M 16F	7AA 37W	15.52	6.82
N>=E (16)	3 NC, 8 LBD, 5 RBD	62.88	4M 12F	5 AA 11W	13.38	5.44

Note. E>N = subjects who recalled emotional words at a higher rate than neutral words;
N>=E = subjects who recalled neutral words at a rate equal to or higher than emotional words

Table K.3
Word Recognition: Case-by-case analysis of all subjects.
Those who display the E.E. versus those who do not display the E.E. on Familiar List (Hits)

	Group	Age	Gender	Race	Education	Occupation	MPO
E>N (49)	19NC,15 LBD,15 RBD	65.24	26M 23F	8A 41W	15.18	6.61	32.03
N>=E (11)	1 NC, 5 LBD, 5 RBD	63.36	6M 5F	4A 7W	13.91	5.73	34.80

Table K.4
Word Recognition: Case-by-case analysis of all subjects.
Those who do not display the E.E. on Foil List (False Alarms)

	Group	Age	Gender	Race	Education	Occupation	MPO
N>=E (7)	5 LBD, 2 RBD	60.00	1M 6F	2A 5W	14.00	7.14	25.29

Table K.5.
Case-by-case analysis of all subjects.
Those who do not display the E.E. on more than one task

	Group	Age	Gender	Race	Education	Occupation	MPO
N>=E (9)	7 LBD, 2 RBD	61.11	2M 7F	3A 6W	13.11	5.33	28.89

Note. E>N = subjects who recalled emotional words at a higher rate than neutral words;
N>=E = subjects who recalled neutral words at a rate equal to or higher than emotional words

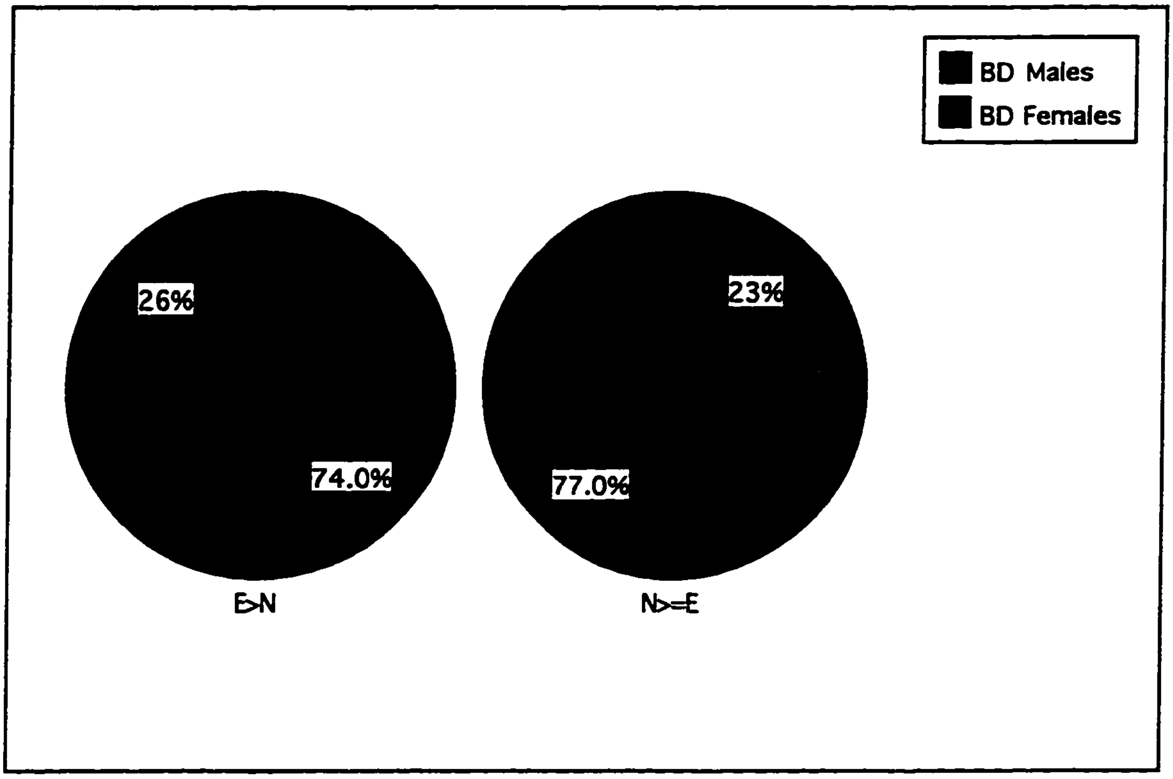

Figure K.1 Word Recall: Case-by-case analysis of those subjects with aberrant emotionality effects

E>N = subjects who recalled emotional words at a higher rate than neutral words
N>=E = subjects who recalled neutral words at a rate equal to or higher than emotional words

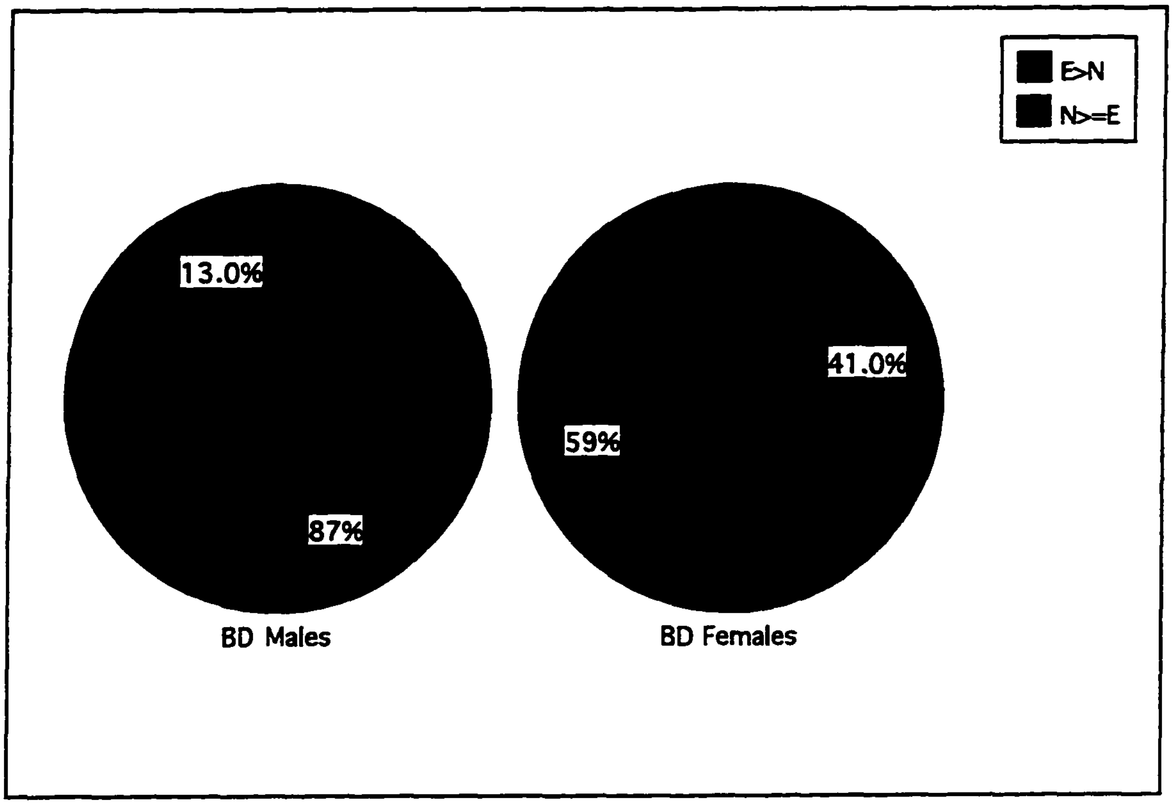

Figure K.2 Percentage of Brain Damaged Males and Females who do and do not demonstrate the Emotionality Effect on the Word Recall Task.

E>N = subjects who recalled emotional words at a higher rate than neutral words;
N>=E = subjects who recalled neutral words at a rate equal to or higher than emotional words.

Appendix L

ANOVA Tables:
Emotionality Variable

1) WORD RECALL TASK: Group (3: NC, LBD, RBD) x Learning Condition (2: generate, read) x Emotionality of Stimulus (2: Emotional, Neutral)

Variables	n	F	df	p
Between:				
Group (3)	60	5.05	(2,57)	.010
Within:				
Condition (2)		15.10	(1,57)	.000
Emotionality (2)		20.09	(1,57)	.000
Interactions:				
Group x Condition		0.48	(2,57)	.620
Group x Emotionality		1.28	(2,57)	.285
Condition x Emot.		2.37	(1,57)	.130
Group x Condition x Emot.		1.46	(2,57)	.240

2) WORD RECALL TASK: Gender (2: male, female) x Learning Condition (2: generate, read) x Emotionality of Stimuli (2: Emotional, Neutral)

Variables	n	F	df	p
Between:				
Gender (2)	60	10.11	(1,58)	.002
Within:				
Condition (2)		16.86	(1,58)	.000
Emotionality (2)		19.23	(1,58)	.000
Interactions:				
Gender x Condition		3.26	(1,58)	.076
Gender x Emotionality		1.03	(1,58)	.316
Condition x Emotionality		2.43	(1,58)	.125
Gender x Cond x Emot		.410	(1,58)	.524

3) WORD RECALL TASK: Side of Lesion (left, right) x Gender (2: male, female) x Learning Condition (2: generate, read) x Emotionality of Stimuli (2: Emotional, Neutral)

Variables	n	F	df	p
Between:				
Side (2)	40	0.56	(1,36)	.458
Gender (2)		4.88	(1,36)	.034
Within:				
Condition (2)		11.95	(1,36)	.001
Emotionality (2)		5.24	(1,36)	.028
Interactions:				
Side x Gender		0.00	(1,36)	.998
Condition x Emotionality		6.62	(1,36)	.014
Side x Condition		1.71	(1,36)	.199
Side x Emotionality		1.03	(1,36)	.317
Gender x Condition		3.90	(1,36)	.056
Gender x Emotionality		2.04	(1,36)	.162
Side x Gender x Condition		1.71	(1,36)	.199
Side x Gender x Emot		0.34	(1,36)	.561

Variables	n	F	df	p
Side x Condition x Emot		0.03	(1,36)	.867
Gender x Condition x Emot		3.44	(1,36)	.072
Side x Gender x Cond x Emot		.076	(1,36)	.784
4) WORD RECALL TASK: Side of Lesion (left, right) x Caudality (2: anterior/posterior, posterior) x Learning Condition (2: generate, read) x Emotionality of Stimuli (2: Emotional, Neutral)				
Between:				
Side (2)	38	1.27	(1,34)	.267
Caudality (2)		0.12	(1,34)	.734
Within:				
Condition (2)		8.58	(1,34)	.006
Emotionality (2)		5.84	(1,34)	.021
Interactions:				
Side x Caudality		0.07	(1,34)	.798
Emotion x Condition		6.62	(1,34)	.015
Side x Emotion		1.17	(1,34)	.288
Side x Condition		0.39	(1,34)	.536
Caudality x Emotion		5.81	(1,34)	.022
Caudality x Condition		0.39	(1,34)	.536
Side x Caudality x Emotion		0.06	(1,34)	.810
Side x Caudality x Condition		0.48	(1,34)	.492
Caudality x Emotion x Cond		0.03	(1,34)	.870
Side x Emotion x Condition		0.03	(1,34)	.870
Side x Caudality x Cond x Emot		0.18	(1,34)	.672
5) WORD RECALL TASK: Side of Lesion (left, right) x Temporal Lobe Involvement (2: with, without) x Learning Condition (2: generate, read) x Emotionality of Stimuli (2: Emotional, Neutral)				
Between:				
Side (2)	36	0.42	(1,32)	.523
Temp.Involvement (2)		0.05	(1,32)	.827
Within:				
Condition (2)		12.20	(1,32)	.001
Emotionality (2)		5.30	(1,32)	.028
Interactions:				
Side x Temp		0.74	(1,32)	.397
Side x Cond		0.17	(1,32)	.686
Side x Emot		0.57	(1,32)	.456
Temp x Cond		0.42	(1,32)	.521
Temp x Emot		0.54	(1,32)	.467
Emot x Cond		15.49	(1,32)	.000
Side x Emot x Cond		0.75	(1,32)	.393
Side x Temp x Emot		2.20	(1,32)	.148
Side x Temp x Cond		0.04	(1,32)	.848
Temp x Emot x Cond		3.47	(1,32)	.072
Side x Temp x Emot x Cond		2.09	(1,32)	.158

6) HITS ON WORD RECOG TASK: Group (NC, LBD, RBD) x Condition (generate, read) x Emotionality of Material (Emotional, Neutral)

Variables	n	F	df	p
Between:				
Group (3)	58	0.95	(2,55)	.393
Within:				
Condition (2)		75.26	(1,55)	.000
Emotionality (2)		37.08	(1,55)	.000
Interactions:				
Group x Condition		0.82	(2,55)	.447
Group x Emotionality		0.96	(2,55)	.388
Condition x Emot.		11.74	(1,55)	.001
Group x Cond x Emot		0.33	(2,55)	.720

7) HITS ON WORD RECOG TASK: Gender (male, female) Condition (generate, read) x Emotionality of Material (Emotional, Neutral)

Between:				
Gender (2)	58	0.02	(1,56)	.894
Within:				
Condition (2)		74.85	(1,56)	.000
Emotionality (2)		37.24	(1,56)	.000
Interactions:				
Gender x Condition		0.45	(1,56)	.505
Gender x Emot.		2.55	(1,56)	.116
Condition x Emot.		11.85	(1,56)	.001
Gender x Cond. x Emot.		0.24	(1,56)	.627

8) HITS ON WORD RECOG TASK: Side of Lesion (left, right) x Gender (2: male, female) x Learning Condition (2: generate, read) x Emotionality of Stimuli (2: Emotional, Neutral)

Between:				
Side (2)	39	1.15	(1,35)	.290
Gender (2)		0.01	(1,35)	.930
Within:				
Condition (2)		51.16	(1,35)	.000
Emotionality (2)		11.89	(1,35)	.001
Interactions:				
Side x Gender		0.74	(1,35)	.397
Condition x Emotionality		8.48	(1,35)	.006
Side x Condition		0.76	(1,35)	.390
Side x Emotionality		0.08	(1,35)	.783
Gender x Condition		0.10	(1,35)	.749
Gender x Emotionality		2.33	(1,35)	.136
Side x Gender x Condition		0.55	(1,35)	.462
Side x Gender x Emotionality		0.20	(1,35)	.136
Side x Condition x Emot		0.11	(1,35)	.740
Gender x Condition x Emot		0.18	(1,35)	.674
Side x Gender x Cond x Emot		0.59	(1,35)	.447

9) HITS ON WORD RECOGNITION TASK: Side of Lesion (left, right) x Caudality (anterior/posterior, posterior) x Learning Condition (Generate, Read) x Emotionality of Stimuli (Emotional, Neutral)

Variables	n	F	df	p
Between:				
Side (2)	37	0.41	(1,33)	.529
Caudality (2)		4.52	(1,33)	.041
Within:				
Condition (2)		49.32	(1,33)	.000
Emotionality (2)		9.91	(1,33)	.003
Interactions:				
Side x Caudality		0.30	(1,33)	.586
Condition x Emot		5.52	(1,33)	.025
Side x Condition		0.60	(1,33)	.443
Side x Emotionality		0.02	(1,33)	.903
Caudality x Cond		4.47	(1,33)	.042
Caudality x Emot		0.15	(1,33)	.699
Side x Caudality x Cond		0.04	(1,33)	.851
Side x Caudality x Emot		1.20	(1,33)	.281
Side x Condition x Emot		0.37	(1,33)	.549
Caudality x Condition x Emot		0.04	(1,33)	.836
Side x Caudality x Cond x Emot		1.09	(1,33)	.303

10) HITS ON WORD RECOGNITION TASK: Side of Lesion (left, right) x Temporal Lobe Involvement (with, without) x Learning Condition (Generate, Read) x Emotionality of Material (Emotional, Neutral)

Between:				
Side (2)	35	0.78	(1,31)	.384
T-lobe (2)		0.92	(1,31)	.345
Within:				
Condition (2)		47.48	(1,31)	.000
Emotionality (2)		13.12	(1,31)	.001
Interactions:				
Side x T-lobe				
Side x Condition		1.35	(1,31)	.254
Side x Emotionality		0.07	(1,31)	.801
T-lobe x Condition		2.63	(1,31)	.115
T-lobe x Emotionality		3.11	(1,31)	.088
Condition x Emot.		11.20	(1,31)	.002
Side x Cond x Emot		0.12	(1,31)	.737
T-lobe x Cond x Emot		4.81	(1,31)	.036
T-lobe x Side x Cond		2.63	(1,31)	.115
T-lobe x Side x Emot		5.78	(1,31)	.022
T-lobe x Side x Cond x Emot		8.03	(1,31)	.008

11) SENTENCE RECALL TASK: Group (NC, LBD, RBD) x Learning Condition (generate, read) x Emotionality of Stimulus (Emotional, Neutral)

Variables	n	F	df	p
Between:				
Group (3)	59	1.54	(2,56)	.224
Within:				
Condition (2)		95.38	(1,56)	.000
Emotionality (2)		0.20	(1,56)	.660
Interactions				
Group x Cond		0.30	(2,56)	.796
Group x Emot		0.02	(2,56)	.976
Cond x Emot		0.03	(1,56)	.872
Group x Cond x Emot		1.15	(2,56)	.325
Gender x Group x Emot		0.20	(2,53)	.818
Gp x Gender x Cond x Emot		0.13	(2,53)	.876

12) SENTENCE RECALL TASK: Gender (male, female) x Condition (generate, read) x Emotionality of Material (Emotional, Neutral)

Between:				
Gender (2)	59	1.83	(1,57)	.181
Within:				
Condition (2)		97.64	(1,57)	.000
Emotionality (2)		0.16	(1,57)	.690
Interactions:				
Gender x Condition		0.38	(1,57)	.538
Gender x Emotionality		0.36	(1,57)	.552
Condition x Emot		0.02	(1,57)	.884
Gender x Cond x Emot		0.33	(1,57)	.568

13) SENTENCE RECALL TASK: Side of Lesion (left, right) x Gender (2: male, female) x Learning Condition (2: generate, read) x Emotionality of Stimuli (2: Emotional, Neutral)

Between:				
Side (2)	39	0.89	(1,35)	.352
Gender (2)		0.43	(1,35)	.516
Within:				
Condition (2)		69.37	(1,35)	.000
Emotionality (2)		0.07	(1,35)	.798
Interactions:				
Side x Condition		0.30	(1,35)	.587
Side x Emotionality		0.05	(1,35)	.833
Gender x Condition		0.36	(1,35)	.551
Gender x Emotionality		0.48	(1,35)	.496
Side x Gender		4.00	(1,35)	.053
Condition x Emotionality		0.16	(1,35)	.689
Side x Cond x Emot		1.16	(1,35)	.290
Side x Gender x Cond		1.80	(1,35)	.188
Side x Gender x Emot		0.27	(1,35)	.608
Gender x Cond x Emot		0.34	(1,35)	.562
Side x Gender x Cond x Emot		0.16	(1,35)	.695

14) SENTENCE RECALL TASK: Side of Lesion (left, right) x Caudality (anterior/posterior, posterior) x Learning Condition (Generate, Read) x Emotionality of Stimuli (Emotional, Neutral)

Variables	n	F	df	p
Between:				
Side (2)	37	0.86	(1,33)	.361
Caudality (2)		0.63	(1,33)	.433
Within:				
Condition (2)		67.95	(1,33)	.000
Emotionality (2)		0.06	(1,33)	.807
Interactions:				
Side x Caudality		0.17	(1,33)	.688
Side x Condition		0.21	(1,33)	.647
Side x Emotionality		0.00	(1,33)	.991
Caudality x Condition		0.04	(1,33)	.841
Caudality x Emot		0.06	(1,33)	.807
Condition x Emot		0.00	(1,33)	.948
Side x Cond x Emot		2.00	(1,33)	.167
Side x Caudality x Cond		0.16	(1,33)	.690
Side x Caudality x Emot		1.09	(1,33)	.303
Caudality x Cond x Emot		0.69	(1,33)	.412
Side x Caudality x Cond x Emot		1.41	(1,33)	.243

15) SENTENCE RECALL TASK: Side of Lesion (left, right) x Temporal Lobe Involvement (with, without) x Learning Condition (Generate, Read) x Emotionality of Material (Emotional, Neutral)

Between:				
Side (2)	35	0.38	(1,31)	.540
T-lobe (2)		4.07	(1,31)	.052
Within:				
Condition (2)		57.17	(1,31)	.000
Emotion (2)		0.00	(1,31)	.985
Interactions:				
Side x T-lobe		0.63	(1,31)	.433
Side x Condition		0.07	(1,31)	.797
Side x Emot		0.02	(1,31)	.901
T-lobe x Cond		0.27	(1,31)	.610
T-lobe x Emot		0.02	(1,31)	.901
Condition x Emot		0.15	(1,31)	.704
Side x T-lobe x Cond		0.00	(1,31)	.982
Side x T-lobe x Emot		0.38	(1,31)	.543
Side x Cond x Emot		1.35	(1,31)	.254
T-lobe x Cond x Emot		0.74	(1,31)	.396
Side x T-lobe x Cond x Emot		2.69	(1,31)	.111

Appendix M

ANOVA Tables: Valence Variable

1) WORD RECALL TASK: Group (3: NC, LBD, RBD) x Learning Condition (2: generate, read) x Valence(2:positive,negative)

Variables	n	F	df	p
Between:				
Group (3)	60	8.01	(2,57)	.001
Within:				
Learning Condition (2)		5.02	(1,57)	.029
Valence (2)		1.46	(1,57)	.232
Interactions				
Group x Condition		2.79	(2,57)	.070
Group x Valence		0.28	(2,57)	.756
Condition x Valence		0.01	(1,57)	.930
Condition x Valence x Group		0.26	(2,57)	.771

2) WORD RECALL TASK: Gender (2: male, female) x Learning Condition (2: generate, read) x Valence(2:positive,negative)

Between:				
Gender (2)	60	3.34	(1,54)	.073
Within:				
Learning Condition (2)				
Valence (2)				
Interactions:				
Gender x Condition		1.12	(1,54)	.296
Gender x Valence		2.66	(1,54)	.109
Gender x Condition x Valence		0.68	(1,54)	.415

3) WORD RECALL TASK: Side of Lesion (left, right) x Gender (2: male, female) x Learning Condition (2: generate, read) x Valence(2:positive,negative)

Between:				
Side of Lesion (2)	40	1.60	(1,36)	.214
Gender (2)		1.23	(1,36)	.274
Within:				
Condition (2)		0.33	(1,36)	.568
Valence (2)		0.89	(1,36)	.352
Interactions:				
Side x Gender		0.12	(1,36)	.732
Side x Condition		0.91	(1,36)	.347
Side x Valence		0.08	(1,36)	.777
Gender x Condition		0.00	(1,36)	.983
Gender x Valence		0.71	(1,36)	.405
Condition x Valence		0.02	(1,36)	.904

	n	F	df	p
Side x Gender x Condition		1.84	(1,36)	.183
Side x Gender x Valence		0.03	(1,36)	.855
Side x Condition x Valence		0.23	(1,36)	.637
Gender x Condition x Valence		2.59	(1,36)	.117
Side x Gender x Condition x Valence		0.59	(1,36)	.446

4) WORD RECALL TASK: Side of Lesion (left, right) x Caudality (2: anterior/posterior, posterior) x Learning Condition (2: generate, read) valence(2:positive,negative)

	n	F	df	p
Between:				
Side of lesion (2)	38	2.86	(1,34)	.100
Caudality (2)		2.86	(1,34)	.100
Within:				
Valence (2)		0.91	(1,34)	.346
Learning Condition (2)		0.05	(1,34)	.832
Interactions:				
Side x Caudality		0.01	(1,34)	.912
Caudality x Valence		0.27	(1,34)	.605
Caudality x Condition		0.15	(1,34)	.700
Caudality x Condition x Valence		5.94	(1,34)	.020
Side x Caudality x Valence		0.91	(1,34)	.346
Side x Caudality x Condition		0.05	(1,34)	.832
Side x Caudality x Condition x Valence		0.08	(1,34)	.785

5) WORD RECALL TASK: Side of Lesion (left, right) x Temporal Lobe Involvement (2: with, without) x Learning Condition (2: generate, read) x Valence(2:positive,negative)

	n	F	df	p
Between:				
Side of Lesion (2)				
Temporal Involvement (2)	36	0.39	(1,32)	.535
Within:				
Valence (2)				
Learning Condition (2)				
Interactions:				
Side x Temp.		0.01	(1,32)	.943
Variables				
Temp x Valence		1.22	(1,32)	.277
Variables				
Temp x Condition		0.80	(1,32)	.377
Side x Temp x Valence		0.43	(1,32)	.516
Side x Temp x Condition		1.64	(1,32)	.210
Temp x Valence x Condition		2.73	(1,32)	.108
Side x Temp x Valence x Condition		2.27	(1,32)	.142

6) WORD RECOGNITION TASK (Hits): Group (3: NC, LBD, RBD) x Learning Condition (2: generate, read) valence(2:positive,negative)

	n	F	df	p
Between:				
Group (3)	58	1.44	(2,55)	.247
Within:				
Valence (2)		3.08	(1,55)	.085
Learning Condition (2)		40.41	(1,55)	.000
Interactions:				
Group x Valence		0.55	(1,55)	.580
Group x Condition		1.96	(2,55)	.151
Valence x Condition		0.18	(1,55)	.670
Group x Valence x Condition		0.64	(2,55)	.530

7) WORD RECOGNITION TASK (HITS): Gender (2: male, female) x Learning Condition (2: generate, read) x Valence(2:positive,negative)

Between:				
Gender (2)	58	0.24	(1,52)	.623
Within:				
Valence (2)				
Learning Condition (2)				
Interactions:				
Gender x Valence		0.99	(1,52)	.324
Gender x Condition		0.51	(1,52)	.478
Gender x Valence x Condition		0.01	(1,52)	.917

8) WORD RECOGNITION TASK (HITS): Side of Lesion (left, right) x Gender (2: male, female) x Learning Condition (2: generate, read) valence (2:positive ,negative)

Between:				
Side of Lesion (2)	39	0.98	(1,35)	.329
Gender (2)		0.59	(1,35)	.449
Within:				
Valence (2)		0.31	(1,35)	.579
Learning Condition (2)		23.32	(1,35)	.000
Interactions:				
Side x Valence		0.00	(1,35)	.954
Side x Condition		1.65	(1,35)	.208
Valence x Condition		0.00	(1,35)	.964
Side x Gender		1.18	(1,35)	.284
Gender x Valence		1.52	(1,35)	.226
Gender x Condition		0.61	(1,35)	.441
Side x Valence x Condition		0.69	(1,35)	.413
Gender x Valence x Condition		0.03	(1,35)	.858
Side x Gender x Valence		0.81	(1,35)	.374
Side x Gender x Condition		0.00	(1,35)	.976
Side x Gender x Valence x Condition		0.00	(1,35)	.996

9) WORD RECOGNITION TASK (HITS ONLY): Side of Lesion (left, right) x Caudality (2: anterior/posterior, posterior) x Learning Condition (2: generate, read) x Valence(2:positive,negative)

Variables	n	F	df	p
Between:				
Side of Lesion (2)	37			
Caudality (2)		3.89	(1,33)	.057
Within:				
Valence (2)				
Learning Condition (2)				
Interactions:				
Caudality x Side		1.14	(1,33)	.294
Caudality x Valence		1.13	(1,33)	.296
Caudality x Condition		5.02	(1,33)	.032
Caudality x Side x Valence		0.47	(1,33)	.497
Caudality x Side x Condition		0.79	(1,33)	.380
Caudality x Valence x Condition		0.06	(1,33)	.814
Caudality x Side x Val. x Condition		0.11	(1,33)	.741

10) WORD RECOGNITION TASK (HITS): Side of Lesion (left, right) x Temporal Lobe Involvement (2: with, without) x Learning Condition (2: generate, read) x Valence(2:positive,negative)

Between:				
Side of Lesion (2)	35			
Temporal Involvement (2)		0.07	(1,31)	.789
Within:				
Valence (2)				
Learning Condition (2)				
Interactions:				
Temp x Side		0.23	(1,31)	.635
Temp x Valence		1.94	(1,31)	.173
Temp x Condition		0.02	(1,31)	.896
Temp x Side x Valence		0.00	(1,31)	.957
Temp x Side x Condition		0.47	(1,31)	.499
Temp x Valence x Condition		0.34	(1,31)	.561
Temp x Side x Valence x Condition		1.91	(1,31)	.177

11) SENTENCE RECALL TASK: Group (3: NC, LBD, RBD) x Learning Condition (2: generate, read) x Valence(2:positive,negative)

	n	F	df	p
Between:				
Group (3)	59	1.62	(2,56)	.207
Within:				
Valence (2)		0.03	(1,56)	.868
Learning Condition (2)		83.91	(1,56)	.000
Interactions:				
Group x Valence		0.13	(2,56)	.880
Group x Condition		0.04	(2,56)	.966
Valence x Condition		0.88	(1,56)	.351
Group x Valence x Condition		1.52	(2,56)	.229

12) SENTENCE RECALL TASK: Gender (2: male, female) x Learning Condition (2: generate, read) x Valence(2:positive,negative)

Between:				
Gender (2)	59	0.61	(1,53)	.439
Within:				
Valence (2)				
Learning Condition (2)				
Interactions:				
Gender x Valence		1.96	(1,53)	.168
Gender x Condition		0.81	(1,53)	.371
Gender x Valence x Condition		2.08	(1,53)	.155

13) SENTENCE RECALL TASK: Side of Lesion (left, right) x Gender (2: male, female) x Learning Condition (2: generate, read) x Valence (2:positive,negative)

Between:				
Side	39	0.65	(1,35)	.425
Gender		0.08	(1,35)	.782
Within:				
Valence		0.04	(1,35)	.834
Learning Condition		68.17	(1,35)	.000
Interactions:				
Side x Gender		2.81	(1,35)	.102
Side x Valence		0.01	(1,35)	.929
Side x Condition		0.02	(1,35)	.888
Gender x Valence		1.16	(1,35)	.289
Gender x Condition		.889	(1,35)	.352
Valence x Condition		0.36	(1,35)	.555
Side x Gender x Valence		0.07	(1,35)	.798
Side x Gender x Condition		1.09	(1,35)	.303
Side x Valence x Condition		0.01	(1,35)	.935
Gender x Val x Condition		2.35	(1,35)	.134
Side x Gender x Val. x Cond.		0.73	(1,35)	.398

14) SENTENCE RECALL TASK: Side of Lesion (left, right) x Caudality (2: anterior/posterior, posterior) x Learning Condition (2: generate, read) valence(2:positive,negative)

	n	F	df	p
Between:				
Side	37			
Caudality		0.46	(1,33)	.504
Within:				
Valence				
Learning Condition				
Interactions:				
Caudality x Side		0.02	(1,33)	.893
Caudality x Valence		0.02	(1,33)	.883
Caudality x Condition		0.08	(1,33)	.778
Caudality x Side x Valence		0.10	(1,33)	.750
Caudality x Side x Condition		1.18	(1,33)	.285
Caudality x Valence x Condition		0.00	(1,33)	.983
Caudality x Side x Val x Condition		2.16	(1,33)	.151

15) SENTENCE RECALL TASK: Side of Lesion (left, right) x Temporal Lobe Involvement (2: with, without) x Learning Condition (2: generate, read) x Valence(2:positive,negative)

Between:				
Side	35			
Temporal Involvement		4.04	(1,31)	.054
Within:				
Valence				
Learning Condition				
Interactions:				
Temp x Side		1.36	(1,31)	.253
Temp x Valence		0.59	(1,31)	.449
Temp x Condition		0.00	(1,31)	.995
Temp x Side x Valence		0.91	(1,31)	.348
Temp x Side x Condition		0.95	(1,31)	.338
Temp x Valence x Condition		3.17	(1,31)	.085
Temp x Side x Val. x Cond.		2.20	(1,31)	.148

Appendix N

Social Life Scale

Please choose one of the following three categories to describe your social life:

2 = good: I am in continuous contact with friends and/or family and engage in activities with them, or I engage in activities that are of interest to me on a regular basis. I am very satisfied with my social life at this time.

1= OK or fine: I have contact with friends or family and occasionally participate in activities that are enjoyable to me. I am fairly satisfied with my social life at this time.

0 = poor: I am rarely in contact with friends or family. I rarely engage in activities of interest to me. I am not satisfied with my social life at this time.

Appendix O
Correlation Matrix

	WAIS	RAVENS	COMP IDEA	READ COMP	MDRS ATTN	MDRS MEM	LMI	LMII	ANIMALS	FAS
WAIS	1.00									
RAVENS	0.56	1.00								
COMPIDEA	0.55	0.50	1.00							
READCOMP	0.65	0.41	0.53	1.00						
MDRSATTN	0.43	0.31	0.28	0.46	1.00					
MDRSMEM	0.22	0.13	-0.01	0.22	0.31	1.00				
LMI	0.58	0.37	0.41	0.44	0.34	0.29	1.00			
LMII	0.58	0.29	0.34	0.32	0.16	0.23	0.76	1.00		
ANIMALS	0.62	0.39	0.39	0.37	0.37	0.31	0.58	0.44	1.00	
FAS	0.56	0.40	0.16	0.38	0.50	0.17	0.44	0.38	0.61	1.00
BECK	-0.29	-0.44	-0.41	-0.13	-0.10	-0.09	-0.16	-0.28	-0.32	-0.15
PANASPOS	-0.16	0.06	-0.10	-0.14	0.10	0.17	-0.08	-0.01	0.10	0.14
PANASNEG	-0.10	-0.25	-0.38	-0.03	0.03	0.09	-0.05	-0.05	-0.16	0.05
DISTRUST	0.05	-0.17	-0.04	0.07	0.03	0.09	0.07	-0.10	0.06	0.08
RIGID	-0.04	-0.08	-0.10	0.04	0.14	-0.14	0.18	-0.12	0.02	0.12
OPTIMIST	0.13	0.15	0.18	0.03	-0.05	-0.21	-0.21	0.08	-0.10	-0.10
SOCLIFE	0.08	0.12	0.10	-0.04	0.14	0.02	0.12	0.35	0.15	0.01
AGE	0.11	-0.04	-0.02	-0.18	-0.13	-0.21	0.16	0.44	-0.04	0.16
EDUCATION	0.72	0.44	0.39	0.34	0.16	0.07	0.54	0.50	0.46	0.37
OCCUPATION	0.56	0.25	0.25	0.30	0.08	-0.02	0.41	0.37	0.26	0.18
MPO	0.07	0.19	-0.23	0.07	0.13	0.08	-0.15	-0.09	0.10	0.47
CONCORDANCE	-0.30	-0.16	-0.17	-0.22	-0.20	-0.17	-0.14	-0.14	-0.20	-0.19
WD RECALL EQ	0.18	0.03	0.22	0.09	0.17	0.10	0.12	0.17	0.16	0.11
WD RECOG EQ	0.23	-0.03	0.17	0.12	0.06	0.03	0.32	0.30	0.20	0.19
SENT RECALL EQ	-0.04	-0.07	-0.18	-0.16	-0.01	-0.00	-0.07	0.04	0.07	0.14
WD RECALL GQ	0.04	0.19	0.09	0.02	0.09	-0.13	-0.05	-0.03	0.21	0.17
WD RECOG GQ	-0.01	0.03	0.01	-0.16	-0.08	-0.04	0.11	-0.02	0.19	0.06
SENT RECALL GQ	0.06	0.03	0.08	0.21	0.27	0.10	-0.11	-0.04	-0.12	0.13

Note.
Boldface indicates p<.05; Underline indicates p<.01; Double underline indicates p<.001
EQ = E-N/E+N; GQ = G-R/G+R (see methods section for full explanation)

Appendix O (cont.)

Correlation Matrix

	BECK	PANAS POS	PANAS NEG	DISTRUSTFUL	RIGID	OPTIMISTIC	SOCIAL LIFE	AGE	EDUCATION	OCCUPATION
WAIS										
RAVENS										
COMPIDEA										
READCOMP										
MDRSATTN										
MDRSMEM										
LMI										
LMII										
ANIMALS										
FAS										
BECK	1.00									
PANASPOS	**-0.33**	1.00								
PANASNEG	**0.59**	-0.17	1.00							
DISTRUST	0.16	0.09	-0.02	1.00						
RIGID	0.22	**-0.27**	0.13	0.20	1.00					
OPTIMIST	-0.25	0.08	**-0.27**	-0.09	**-0.27**	1.00				
SOCLIFE	**-0.37**	**0.28**	-0.14	-0.21	-0.25	-0.03	1.00			
AGE	-0.13	-0.11	0.05	0.04	-0.04	0.06	0.16	1.00		
EDUCATION	-0.15	**-0.30**	-0.01	-0.05	-0.00	0.08	-0.01	0.11	1.00	
OCCUPATION	-0.11	-0.25	-0.03	0.08	0.14	0.07	-0.03	0.21	**0.71**	1.00
MPO	-0.02	0.05	0.22	-0.03	0.07	0.04	-0.04	0.15	0.12	0.02
CONCORDANCE	0.13	-0.13	0.22	-0.08	0.22	0.16	-0.19	-0.08	-0.19	-0.14
WD RECALL EQ	-0.09	0.02	0.07	-0.01	**0.25**	-0.05	0.08	0.08	0.05	0.12
WD RECOG EQ	-0.02	-0.06	0.18	-0.03	0.04	-0.17	0.14	0.08	0.12	-0.00
SENT RECALL EQ	-0.15	0.14	0.01	-0.03	**-0.29**	-0.04	0.22	0.15	0.10	-0.04
WD RECALL GQ	-0.10	0.16	-0.02	-0.21	-0.19	0.01	0.04	0.04	-0.10	-0.12
WD RECOG GQ	-0.01	-0.10	0.03	0.04	0.08	-0.15	-0.11	0.03	0.14	0.06
SENT RECALL GQ	-0.16	-0.02	-0.05	-0.09	0.09	-0.08	0.22	-0.04	-0.06	0.01

Appendix O (cont.)
Correlation Matrix

	MPO	CONCORDANCE	WD RECALL EQ	WD RECOG EQ	SENT RECALL EQ	WD RECAL GQ	WD RECOG GQ	SENT RECALL GQ
WAIS								
RAVENS								
COMPIDEA								
READCOMP								
MDRSATTN								
MDRSMEM								
LMI								
LMII								
ANIMALS								
FAS								
BECK								
PANASPOS								
PANASNEG								
DISTRUST								
RIGID								
OPTIMIST								
SOCLIFE								
AGE								
EDUCATION								
OCCUPATION								
MPO	1.00							
CONCORDANCE	-0.09	1.00						
WD RECALL EQ	-0.16	0.21	1.00					
WD RECOG EQ	-0.05	-0.03	0.08	1.00				
SENT RECALL EQ	0.52	-0.09	-0.06	-0.02	1.00			
WD RECALL GQ	0.08	-0.07	0.02	-0.10	0.09	1.00		
WD RECOG GQ	-0.06	-0.07	-0.20	0.11	0.06	0.18	1.00	
SENT RECALL GQ	0.00	-0.20	0.02	0.15	0.07	-0.06	0.12	1.00

Appendix P

Data from LBD patients

	Language Disordered (n=13)	Non-language Disordered (n=7)
Free Recall Task		
Emotional	25.00	37.50
Neutral	24.04	25.89
Recognition Task		
Read/Emotional	69.71	83.04
Read/Neutral	59.62	55.36
Sentence Recall Task		
Emotional	34.62	34.82
Neutral	27.89	39.29

Appendix Q

Analysis of False Alarm Data

In my pilot study, which was conducted on 30 college students, I noticed that there were many more false alarms on the recognition task (i.e., errors of commission; responding affirmatively to unseen stimuli) in response to emotional stimuli as compared to neutral stimuli. In our main study we found that this was also the case. Directly below these results are presented, followed by a discussion of these results and a summary table of the F, df, and p values from the ANOVAs.

Analysis of Group. Figure Q.1 depicts the false alarm rate in emotional and non-emotional conditions for each of the primary groups. The false alarm rate is highest in the group with left brain damage (mean = 15.12). The NC group obtained a somewhat lower false alarm rate (mean = 11.80) and the RBD group obtained the lowest rate of false alarms (mean = 7.31). The difference between these means represented a statistical trend, $F(2,57) = 2.66$, $p = .078$ in the 3 (group) x 2 (stimulus emotionality) ANOVA applied to these data. Post-hoc tests revealed that only the difference in false alarm rate between the two brain-damaged groups represented a statistical trend ($p=.072$). Figure Q.1 also demonstrates that the false alarm rate is higher for emotional words (mean = 14.37) than it is for neutral words (mean = 5.83). All groups appear to show a similar difference in false alarm rate between emotional and neutral material, which was confirmed by the failure for group and emotionality factors to interact in the ANOVA described above.

Figure Q.2 depicts the rate of false alarms for positive and negative stimuli. We again see the group difference (more false alarms for the LBD group than the RBD group) that was confirmed by a trend for the group factor, $F(2,57) = 2.48$, $p = .093$

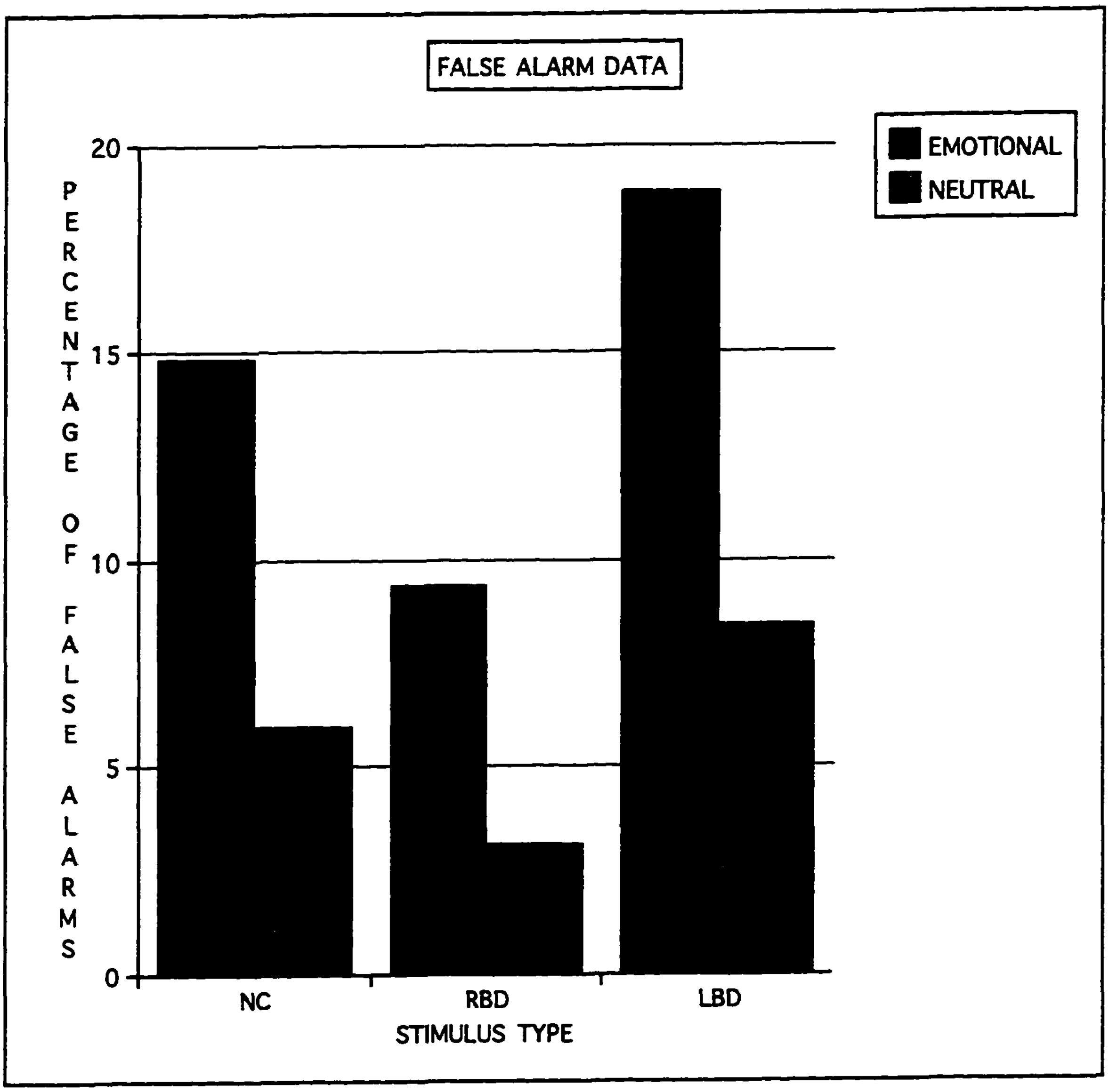

Figure Q.1. Percent of false alarms committed by normal control subjects, right brain-damaged subjects, and left brain-damaged subjects for emotional and neutral words on the word recognition task.

NC = normal control group (n=20); LBD = left brain-damaged group (n=20); RBD = right brain-damaged group (n=20)

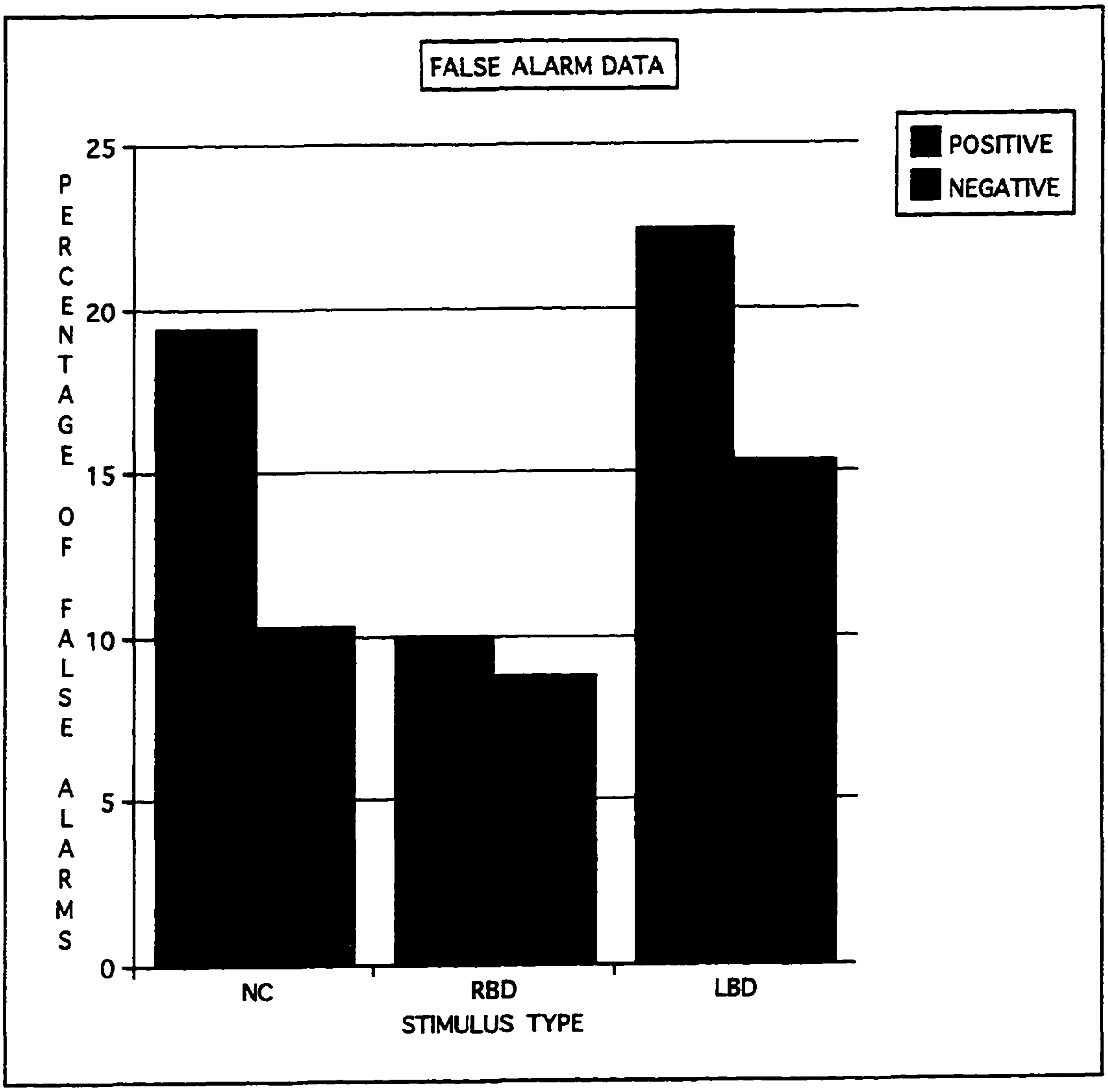

Figure Q.2. Percent false alarms committed by normal control subjects, left brain-damaged subjects and right brain-damaged subjects for positive and negative words.

NC = normal control subjects (n=20); LBD = left brain-damaged subjects (n=20); RBD = right brain-damaged subjects (n=20).

in the 3 (Group) x 2 (valence) ANOVA which was applied to this data. Furthermore,we see that there were more false alarms for positive stimuli (mean = 17.29) than for negative stimuli (mean = 11.46). The significance of this difference was confirmed by the main effect of the valence factor, F (1,57) = 12.91, p = .001. Although this valence effect is less apparent in the RBD group, the interaction between group and valence was not significant.

Analysis of Caudality. Figure Q.3 depicts the false alarm rate for left and right brain-damaged groups with and without anterior damage. There are several interesting findings depicted in this figure. First we can see again that the group with left-brain damage committed more false alarms (mean = 15.12) than the group with right-brain damage (mean = 7.30). We also see, as in the analysis of the total sample, that there are more false alarms committed for emotional stimuli (mean = 14.55) than for neutral stimuli (mean = 5.92). We also see some influence of laterality and caudality, such that in patients with right brain damage, the difference score between emotional and neutral false alarms is similar in patients with damage limited to posterior regions (12.11 - 5.46 = 6.65) and in patients whose damage includes anterior regions (7.10 - 1.14 = 5.86). However, in patients with left brain damage, the difference between the false alarm rate for emotional and neutral stimuli is much larger in patients with damage to posterior regions (24.14 - 6.82 = 17.32) than in patients whose damage includes anterior regions (14.06 - 11.72 = 2.34).

The main effects of laterality, F (1,34) = 5.48, p = .025, and emotionality, F (1,34) = 16.22, p = .000 were confirmed in the 2 (laterality: right, left) x 2 (caudality: frontal lesion, no frontal lesion) x 2 (stimulus emotionality: emotional, neutral) ANOVA applied to these data. Furthermore, there were trend effects for the two-way interaction between emotionality and caudality, F (1,34) = 3.82, p = .059, and

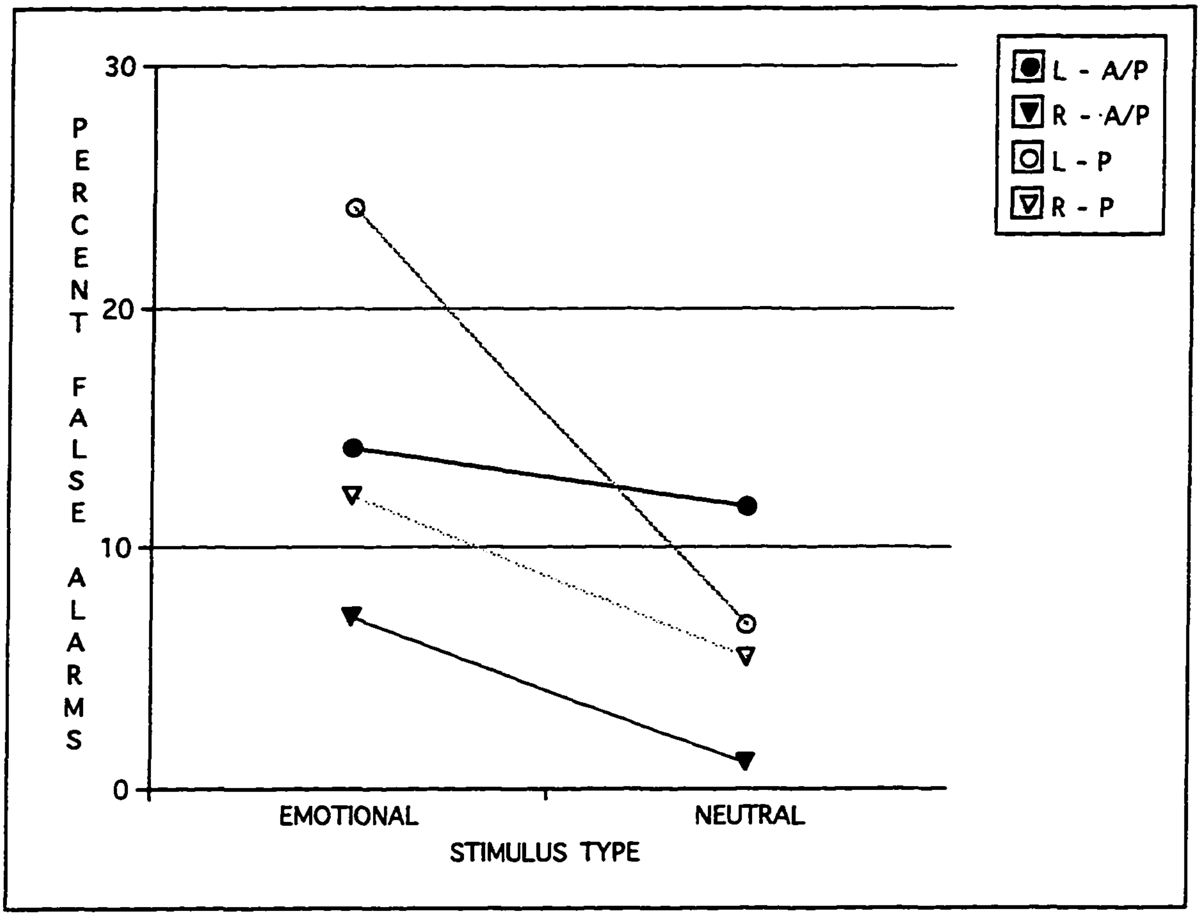

Figure Q.3. Percent of false alarms committed by patients with left and right frontal lobe damage and patients with left and right non-frontal lobe brain-damage for emotional and neutral words on the recognition task.

L - A/P = subjects with left hemisphere frontal lobe damage (n=8); L - P = subjects with left hemisphere non-frontal lobe damage (n=11); R - A/P = subjects with right hemisphere frontal lobe damage (n=11); R - P = subjects with right hemisphere non-frontal lobe damage (n=8).

for the three-way interaction between emotionality, caudality, and laterality, F (1,34) = 3.18, p = .084.

The two-way interaction indicates that the difference between emotional false alarm rate and neutral false alarm rate was larger in the patients with circumscribed posterior damage (18.13 - 6.14 = 11.99) than the patients whose lesions include the frontal lobe (10.58 - 6.43 = 4.16). The two way interaction also indicated that the difference in false alarm rate between frontal and non-frontal groups was larger for emotional stimuli (18.13 - 10.58 = 7.55), than for neutral stimuli (6.43 - 6.14 = 0.29).

The three-way interaction was followed up by multiple paired t-tests. It was found that the difference in the rate of emotional and neutral false alarms was significant in three of the groups, that is, both anterior and posterior RBD patients and anterior LBD patients, but the difference between emotional and neutral false alarms was not significant in the left frontal lobe patients. T-tests also found that there were no differences between the false alarm rate of frontal and non-frontal patients with lesions in either hemisphere, and for both emotional and neutral stimuli. Further post-hoc analyses found that caudality effects were not present in either group, for either stimulus type. Also, laterality effects were not present in posterior patients for either stimulus type, or in frontal lobe patients for emotional material. However, there were laterality effects in the neutral false alarm data of frontal lobe patients, t (1,17) = 4.65, p = .046.

When false alarms were analyzed for the effect of valence in these patients, we again found a main effect of laterality, F (1, 34) = 4.78, p = .036, such that patients with left-brain damage committed more emotional false alarms (mean = 19.10) than patients with right-brain damage (mean = 9.60). We also found a trend for the effect of caudality, F (1,34) = 3.01, p = .092, such that subjects with circumscribed posterior lesions committed more emotional false alarms (mean = 18.13) than did their counterparts whose lesions included anterior areas (mean = 10.58).

Furthermore, there was an effect of valence, F (1,34) = 4.78, p = .053, such that subjects committed more false alarms with positive stimuli (mean = 16.45) than with negative stimuli (12.67). Finally, with the NCs removed from the analysis there was a trend for the interaction between valence and laterality factors, F (1,34) = 3.39, p = .074, such that patients with left-brain damage exhibit the effects of valence, but patients with right-brain damage do not. That is, the performance of the left brain-damaged group dissociated with respect to positive (mean = 22.80) and negative (mean = 15.41) false alarms, t (19) = 2.63, p = .016; but the performance of the right brain damaged group was equivalent across valence types (positive mean = 9.77 vs. negative mean = 9.45; t [19] = .483, p = .634). This interaction also demonstrates that the two groups (RBD, LBD) are more disparate in their false alarm rate with positive stimuli (22.80 - 9.77 = 13.03, t [19] = 6.04, p = .019) than with negative stimuli (15.41 - 9.45 = 5.96, t [19] = 2.44, p = .127).

Analysis of Temporal Lobe Involvement. In the analysis of false alarms for patients with and without temporal lobe damage we found that left brain-damaged patients committed more false alarms than right brain-damaged patients (as previously described) and that more false alarms were committed for emotional stimuli (mean = 14.32) than for non-emotional stimuli (mean = 4.86). However, the patients with and without temporal lobe involvement performed similarly in their rate of false alarms overall and with each stimulus type. These observations were confirmed by the 2 (laterality: right, left) x 2 (temporal lobe damage, no temporal lobe damage) x 2 (stimuli: emotional, neutral) mixed ANOVA which revealed a main effect of laterality, F (1,32) = 4.29, p = .046, a main effect of emotionality, F (1,32) = 20.90, p = .000, and no main or interactive effects involving the temporal lobe factor.

In the analysis of valence in the false alarm data of patients with and without temporal lobe damage, we found, again, that subjects with left brain damage committed more emotional false alarms (mean = 19.27) than patients with right brain damage (mean = 9.69) . Furthermore, positive false alarms (mean = 16.49) were committed at a higher rate than negative false alarms (mean = 12.15). The significance of these main effects were confirmed by the 2 (temporal involvement) x 2 (laterality) x 2 (valence) mixed ANOVA applied to this data. This analysis also revealed two interactions. The first interaction, between valence and laterality of lesion, was previously described in the analysis of caudality. To recap, the patients with left-sided lesions exhibited valence effects but the patients with right-sided lesions did not. The second interaction, between valence and temporal lobe involvement, is depicted in Figure Q.4 and indicates that the patients without temporal lobe damage display a dissociation in performance based on valence, but the patients with temporal damage do not. That is, patients with non-temporal lobe lesions committed more positive (mean = 18.09) than negative (mean = 9.94) false alarms, which was confirmed by a post-hoc paired t-test, t (19) = 2.37, p = .028. However, the patients with temporal lobe damage committed the same number of false alarms in the positive (mean = 14.98) and negative (mean = 14.93) conditions, t (19) = .223, p = .827. Thus, patients with non-temporal or left-sided lesions exhibit valence effects in their rate of false alarms, but these two factors do not interact.

Analysis of Gender. Unlike in the analysis of hit rate on this task, in the analysis of false alarms gender differences were found. Figure Q.5 portrays the rate of false alarms committed by males and females for emotional and neutral words on the recognition task. As seen in this figure, males committed more false

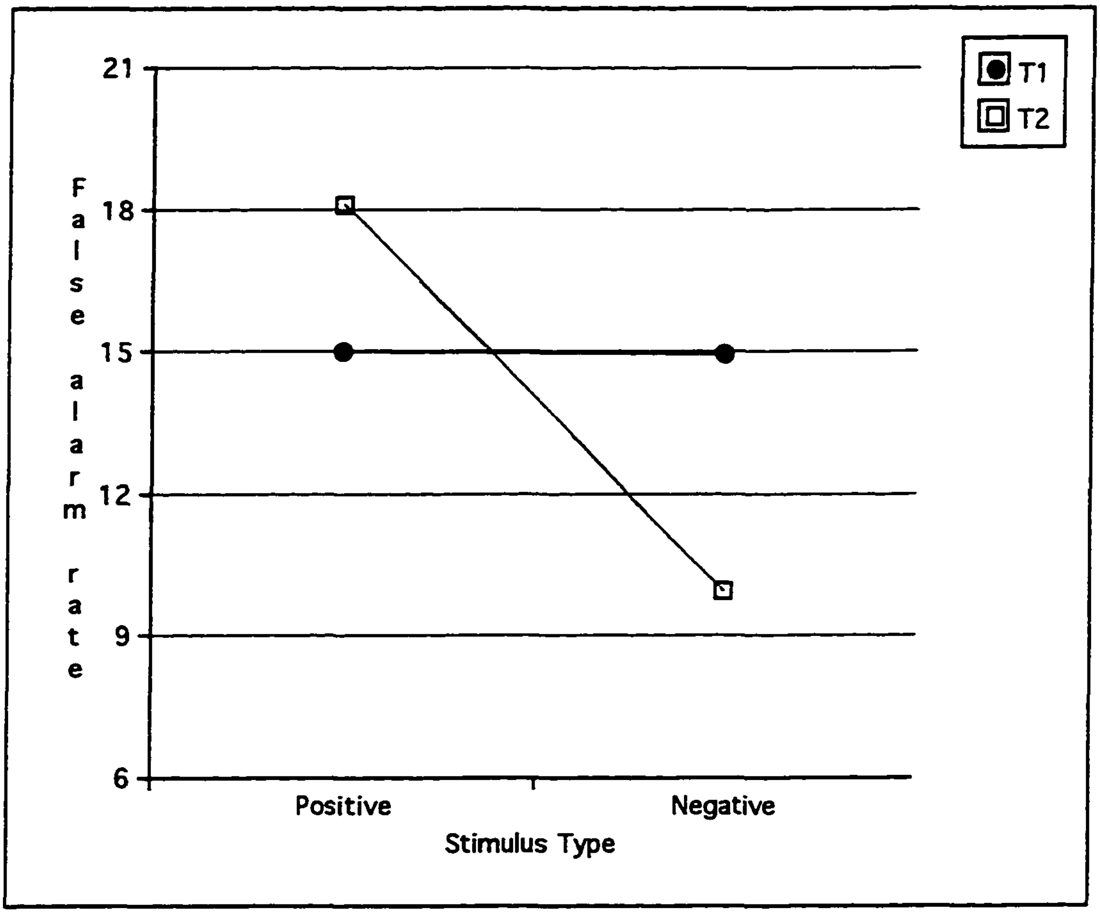

Figure Q.4. Percent of false alarms committed by patients with temporal lobe damage and patients without temporal lobe damage for positive and negative words on the recognition task.

T = Subjects with lesions involving the temporal lobe (n=16); No T = subject group with lesions not involving the temporal lobe (n=20).

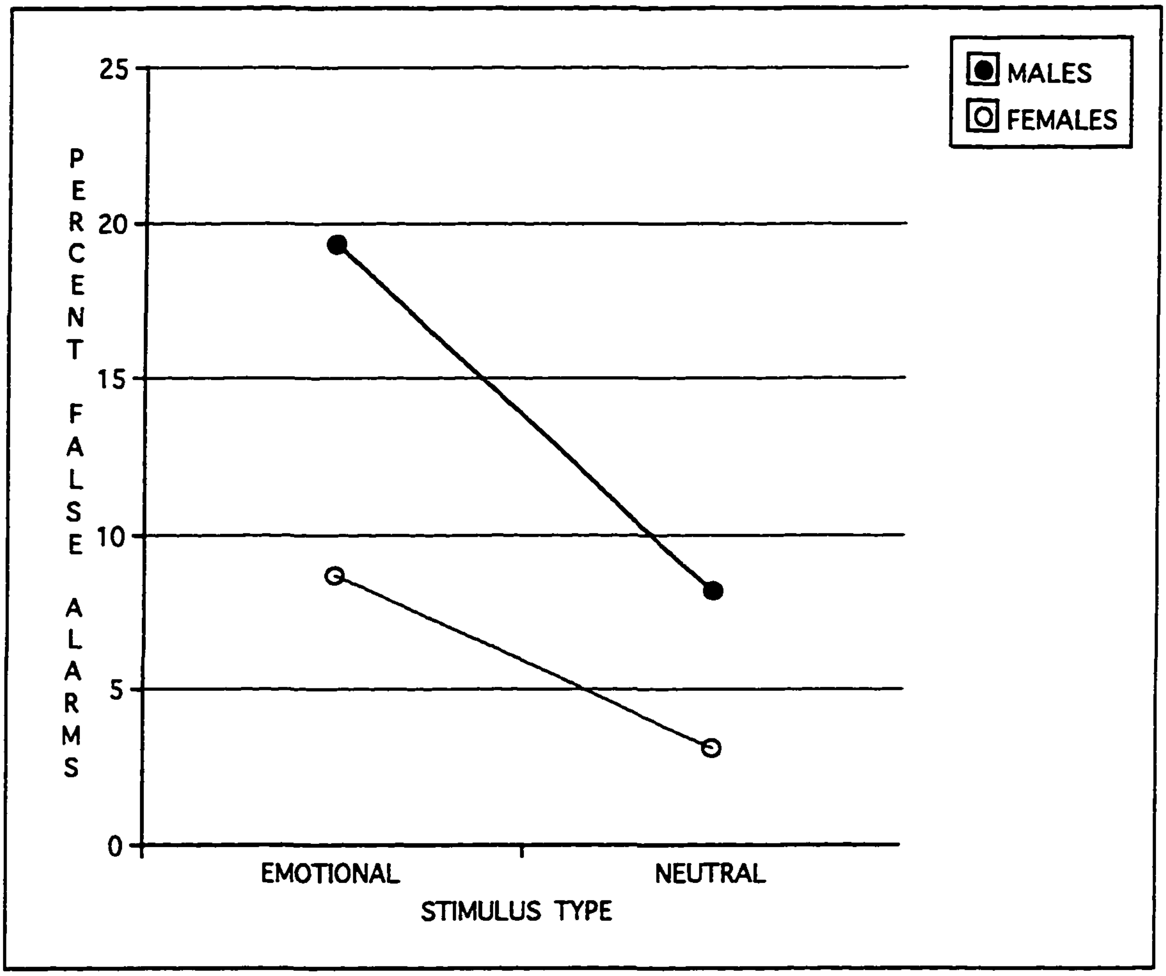

Figure Q.5. Percent of false alarms committed by male and female subjects for emotional and neutral words on the recognition task.

Males (n=32); Females (n=28).

alarms (mean = 12.72) than females (mean = 9.19) and more false alarms were committed for emotional stimuli (mean = 14.37) than for neutral stimuli (mean = 5.83). Furthermore, the difference in false alarm rate for emotional and neutral stimuli is larger in males (19.18 - 8.01 = 11.17) than in females (9.21 - 3.27 = 6.06). Also, the difference in false alarm rate between males and females is larger for emotional stimuli (19.18 - 9.21 = 9.97) than for neutral stimuli (8.01 - 3.27 = 4.74). These main effects of gender (F [1,58] = 9.60, p = .003) and emotionality (F [1,58] = 32.07, p = .000) were confirmed in the 2 (gender) x 2 (emotionality) ANOVA applied to the data. Furthermore, the gender x emotionality interaction represented a statistical trend, F (1,58) = 3.54, p = .065. Post hoc t-tests revealed that all differences were significant, thus the interaction simply indicates that the emotionality effect on false alarms is stronger in males than in females, and that gender differences are larger for emotional false alarms than for neutral false alarms.

In the analysis of gender and false alarm data with the patients only, this interaction did not occur. That is, a 2 (laterality) x 2 (gender) x 2 (emotionality) mixed ANOVA applied to the data revealed a significant main effect for laterality (F [1,36] = 4.09, p = .051, which was previously described), a trend effect for gender (F [1,36] = 3.78, p = .060, similar to the effect described directly above), and a main effect of emotionality (F [1,36] = 15.84, p = .000). However, there were no interactions between any of these factors.

In terms of valence and gender effects in the whole sample, we found again that males committed more emotional false alarms than females (19.18 vs. 9.21). We also found that positive stimuli elicited more false alarms than negative stimuli (17.29 vs. 11.46). These observations were supported by the 2 (gender) x 2 (valence) ANOVA applied to the data, which revealed a main effect for gender, F

(1,58) = 10.15, p = .002, and a main effect for valence, F (1,58) = 11.96, p = .001, with no interaction between these factors.

In the analysis of gender and valence effects in the false alarm data of brain-damaged patients, there were again performance differences found based on gender (F [1,36] = 4.07, p = .057), laterality (F [1,36] = 3.86, p = .051), and valence (F [1,36] = 3.78, p = .060) in the 2 (gender) x 2 (laterality) x 2 (valence) ANOVA applied to the data. However, there was also an interaction between gender and valence, F (1,36) = 3.00, p = .092, such that valence effects were present in the performance of male patients but not in female patients. More specifically, males committed more false alarms for positive stimuli than for negative stimuli (21.35 vs. 14.35; t [22] = 2.44, p = .023), but for females, the rate of false alarms did not differ between positive and negative stimuli (9.46 vs. 9.06, t [16] = 0.00, p = .99). Furthermore, this interaction indicates that the difference in false alarm rate between the genders is larger for positive stimuli (21.35 - 9.46 = 11.89; t [38] = 7.11, p = .011) than for negative stimuli (14.35 - 9.06 = 5.39; t [38] = 2.12, p = .153).

Discussion of false alarm results

We found that increasing the emotionality of stimuli resulted in increases in the rate of false alarms. Thus, although emotional stimuli were recalled and recognized at higher rates than neutral stimuli, their presence in a distractor list resulted in a higher error rate. It can be said, therefore, that in the circumstance where one must reject stimuli not previously seen, emotionality had a negative impact on performance. Borrowing terminology from the generation literature, we refer to this as a reverse emotionality effect. This reverse emotionality effect, however, tells us nothing about hemispheric theories of emotional processing because it occurred in all groups.

The explanation of an intervening arousal mechanism between the emotional components of stimuli and their effect on memory is also useful in the interpretation of the reverse emotionality effect, or the increased number of false alarms associated with emotional stimuli. Since the sense of familiarity may also be coupled with internal changes in arousal (Jacoby & Dallas, 1981; Mandler, 1980) the increased arousal brought about when reading an emotional word may be interpreted as a feeling of familiarity. Regardless of other information that an individual may use in the decision process, this sense of familiarity or "feeling of knowing" will often bias a subject's response (Reder, 1987). This theory would explain why emotional words are recalled and recognized at a higher rate and why they are also more difficult to reject when it is necessary to do so.

There were also performance differences on the foil list based on valence. That is, there were more false alarms for positive than negative words. However, analyses with the brain-damaged subjects alone revealed that this finding was only true for a subset of patients. That is, patients with left brain damage, patients with temporal lobe damage, and brain-damaged males committed more false alarms for positive stimuli than for negative stimuli. However, right brain-damaged patients, patients with non-temporal lobe damage, and brain-damaged females had an equal rate of false alarms for positive and negative material. Since false alarms are errors of commission and since patients with left hemisphere damage committed more of these positive than negative errors, this provides partial support for the valence theory of emotional processing.

As I proposed for the interpretation of emotionality effects in false alarm data, the valence effects may be similarly due to increases in arousal for positive stimuli as compared to negative stimuli, making it easier to recall and recognize positive words, and making it more difficult to reject positive stimuli when it is necessary to do so.

The interpretations of valence effects for the hit rate on the recognition task may be similarly used to interpret valence effects in false alarms. For example, Isen (1985) proposed that the richer connectivity for positive words may lead to better memory for such words due to the increase in the number of associations that can serve as retrieval cues. Here we are suggesting that these vast interconnections of positive material may also serve to confuse the subject during this task. That is, when a negative word appears, the decision processes may be relatively straightforward. Either the word was activated during the encoding phase and is familiar to the subject, or it was not. On the other hand, when a positive word appears, even if it was not on the original list, it may have been automatically activated by several of the target words during the encoding phase. Thus, in a sense, the foil word is familiar, since it was activated previously. Furthermore, when a positive foil word appears on the retrieval task it may re-activate one or more of the positive stimulus words, which would also result in a feeling of familiarity.

Although this is a plausible explanation for the main effects of valence in hit rate, it does not help explain why several types of patients were differentially influenced by the valence of emotional distractor words. It is interesting to conjecture about why such differences occurred, especially given the finding that there were no such group differences in the recognition of previously seen positive and negative words. Another idea put forth by Isen (1985) may help to explain these dissociations. She suggested that positive words help to maintain positive mood states. Thus, in an effort to gain or maintain a positive mood subjects may be biased to respond affirmatively to positive material. Although there were no differences found between groups in terms of positive mood state, it is possible that some patients were more desirous of a positive mood than others, and thus were more biased toward responding affirmatively to positive words.

In accord with the valence hypothesis, one might have predicted results in the opposite direction for the left brain-damaged patients. That is, if the left hemisphere is hypothesized to process positive emotion, then left brain damage should impinge upon the influence of positive emotional material. Our results, however, suggest that rather than causing a depletion of positive words from the verbal lexicon, or some kind of disconnection which would interfere with the recognition of positive words, left brain damage interferes with the process of discriminating between positive words.

Summary of analysis of emotionality in the false alarm data

1) FALSE ALARMS ON WORD RECOGNITION TASK: Group (NC, LBD, RBD) x Emotionality of Stimuli (Emotional, Neutral)

Variables	n	F	df	p
Between:				
Group (3)	60	2.66	(2,57)	.078
Within				
Emotionality (2)		31.89	(1,57)	.000
Interactions:				
Group x Emotionality		0.66	(2,57)	.520

2)FALSE ALARMS ON WORD RECOGNITION TASK: Gender (male, female) x Emotionality of Stimuli (Emotional, Neutral)

Variables				
Between:				
Gender (2)	60	9.60	(1,58)	.003
Within:				
Emotionality (2)		32.07	(1,58)	.000
Interaction:				
Gender x Emot.		3.54	(1,58)	.065

3) FALSE ALARMS ON WORD RECOGNITION TASK: Side of lesion (right, left) x Gender (male, female)) x Emotionality of Stimuli (Emotional, Neutral)

	n	F	df	p
Between:				
Side (2)	40	4.09	(1,36)	.051
Gender (2)		3.78	(1,36)	.060
Within:				
Emotionality (2)		15.84	(1,36)	.000
Interactions:				
Side x Gender		0.07	(1,36)	.796
Side x Emotionality		0.917	(1,36)	.345
Gender x Emotionality		1.41	(1,36)	.243
Side x Gender x Emot.		0.61	(1,36)	.441

4) FALSE ALARMS ON WORD RECOGNITION TASK: Side of Lesion (left, right) x Caudality (2: anterior/posterior, posterior) x Emotionality of Stimuli(2:Emotional, Neutral)

Between:				
Side (2)	38	5.49	(1,34)	.025
Caudality (2)		1.21	(1,34)	.280
Within:				
Emotionality (2)		16.22	(1,34)	.000
Interactions:				
Side x Caudality		0.1	(1,34)	.756
Side x Emotionality		0.76	(1,34)	.385
Caudality x Emotionality		3.82	(1,34)	.059
Side x Caudality x Emot.		3.18	(1,34)	.084

5)FALSE ALARMS ON WORD RECOGNITION TASK: Side of Lesion (left, right) x Temporal Lobe Involvement (with, without) x Emotionality of Stimuli (Emotional, Neutral)

Variables	n	F	df	p
Between:				
Side (2)	36	4.29	(1,32)	.046
Temp.Involve.(2)		0.13	(1,32)	.717
Within:				
Emotionality (2)		20.90	(1,32)	.000
Interactions:				
Side x Temp		0.00	(1,32)	.986
Side x Emotionality		2.02	(1,32)	.165
Temp x Emotionality		0.01	(1,32)	.919
Side x Temp x Emot.		0.93	(1,32)	.342

Summary of analysis of valence in the false alarm data

1)WORD RECOGNITION TASK (FALSE ALARMS): Group (3: NC, LBD, RBD) xValence (2:positive,negative)

	n	F	df	p
Between:				
Group (3)	60	2.48	(2,57)	.093
Within:				
Valence (2)		12.91	(1,57)	.001
Interactions				
Group x Valence		2.10	(2,57)	.132

2) WORD RECOGNITION TASK (FALSE ALARMS): Gender (2: male, female) x Valence 2:positive,negative)

Between:				
Gender (3)	60	10.05	(1,58)	.002
Within:				
Valence (2)		11.96	(1,58)	.001
Interactions				
Gender x Valence		2.40	(1,58)	.127

3) WORD RECOGNITION TASK (FALSE ALARMS): Side of Lesion (left, right) x Gender (2: male, female) xValence(2:positive ,negative)

Between:				
Side of Lesion (2)	40	3.86	(1,36)	.057
Gender (2)		4.07	(1,36)	.051
Within:				
Valence (2)		3.78	(1,36)	.060
Interactions:				
Side x Gender		0.03	(1,36)	.854
Side x Valence		1.65	(1,36)	.207
Gender x Valence		3.00	(1,36)	.092
Side x Gender x Valence		0.01	(1,36)	.929

4)WORD RECOGNITION TASK (FALSE ALARMS): Side of Lesion (left, right) x Caudality (2: anterior/posterior, posterior) xValence(2:positive,negative)

	n	F	df	p
Between:				
Side of Lesion (2)	38	4.78	(1,34)	.036
Caudality (2)		3.01	(1,34)	.092
Within:				
Valence (2)		4.04	(1,34)	.053
Interactions				
Side x Caudality		0.34	(1,34)	.563
Caudality x Valence		0.68	(1,34)	.416
Side x Valence		3.39	(1,34)	.074
Caudality x Side x Valence		0.05	(1,34)	.818

5) WORD RECOG TASK(FALSE ALARMS): Side of Lesion (left, right) x Temporal Lobe Involvement (2: with, without) x Valence(2:positive,negative)

Between:				
Side of Lesion (2)	36	4.05	(1,32)	.053
Temporal Involvement (2)		0.04	(1,32)	.854
Within:				
Valence (2)		5.24	(1,32)	.029
Interactions:				
Temp x Side		0.17	(1,32)	.680
Temp x Valence		5.11	(1,32)	.031
Side x Valence		6.55	(1,32)	.015
Temp x Side x Valence		1.07	(1,32)	.308

Appendix R

Table of Post-Hoc Analyses

Analyses involving the emotionality variable

WORD RECALL

Post-hoc analyses for Group (3) x Learning Condition (2) x Stimulus Emotionality (2) ANOVA - whole sample

Variables	t	df	p
Group			
RBD vs. LBD			
LBD vs. NC	6.57	19	.000
RBD vs. NC	2.67	19	.015

Post-hoc analyses for Laterality (2) x Caudality (2) x Learning Condition (2) x Stimulus Emotionality (2) ANOVA - patients only

Variables	t	df	p
Condition x Emotionality			
Generate Emot vs. Generate Neut	.550	36	.586
Read Emot vs. Read Neut	3.52	36	.001
Generate Emot vs. Read Emot	4.82	38	.000
Generate Neut vs. Read Neut	4.82	38	.000
Caudality x Emotionality			
Frontal Emot vs. Frontal Neut	.091	18	.929
Frontal Emot vs. Non-frontal Emot	1.54	36	.223
Frontal Neut vs. Non-frontal neut	.791	36	.380
Non-frontal emot vs. Non-frontal neut	2.93	18	.009

Post-hoc analyses for the Gender (2) x Learning Condition (2) x Stimulus Emotionality (2) ANOVA - whole sample

Variables	t	df	p
Condition x Gender			
Female Read vs. Male Read	2.50	58	.067
Female Generate vs. Male Generate	5.87	58	.007
Female Generate vs. Female Read	3.14	27	.004
Male Generate vs. Male Read	2.23	31	.033

Post-hoc analyses for Gender (2) x Laterality (2) x Learning Condition (2) x Stimulus Emotionality (2) ANOVA - patients only

Variables	t	df	p
Gender x Condition x Emotionality			
Female GE vs. Male GE	1.03	38	.317
Female RE vs. Male RE	1.60	38	.214
Female GN vs. Male GN	10.94	38	.002
Female RN vs. Male RN	.430	38	.516
Male GE vs. Male GN	2.03	22	.054
Male RE vs. Male RN	2.52	22	.019
Male GE vs. Male RE	.423	22	.677
Male GN vs. Male RN	1.18	22	.250
Female GE vs. Female GN	1.30	16	.214
Female RE vs. Female RN	2.55	16	.021
Female GE vs. Female RE	.098	16	.924
Female GN vs. Female RN	3.45	16	.003

Post-hoc analyses for Temporal Lobe Involvement (2) x Laterality (2) x Learning Condition (2) x Emotionality (2) ANOVA - patients only (T1=temporal lobe damage is present; T2 = no temporal lobe damage)

Temporal Lobe Involvement x Condition x Emotionality			
T1 GE vs. T2 GE	1.08	34	.306
T1 GN vs. T2 GN	.868	34	.358
T1 RE vs. T2 RE	.060	34	.808
T1 RN vs. T2 RN	.594	34	.446
T1 GE vs. T1 GN	1.44	15	.168
T1 RE vs. T1 RN	2.71	15	.016
T1 GE vs. T1 RE	.471	15	.644
T1 GN vs. T1 RN	3.51	15	.003
T2 GE vs. T2 GN	.959	19	.350
T2 RE vs. T2 RN	2.76	19	.012
T2 GE vs. T2 RE	.621	19	.542
T2 GN vs. T2 RN	3.00	19	.007

WORD RECOGNITION TASK

Post-hoc analyses for Group (3) x Learning Condition (2) x Emotionality (2) ANOVA - whole sample

Variables	t	df	p
Condition x Emotionality			
Generate Emot vs. Generate Neut	2.16	57	.035
Read Emot vs. Read Neut	5.51	57	.000
Generate Emot vs. Read Emot	7.58	57	.000
Generate Neut vs. Read Neut	6.20	57	.000

Post-hoc analyses for Laterality (2) x Caudality (2) x Learning Condition (2) x Stimulus Emotionality (2) ANOVA - patients only

Caudality x Condition			
Gen Frontal vs. Gen Non-frontal	.580	36	.362
Read Frontal vs. Read Non-frontal	7.10	36	.011
Gen Frontal vs. Read Frontal	4.82	18	.000
Gen Non-frontal vs. Read Non-frontal	4.14	18	.001
Condition x Emotionality			
GE vs. RE	4.82	38	.000
GE vs. GN	4.82	38	.000
RE vs. RN	3.52	36	.001
GN vs. RN	.550	36	.586

Post-hoc analyses for Temporal Lobe Involvement (2) x Laterality (2) x Learning Condition (2) x Emotionality (2) ANOVA - patients only

Temporal Involvement x Emotionality			
T1 Emot vs. T2 Emot	.095	34	.760
T1 Neut vs. T2 Neut	2.23	34	.144
T1 Emot vs. T1 Neut	2.727	15	.016
T2 Emot vs. T2 Neut	1.069	19	.298
Temporal Lobe Involvement x Condition x Emotionality			
T1 GE vs. T2 GE	.114	33	.738
T1 GN vs. T2 GN	.001	33	.974
T1 RE vs. T2 RE	.008	33	.928
T1 RN vs. T2 RN	3.53	33	.069

Variables	t	df	p
T1 GE vs. T1 GN	.126	15	.901
T1 RE vs. T1 RN	3.81	15	.002
T1 GE vs. T1 RE	3.36	15	.004
T1 GN vs. T1 RN	5.22	15	.000
T2 GE vs. T2 GN	.538	18	.597
T2 RE vs. T2 RN	1.04	18	.308
T2 GE vs. T2 RE	3.22	18	.005
T2 GN vs. T2 RN	2.65	18	.016
Laterality x Temporal Lobe Involvement x Condition x Emotionality			
LBDs - T1 GE vs. T2 GE	.087	16	.772
LBDs - T1 GN vs. T2 GN	.332	16	.573
LBDs - T1 RE vs. T2 RE	.074	16	.789
LBDs - T1 RN vs. T2 RN	.000	16	1.00
LBDs - T1 GE vs. T1 GN	3.50	8	.008
LBDs - T1 RE vs. T1 RN	3.10	8	.014
LBDs - T1 GE vs. T1 RE	0.17	8	.865
LBDs - T1 GN vs. T1 RN	1.80	8	.108
LBDs - T2 GE vs. T2 GN	1.17	8	.273
LBDs - T2 RE vs. T2 RN	2.82	8	.022
LBDs - T2 GE vs. T2 RE	.189	8	.855
LBDs - T2 GN vs. T2 RN	2.60	8	.032
RBDs - T1 GE vs. T2 GE	.024	15	.879
RBDs - T1 GN vs. T2 GN	.135	15	.718
RBDs - T1 RE vs. T2 RE	.151	15	.703
RBDs - T1 RN vs. T2 RN	9.77	15	.007
RBDs - T1 GE vs. T1 GN	1.94	6	.099
RBDs - T1 RE vs. T1 RN	5.22	6	.002
RBDs - T1 GE vs. T1 RE	.000	6	1.00
RBDs - T1 GN vs. T1 RN	4.264	6	.005
RBDs - T2 GE vs. T2 GN	3.50	9	.007
RBDs - T2 RE vs. T2 RN	1.04	9	.322
RBDs - T2 GE vs. T2 RE	.772	9	.460
RBDs - T2 GN vs. T2 RN	.677	9	.515
LBD T1GE vs. RBD T1GE	.075	13	.928

Variables	t	df	p
LBD T1GN vs. RBD T1GN	.137	13	.874
LBD T1RE vs. RBD T1RE	.039	13	.962
LBD T1RN vs. RBD T1RN	2.39	13	.131
LBD T2GE vs. RBD T2GE	.050	17	.826
LBD T2GN vs. RBD T2GN	2.59	17	.126
LBD T2RE vs. RBD T2RE	.522	17	.480
LBD T2RN vs. RBD T2RN	.793	17	.386

SENTENCE RECALL

Post-hoc analyses for Gender (2) x Laterality (2) x Learning Condition (2) x Emotionality (2) ANOVA - patients only

Laterality x Gender			
LBD Female vs. LBD Male	1.911	18	.184
RBD Female vs. RBD Male	2.500	17	.132
LBD Female vs. RBD Female	5.27	15	.038
LBD Male vs. RBD Male	.579	22	.455

Post-Hoc Analyses
involving the valence variable

WORD RECALL

Post-hoc analyses for Group (3) x Learning Condition (2) x Valence(2) ANOVA - whole sample

Group x Condition			
LBD Gen vs. LBD Read	1.35	19	.192
RBD Gen vs. RBD Read	.228	19	.822
NC Gen vs. NC Read	3.05	19	.006
LBD Gen vs. RBD Gen	.620	38	.436
LBD Gen vs. NC Gen	22.70	37	.000
RBD Gen vs. NC Gen	9.22	38	.004
LBD Read vs. RBD Read	2.77	38	.104
LBD Read vs. NC Read	10.76	37	.002
RBD Read vs. NC Read	.380	38	.541

Post-hoc analyses for Laterality (2) x Caudality (2) x Learning Condition (2) x valence (2):

Variables	t	df	p
Caudality x Condition x Valence			
Frontal Gen Pos vs. Frontal Gen Neg	.754	18	.461
Frontal Read Pos vs. Frontal Read Neg	1.43	18	.169
Frontal GenPos vs. Frontal Read Pos	.920	18	.370
Frontal Gen Neg vs. Frontal Read Neg	1.44	18	.166
Non-frontal GenPos vs. Non-frontal GenNeg	1.89	18	.074
Non-frontal RdPos vs. Non-frontal RdNeg	.766	18	.454
Non-frontal GenPos vs. Non-frontal RdPos	1.58	18	.131
Non-frontal GenNeg vs. Non-frontal RdNeg	1.06	18	.301
Frontal GenPos vs. Non-frontal GenPos	5.12	36	.030
Frontal GenNeg vs. Non-frontal GenNeg	.000	36	1.00
Frontal ReadPos vs. Non-frontal ReadPos	.000	36	1.00
Frontal ReadNeg vs. Non-frontal ReadNeg	2.51	36	.122

WORD RECOGNITION

Post-hoc analyses for Laterality (2) x Caudality (2) x Learning Condition (2) x valence (2) - patients only

Caudality x Condition			
Frontal Gen. vs. Non-frontal Gen.	.850	35	.363
Frontal Read vs. Non-frontal Read	1.01	35	.321
Frontal Gen vs. Frontal Read	.577	17	.571
Non-frontal Gen vs. Non-frontal Read	.411	18	.686

SENTENCE RECALL

Post-hoc analyses for Temporal Lobe Involvement (2) x Laterality (2) x Learning Condition (2) x Emotionality (2) ANOVA - patients only

Temp x Valence x Condition			
T1 GenPos vs. T2 GenPos	.714	33	.404
T1 GenNeg vs. T2 GenNeg	1.84	33	.184
T1 ReadPos vs. T2 ReadPos	12.5	33	.001
T1 ReadNeg vs. T2 ReadNeg	0.190	33	.666
T1 GenPos vs. T1 GenNeg	.823	14	.424

Variables	t	df	p
T1ReadPos vs. T1 ReadNeg	1.60	14	.131
T1 GenPos vs. T1 ReadPos	6.44	14	.000
T1 GenNeg vs. T1 ReadNeg	3.01	14	.009
T2 GenPos vs. T2 GenNeg	0.14	19	.883
T2 ReadPos vs. T2 ReadNeg	1.16	19	.258
T2 GenPos vs. T2 ReadPos	4.47	19	.000
T2 GenNeg vs. T2 ReadNeg	4.76	19	.000

WORD RECOGNITION (FALSE ALARMS)

Post-hoc analyses for Group (3) x Stimulus Emotionality (2) ANOVA applied to false alarm data

Group			
LBD vs. RBD	5.31	38	.027
NC vs. LBD	.702	38	.407
NC vs. RBD	2.09	38	.156

Post-hoc analyses for Gender (2) x Stimulus Emotionality (2) ANOVA applied to false alarm data

Gender x Emotionality			
Male Emot vs. Male Neut	5.61	31	.000
Female Emot vs. Female Neut	2.54	27	.017
Male Emot vs. Female Emot	10.04	58	.002
Male Neut vs. Female Neut	4.32	58	.042

Post-hoc analyses for Laterality (2) x Caudality (2) x Emotionality (2) ANOVA applied to false alarm data:

Caudality x Emotionality			
Frontal Emot vs. Frontal Neut	1.71	18	.104
Frontal Emot vs. Non-frontal Emot	4.08	36	.051
Frontal Neut vs. Non-frontal neut	.037	36	.849
Non-frontal emot vs. Non-frontal neut	4.09	18	.001

Side x Caudality x Emotionality			
Left Frontal Emot vs. Left Frontal Neut	.501	7	.632
Left Frontal Emot vs. Left Non-frontal Emot	1.99	17	.177
Left Frontal Neut vs. Left Non-frontal neut	.674	17	.423
Left Non-frontal emot vs. Left Non-frontal neut	3.76	10	.004

Variables	t	df	p
Rt. Frontal Emot vs. Rt. Frontal Neut	1.97	10	.077
Rt. Frontal Emot vs. Rt. Non-frontal Emot	1.03	17	.325
Rt. Frontal Neut vs. Rt. Non-frontal neut	2.28	17	.150
Rt. Non-frontal emot vs. Rt. Non-frontal neut	2.23	7	.061
Left frontal emot vs. Rt. frontal emot.	1.93	17	.182
Left non-frontal emot vs. Rt non-frontal emot	2.87	17	.109
Left frontal neut vs. Rt. frontal neut	4.65	17	.046
Left non-frontal neut vs. Rt. non-frontal neut	.094	17	.763

Summary Table of post-hocs for analysis of valence in the false alarm data

Post hoc analyses for Group (3) xValence (2) ANOVA - false alarms

Group			
LBD vs. RBD	4.99	38	.032
RBD vs. NC	2.01	38	.164
LBD vs. NC	.745	38	.394

Post hoc analyses for Laterality (2) x Gender (2) x Valence(2) ANOVA

Gender x Valence			
Female Pos vs. Male Pos	7.11	38	.011
Female Neg vs. Male Neg	2.12	38	.153
Female Pos vs. Female Neg	0.00	16	1.00
Male Pos vs. Male Neg	2.43	22	.023

Post hoc analyses for Laterality (2) x Caudality (2) xValence (2) ANOVA for false alarms

Laterality x Valence			
LBD pos vs. RBD pos	6.04	38	.019
LBD neg vs. RBD neg	2.44	38	.127
LBD pos vs. LBD neg	2.63	19	.016
RBD pos vs. RBD neg	0.48	19	0.63

Post hoc analyses for Laterality (2) x Temporal Lobe Involvement (2) x Valence (2) ANOVA for false alarms

Temporal Lobe Involvement x Valence			
T1 pos vs. T2 pos	.068	34	.796
T1 neg vs. T2 neg	1.58	34	.218
T1 pos vs. T1 neg	0.22	15	.827
T2 pos vs. T2 neg	2.37	19	.028

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