AN INVESTIGATION OF CEREBRAL ASYMMETRY, ECHOIC MEMORY, AND THE STIMULUS SUFFIX EFFECT

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTD.)

LIST OF FIGURES

LIST OF FIGURES (CONTD.)

APPENDICES

APPENDICES (CONTD.)

ABSTRACT

Echoic memory and hemispheric processing of two semantic categories of words were investigated utilizing a stimulus suffix paradigm under four delay conditions. The magnitude of the stimulus suffix effect was evaluated when combinations of concrete and abstract word lists and suffixes were monoaurally presented to the left and right ears. The results showed that the stimulus suffix effect occured for all information presented to both ears but was less pronounced when information was presented to the right ear. A right ear advantage for all information as well as a right ear advantage for abstract information was found. In addition, the right ear showed superior recall of abstract stimulus list and suffix combinations over other list and suffix combinations. Increasing delays between list and suffix presentation led to an increase in recall frequencies for terminal positions in the lists, but this increase was not systematic with delay. Results suggest that the right ear advantage often reported is due to right ear advantage for abstract information, and that echoic memory persists for at least 8 secs. These findings support the dual-trace processing model of hemispheric function and suggest that echoic memory may persist longer than the 2 secs implied by earlier researchers.

INTRODUCTION

"Rules ... can be useful, but they do not determine the practice of an art; they are maxims, which serve as a guide to an art only if they can be integrated into the practical knowledge of the art. They cannot replace this knowledge." (Polanyk, 1958, pp. 49-50)

A model for echoic (auditory) memory analogous to the three stage iconic (visual) memory has been proposed by many researchers. Investigations in this area have, however, yielded inconsistent and incongruous results as it is difficult to equate each level of visual memory with an appropriate auditory level. In addition, because of the arbitrary criteria adopted, there is little agreement as to which experiments fit into each stage or, indeed, how many stages are involved. Attempts to classify auditory memory into stages analogous to those of visual memory (see Massaro, 1972) have been controversial because they lack the necessary experimental evidence.

Typically, with stimulus list presentation, the level of performance for auditorily presented stimuli has been superior to that of visual presentation for the terminal items in the list (modality effect). This effect was considered by Crowder (1969) to be a function of echoic memory. However, Crowder (1969) and Crowder and Morton (1969) also found that the level of performance for an auditorily presented list could be reduced to a level comparable with that for visual presentation by the addition of a redundant item (stimulus suffix) at the end of a stimulus list. The effect of the stimulus suffix item on an auditorily presented list has been termed the 'stimulus suffix effect', and has been demonstrated by a large number of researchers (eg. Dallett, 1965; Crowder, 1969, 1971; Crowder & Morton, 1969; Morton, 1969; Morton & Holloway, 1970; Morton, Crowder, & Prussin, 1971; Watkins & Todres, 1979, 1980; Watkins & Watkins, 1980).

Studies by Crowder (1969, 1971) and Morton (1969) have also demonstrated that the modality effect can be maintained despite presentation of a suffix, provided presentation of the suffix is sufficiently delayed. As these researchers failed to isolate a stimulus suffix effect with delays exceeding 2 secs, it was further suggested that echoic memory is highly transitory and does not persist for longer than 2 secs. These findings have led Crowder and Morton (1969) and Morton et al., (1971) to postulate the existence of a 'precategorical acoustic storage' (PAS), a system that is said to hold information in a relatively unprocessed form for up to 2 secs. Basically, this model hypothesises a sensory store for auditory-verbal stimuli that contains information about one item at any one time. In a typical short-term memory task, such as serial recall of a 7 - 9 digit list, the information about the last item resides in PAS long enough (i.e. up to 2 secs) to be used by the subject. The effect of the suffix is thus, to prevent the subject from using the information in PAS about the last item either by displacing the information from PAS (Crowder & Morton, 1969), or, by reducing the time available for the read out of the information stored there (Crowder, 1971), hence reducing recall of the terminal items and resulting in the suffix effect. The similarity between PAS and echoic memory rests on the premise that both systems are said to decay within about 2 secs. Thus, any delays between stimulus list and suffix presentation which exceed the proposed 2 secs should not yield a suffix effect.

Recent evidence, however, suggests that echoic memory may persist a great deal longer than 2 secs as implied by Crowder (1969, 1971, 1976). Watkins and Todres (1979, 1980) and Watkins and Watkins (1980), in a series of experiments, delayed the presentation of the stimulus suffix item for up to 20 secs and still found a characteristic suffix effect with delays of up to 20 secs, and a modality effect with delay of up to 18 and 20 secs. These researcheres interpret these results as indicative that echoic memory persists for at least 20 secs. This is consistent with what is known of echoic memory, as both the suffix and modality effects are said to be a function of echoic memory. However, these researchers also found that as the delay between list and suffix presentation increased so did the number of terminal items recalled. Based on these data, an additional, alternative explanation, based on the possibility that some rehearsal may occur during the delay period between list and suffix presentation was proposed by Watkins and Todres (1980). This explanation was based on the premise that the rehearsal may be used to set up a more effective, suffix-resistent memory, one that will persist after echoic memory has faded. However, it is difficult to equate these results and explanation with Crowder's (1971) PAS system according to which no suffix effect should occur with delays exceeding 2 secs. Further, as both the suffix and modality effects are said to be a function of echoic memory, the above results do not equate with what is known of echoic persistence and reflect the indeterminacy that surrounds the current status of echoic memory making a clear case for the necessity for further investigations to be carried out in this, as yet uncertain, area.

Apart from investigating the effect of the stimulus suffix on echoic memory, researchers have concentrated on investigating some of the properties of the stimulus suffix effect. Research has specifically centered on such variables as the class of items being used in both list and suffix presentation and the effect of these variables on auditory location (i.e. ear of presentation). Morton et al. (1971) in a series of experiments on the properties of the suffix effect have established the independence of the stimulus suffix effect of the semantic content of the items used in both list and suffix presentation as well as the independence of this effect of the auditory location of these items. These authors, as well as reporting a characteristic stimulus suffix effect with meaningful word items, reported no difference in the effect of the suffix with monoaural and binaural stimulus presentation, nor with conditions involving ipsilateral presentation (i.e. where both list and suffix were presented to the same ear) or contralateral presentation (where the list was presented to one ear and the suffix to the opposite ear). In all cases no differences in performance as a function of ear of presentation were reported.

The failure by these authors to obtain significant ear differences is contrary to the existing evidence on laterality effects. There is considerable evidence to suggest that verbal information presented to the right ear (connected to the left cerebral hemisphere of the brain) is processed better than verbal information presented to the left ear (connected to the right cerebral hemisphere). This evidence, based on studies involving both normal and brain damaged subject (as well as physiological studies involving investigations on the anatomical structure of the non-living brain via surgical disection) suggest that the left hemisphere of the brain is specialized for speech processing (eg. Bartholomeus, 1975; Bogen & Bogen, 1976; Critchley, 1972; Curry, 1967; Galaburda, LeMay, Kemper, & Geschwind, 1978; Kimura, 1961 a, b, 1964, 1967, 1973; Milner, 1971; Morais & Bertleson, 1975; O'Neill & Paivio, 1978), whereas the right hemisphere is used for perceiving non-speech sounds (eg. Broadbent & Gregory, 1964; Bryden, 1963; Deutsch, 1970; Kimura & Folb, 1968; Liberman, 1974; Tsunoda, 1975). Further evidence, derived from dichotic listening experiments indicates that when two conflicting sounds are presented simultaneously to the two ears, the right ear shows an advantage for perceiving digits, words, consonants, and for recognition of a speaker's voice, while the left ear is better at perceiving clicks, pitch patterns, and melodies (Milner, 1971). Similar evidence has been obtained from studies involving monoaural presentation paradigms (eg. Bakker, 1970).

More recently some researchers have further proposed that the left hemisphere processes abstract information (eg. peace, sincerity) better than it does concrete (house, book) information (McFarland, McFarland, Bain, & Ashton, 1978; O'Neill & Paivio, 1978).

The aim of the present study is to investigate further some of the elements pertaining to the above areas of research. Of particular interest are such variables as echoic persistence as a function of the stimulus suffix effect (eg. Crowder, 1969, 1971; Watkins & Todres, 1979, 1980; Watkins & Watkins, 1980), and the effect of differential processing of abstract and concrete information by the two hemispheres as a function of ear of presentation (eg. McFarland et al., 1978; O'Neill & Paivio, 1978).

1.01 Properties of Echoic Memory: Theory and Research

Neisser (1967) first suggested the term 'echoic' memory for the auditory equivalent of iconic (visual) memory (see Sperling, 1967). Echoic memory is referred to by Massaro (1970) as pre-perceptual auditory memory, and like iconic memory is subject to masking at two levels. One level probably reflecting a disruption of the input to the system, the other an interference in the recovery process. Evidence for a comparable sensory buffer between the two memory systems is abundant, although the precise nature and limits of the echoic memory system have not as yet been clearly established (see Baddeley & Patterson, 1976). The situation is further complicated by the probability that there are two separate perceptual and memory systems for speech and non-speech sounds (Deutsch, 1970; Kimura & Folb, 1968).

Various experimental methods have been devised for studying echoic memory and these include sampling, recognition, and masking methods. Experiments utilizing the sampling method rely primarily on the subjects being able to verbally categorize input information either by being overloaded or by being instructed to ignore messages they hear (eg. Anderson, 1960; Colle, 1980; Darwin et al., 1972; Erickson & Johnston, 1964; Glucksberg & Cowan, 1970; Moray et al., 1965; Norman, 1969; Triesman & Rostron, 1972). In the former situation subjects are presented with detailed information and are then required to report selected aspects of the input information (eg. Anderson, 1960; Colle, 1980; Darwin et al., 1972; Moray et al., 1965; Triesman & Rostron, 1972) while in the later situation selected aspects of the input situation are ignored (eg. Erickson & Johnston, 1964; Glucksberg & Cowan, 1970; Norman, 1969). The recognition method includes broad-band noise repetition (eg. Guttman & Julesz, 1963) and dichotic delayed speech experiments (eg. Triesman, 1964). In both experiments the dependent measure is the detection of repetition. In the first instance, repeating segments of white noise are presented to subjects for detection of noise repetition, accurate perception of repetition being thought to indicate the duration of echoic memory. In the second instance, in a dichotic listening situation, one message is attended to while the other is ignored. The difference in detection lags between attended and ignored messages being indicative of the duration of echoic memory. The masking method involves the impairing of performance by masking the input with either tones (eg. Jeffress, 1972; Massaro, 1970, 1972, 1975) or words (eg. the suffix effect, Crowder, 1967; Crowder & Morton, 1969; Dallett, 1965; Morton et al., 1971; Morton & Holloway, 1970). By suffix is meant a redundant item appended at the end of a list of memory items which subjects are not required to recall.

Two additional properties of echoic memory which have been identified are the modality effect, that is, the advantage of auditory over visual presentation (Crowder, 1971, 1978; Crowder & Morton, 1969; Engle, Clark, & Cathcart, 1980), and the dependence of the modality and suffix effects on the class of speech sounds being remebered (Crowder, 1971, 1978; Watkins, Watkins, & Crowder, 1974).

Dallett (1965) and Crowder (1967) provided the first data on the suffix effect. This work has been considerably extended in the collaborative research of Crowder and Morton (eg. Crowder, 1971; Crowder & Morton, 1969; Morton & Holloway, 1970). Although the suffix effect has been demonstrated in free recall (Engle, 1974), the vast majority of suffix studies have involved serial recall.

Generally, recall of items from a list that exceeds the capacity of short-term memory follows a bowed serial position function. That is, recall is better on the first few items (primacy effect) and on the last one or two items (recency effect) than on intermediate items. However, under auditory presentation conditions, the addition of one extra item at the end of the list impairs recall for the terminal items, even when subjects are instructed to ignore this suffix and omit it from their recall of the list. This elimination of the recency effect is known as the stimulus suffix effect (Crowder, 1967; Crowder & Morton, 1969). Following a proposal by Crowder and Morton (1969) the effect is usually attributed to loss of echoic memory.

In a typical suffix experiment an eight-item list is presented aurally at a rate of two items per sec for immediate ordered recall. In the control condition, following the last memory item, either silence or some other non-verbal cue indicate the end of the list. In the experimental condition, a spoken word (stimulus suffix) is presented after the last memory item in accordance with the prevailing rate of presentation. In most studies the word 'zero' has been used as the suffix but any other word produces the same effect (Crowder, 1976). This extra verbal item occurs on every trial in the same location (i.e. following the last item in the list) over a substantial block of trials. The subject is informed in advance that this extra item will occur on every trial and that he need pay no attention to it. He is further informed that he may find the suffix convenient as a cue for commencing recall of the memory list. The subject is, therefore, prepared for the suffix on every trial. The suffix, thus, should pose no additional memory load, just as, for example, silence in the control condition should pose no additional memory load. However, the presence of a suffix masks the last serial position resulting in depressed scores on the last portion of the list.

It was the claim of Crowder and Morton (1969) that the recall advantage of auditory over visual presentation was a function of echoic memory, and that this advantage could be removed by the stimulu suffix, restoring performance to a level consistent with that of visual presentation. Support for this claim has come from a number of experiments (eg. Crowder, 1967; Crowder & Morton, 1969; Morton & Holloway, 1970; Morton et al., 1971; Watkins & Todres, 1979, 1980; Watkins & Watkins, 1980). Crowder (1971, expt. V) also found that stimuli which failed to yield a suffix effect also failed to yield a modality effect, that is the advantage of auditory over visual presentation. Whereas a modality effect occurred with vowels, Crowder found that the modality effect was absent when the presented stimuli consisted of stop consonants (such as b, g, d). Additional supportive evidence for this effect is provided by Crowder (1978) and Watkins et al. (1974) who found that the modality effect is reduced, if not eliminated, when the list items differ phonologically not only in their stop consonants, but also that the effect is reduced with both serial and free recall conditions. According to Crowder (1971, 1976) the correspondence between the modality and suffix effects cannot be ignored and is important in that both effects a) appear on the last few serial positions of a memory list, and, b) are absent when subjects are remembering a list of stop consonants. Further, these findings are consistent with the assumption that echoic information is overwritten by the suffix, as no effect would be expected with materials that do not give rise to a modality effect and where there is no meaningful information to overwrite.

An alternative explanation (Kahneman, 1973; Kahneman & Henik, 1977) proposes that the stimulus suffix effect is the result of integration of the suffix item with the stimulus list items. This explanation is based on the concept of pre-attentive grouping processes and departs from the premise that once the perceptual groups are formed interference operates only within each perceptual group. The disruptive effect of the the interfering item can be greatly reduced only if the item is segregated in a unit of its own. Kahneman (1973) tested this hypothesis in a visual modality experiment and found supporting evidence. However, Penney (1978), in an experiment designed to test the effect of the suffix under grouping conditions (where the suffix was included in the same perceptual unit as a number of memory items) failed to find support for this theory under auditory conditions. To the extent that temporal separation was effective in defining perceptual groups, Kahneman's (1973) explanation does not apply to the auditory modality and, hence, leaves the modality effect unexplained.

The lack of any comparable selective effect of a visual suffix on the recall of an auditory list, and of an auditory suffix on the recall of a visually presented list (Morton & Holloway, 1970) reflects further the importance of both the modality and stimulus suffix effects as means for exploring the nature of echoic memory. On the experimental level, the suffix effect offers one possible approach for investigating the nature of echoic memory as it enables the examination of the nature of echoic persistence, that is, of the duration of information in the echoic system. Experimental studies and theorethical views relating to echoic persistence will be reviewed in the ensuing section.

1.02 Echoic Persistence

Of the various experimental techniques available to evaluate echoic memory not all converge on an echoic system with the same temporal properties. However, with the exception of the masking experiments by Massaro (1970) which yielded results to suggest a 250 millisecond store for pitch identification, few research efforts pose any objection to a 2 sec echoic memory (eg. Crowder, 1969, 1972, 1976; Darwin et al., 1972; Morton, 1976; Morton et al., 1971). Evidence which supports this notion of a transitory echo comes primarily from research with a suffix effect (Crowder, 1969, 1971). In one experiment (Crowder, 1969), stimulus list items were presented at an inter-item rate of one every 0.5 sec, with a suffix occuring at 0.5, 2, 5, and 10 sec delays. A typical suffix effect, that is a reduction in the recall of terminal items, was obtained with the 0.5 sec delay, while with longer delays the effect was relatively small. In another experiment (Crowder, 1971), list items were again presented at an inter-item rate of 0.5 secs but the suffix delays varied between 0.5 and 1.5 secs. The effect of the suffix was found to decline with increasing delay. These results led Crowder to conclude that echoic information of the last one or two items persists for up to 2 secs and is largely destroyed by the presentation of the stimulus suffix within this interval.

Evidence for a greater echoic persistence comes from Routh and Mayes (1974) who found that echoic information persisted for a longer period if subjects were prevented from rehearsing (and thus encoding information into a modality-independent form) during the interval between list and suffix presentation. The implication, from the results of their study, is that echoic information decays within 1.6 and 3.2 not 2 secs as implied by Crowder. There is other evidence to suggest that echoic memory may survive longer than 2 or 3 seconds. For instance, Watkins and Todres (1980, expt. I) set out to determine the effects of delaying the suffix by 2, 4, 8, 16, and 20 secs. These researchers used a sequence of 68 eight-letter lists, four of which were used for practice. Items were presented at a rate of 1 per sec (i.e. time for inter-item rehearsal was increased),the letter 'A' defining the suffix condition. A characteristic suffix effect was obtained with delays of up to 20 secs, but the results also indicate that the effect decreased systematically as the delay before presentation of the suffix was increased. Based on these findings Watkins and Todres (1980) proposed that the failure by Crowder (1969) to obtain a suffix effect when a 2 sec suffix delay was used may have been the result of using a 0.5 sec rate of presentation. For instance, with a free rather than serial recall paradigm, and with a presentation rate of one item per sec, both the modality effect (Murdock & Walker, 1969) and the suffix effect (Engle, 1974, Roediger & Crowder, 1976) extend over approximately the last six serial positions. These studies lend support to Watkins and Todres (1980) claim that echoic information may be considerably more persistent than is usually thought. In fact, Watkins and Watkins (1980, expt. VI) delayed the recall of both auditorily and visually presented lists for up to 18 secs and still found a modality effect. However, these researchers also found a substantial decline in the suffix effect with increasing delay, which lends support to the common assumption that echoic memory decays relatively rapidly. As a result, the more echoic memory that has faded away the less will remain to be erased by the suffix.

To reconcile their conclusions that the echo has a useful life of less than 2 secs, with an echoic interpretation of the modality and suffix effect, Crowder (1972) and Morton (1970) assumed that echoic information is encoded into some more durable form immediately following list presentation and before the terminal items are recalled, so that the echo influences recall only directly. They assume thus, that incoming linguistic information is first registered in a precategorical sensory store. The properties of this sensory store are reviewed in the following section.

1.03 The Crowder, Morton, and Prussin Approach: A basic assumption of the existence of a precategorical acoustic storage

Crowder and Morton (1969) and Morton et al. (1971) have postulated the existence of a verbal form of echoic memory called 'precategorical acoustic storage' (PAS). This is conceived as being a property of the nervous system responsible for the extraction of phonological features from a speech input. The PAS sensory storage system is said to hold information in a relatively unprocessed form for up to 2 secs (Crowder, 1972; Morton, 1970). Based on the properties of the PAS, Crowder and Morton (1969), and Morton et al. (1971) have suggested a theoretical explanation for the suffix and recency effects. These authors contend that under normal auditory presentation conditions, the last one or two items in a list remain in PAS at the time of recall, giving the subject information upon which to base his recall of these items. However, under stimulus suffix conditions, the stimulus suffix displaces or eliminates the information about the last list elements from PAS making recall of them equal to intermediate list items whose traces have also been eliminated from PAS. As the PAS system is assumed to be at a processing stage prior to identification, then the displacing effect on earlier echoic traces will occur whether a new item entering the memory system is a memory item or a redundant suffix item.

Crowder (1976) suggests that the contribution of PAS is both parallel and supplementary to echoic memory. Parallel because information concerning the last item is assumed to be held simultaneously in postcategorical memory and in the echoic memory store. Supplementary because the subject has two types of information available concerning the last items of the list and as a result can correct any information with the postcategorical verbal information. Thus, during the interval between presentation of the last item and the initiation of overt recall, a comparison is made by the subject between his verbal memory of the last item and the decaying echoic trace of the same item, using the former to correct the latter. When the suffix occurs following the last item in the list, readout of the echoic information from PAS is prevented and subject is left to rely only on the categorical information (i.e. the verbal memory of the items).

There is a certain amount of evidence concerning the operational function of the PAS. This evidence has been primarily obtained from various experiments involving the use of the stimulus suffix, and shows up most clearly if immediate recall of an acoustically presented digit sequence is compared with recall following a similar visual presentation paradigm (Morton et al., 1971). The last few digits are more accurately recalled when presented acoustically (Craik, 1969; Murdock & Walker, 1969). However, the effect can be reduced by following the acoustic sequence with an irrelevant spoken suffix even though subjects are instructed to ignore it. In comparison, a visual suffix has no such effect (Crowder, 1976; Crowder & Morton, 1969; Morton, 1968; Morton & Holloway, 1970). One might expect that ordered spoken recall would also obliterate the effect since the subject's own voice would erase the information in PAS. This does not occur however, possibly because the subject rapidly transfers the information to a more durable system before beginning to recall (Baddeley & Patterson, 1976).

Morton and Chambers (1976) and Murdock (1974) describe the two characteristic shapes of error function which are evident in the serial recall of list items. With normal acoustic presentation or with visual presentation with vocal rehearsal an acoustic curve is obtained in which the number of errors made on the terminal items in the list is approximately equal to the number of errors made on the initial items. With visual presentation or with acoustic presentation with a stimulus suffix, a visual curve is obtained in which the number of errors on the terminal items is roughly equal to the number of errors made in the middle of the list.

The PAS explanation of the suffix effect has been supported by much empirical data. Compatible with this explanation are the findings that non-linguistic auditory suffixes fail to cause a suffix effect (Crowder, 1971) even when subjects are forced to process them (Morton & Chambers, 1976). Further, Morton and Holloway (1970) found that a visual suffix has no effect on an acoustically presented list. Supportive evidence is also provided by Crowder (1969) who found that the magnitude of the suffix diminishes as the interval between the list items and the suffix is increase, and Morton et al. (1971) who found no interaction between the semantic relationship of the list and suffix items.

An alternative explanation presented by Massaro (1972) suggests that the recency and suffix effects result from short-term memory (STM) storage. Massaro attributes the recency effects to the fact that the final list items are still present in the STM, thus making them accessible for recall. The stimulus suffix effect either eliminates memory codes for the last list items from STM or interferes with the construction of the codes for these items in some way. Salter (1975) has argued against the STM explanation on the bases of its large capacity (more than the one or two items affected by the stimulus suffix), and the semantic interference effect he obtained by manipulating the semantic relationship between the suffix and the list items (Salter & Colley, 1977; Salter, Springer, & Bolton, 1976). Salter and Colley (1977) in fact found that the magnitude of the suffix effect can depend on the associative connection between the suffix and the list items. For instance, these authors found that recall of the terminal list items was better with a synonymic than with a non-synonymic suffix. These results run counter to the PAS explanation (which suggests interference among precategorized acoustic traces) and can be interpreted as evidence for suffix interference arising from categorical similarity. However, these objections to Massaro's (1972) STM interpretation seem less severe when one considers evidence that categorical information may indeed be available in STM (Shulman, 1972) and that the stimulus suffix may not occur as a function of removing or disrupting selected list items from storage, but by preventing a suitable STM code from ever being constructed for those items. In fact, owing to the inconclusiveness of the verbal nature of STM (for instance, Wickelgren (1969) has argued that the STM trace may be auditory or articulatory, or, indeed, neither purely one or the other), the STM explanation is also consistent with evidence for the PAS explanation of the suffix effect.

Experimental studies and theoretical views relating to both PAS and the suffix effect will be reviewed in the following section which deals primarily with the processual properties of the stimulus suffix effect.

1.04 Properties of the Stimulus Suffix Effect

In a series of experiments Crowder (1971, 1972) and Morton et al. (1971) have established a number of properties for the suffix effect. Firstly, evidence suggests that the longer the delay between item and suffix presentation the smaller the suffix effect (eg. Crowder (1969, 1973) has found that no suffix effect occurs if between 2 to 5 secs lapse before presentation of the suffix). These findings are consistent with those found in other masking situations, such as visual masking and the masking of tones, and have led Massaro (1970) to propose that the echoic trace must have decayed by this time. In addition, however, Crowder (1976) suggests that the delay may be simply a measure of how long it takes subjects to read out, or utilized the information in the echoic trace. Displacement of the echoic trace may, therefore, not affect performance because the subject has already abstracted all the available information. However, there is a good deal of evidence to suggest that echoic memory may last a great deal longer than assumed by these theorists. Watkins and Todres (1979) and Watkins and Watkins (1977, 1980), contrary to Crowder, found a characteristic suffix effect with delays of 16and 20secs, and Watkins and Watkins (1980, expt. VI) found a modality effect after a delay of 18 secs. These findings suggest that it is possible to obtain a suffix effect with lengthy suffix delays.

Another property of the suffix is its independence of the semantic content of the item used as the suffix (Crowder, 1976). The masking effect of the suffix is the same whether the suffix is an item drawn from the same or different set as the list items (for example, the word 'recall', 'nought' or 'zero'), or by some nonsense obtained by playing a word in reverse (Crowder & Raeburn, 1970; Morton et al., 1971). Thus, provided the suffix is a speech sound, its precise nature and relation to the list items is of little consequence. However, the magnitude of the suffix effect can be affected by the semantic relationship between the suffix and the stimulus items (Salter & Colley, 1977; Salter et al., 1976). Further, the suffix effect is not independent of the type of speech sounds being remembered. Crowder (1971) has shown that when subjects are required to remember strings of consonant/vowel syllables where the discriminable information is contained only in the stop consonants (eg., b, g, t), there is neither a recency effect in the control condition nor a suffix effect in the experimental condition.

Memory items tend to differ with regard to the initial stop consonants in each syllable. When vowels provide the information to be remembered (such as in a series like goo, gah, gee) a perfect suffix effect results. According to the Crowder and Morton theory of PAS, there is no a priori reason why the suffix effect should depend on the class of speech sounds to be remembered. This differential effect has led Crowder (1971) and Baddeley (1974) to suggest that echoic memory holds information about vowels better than it does information about stop consonants. Further, Watkins and Watkins (1973) have found that the size of the effect is indifferent to whether the list words are one or four syllables in length. This suggests that acoustic factors might not be major determinants of the interference between the suffix and list because if this were the case, one would expect a differential disruption for two and four syllable length words (with the major disruption occuring at the two-syllable word level where two two-syllable words would be subject to interference as opposed to only one in the four syllable word condition). A further demonstration that acoustic factors need not be crucial to obtain the suffix effect comes from Spoehr and Corin (1978) who found a suffix effect when sound was articulated but not spoken.

The dependence of the stimulus suffix effect on the similarity between the stimulus series and the suffix item when the similarity is varied along physical dimensions is another characteristic of the stimulus suffix effect. The suffix has been found to have a reduced effect when presented in a different voice from that of the list items to be recalled (Morton et al., 1971, expts. XIV and XV). That is, if the voice reading the memory lists differs from the voice speaking the suffix item, a significantly smaller effect occurs than when both stimulus suffix and stimulus list voices match (for example, a smaller effect will occur if a male (or female) speaker read both the list and suffix items). A reduced suffix effect is also obtained when the stimulus suffix and the list of items to be recalled are delivered from different apparent locations in auditory space. For instance, Morton et al., (1971, expt. VII) have shown that if the stimulus list is delivered to one ear and the stimulus suffix to the opposite (contralateral) ear, a smaller effect occurs than if both stimulus list and suffix are delivered to the same (ipsilateral) ear. This is consistent with the notion that PAS is largely a property of processes which follow those mechanisms implicated in the selection of a particular acoustic channel. Further, a comparison of data for monoaurally presented stimulus list and suffix items with that for binaural presentation revealed a smaller suffix effect for binaural presentation (Morton et al., 1971, expt. II). These authors, however, failed to report left/right ear differences in terms of the total performance for each ear (i.e. number of items correctly recalled as a function of ear of presentation).

With language processing in general, significant left/right ear differences in performance have been obtained. When, for instance, competing sets of words or digits are presented simultaneously to the two ears, those presented to the right ear are recalled more adequately than those presented to the left (Kimura, 1964, 1966, 1973). These differences in the processing of verbal information have been attributed to hemispheric specialization of function. This concept and related studies are reviewed in the following section.

2.01 Hemispheric Processing of Speech and Non-Speech Sounds: Evidence for Lateral Differences

In a review of hemispheric specialization Studdert-Kennedy and Shankweiler (1970) concluded that the specialization of the dominant hemisphere in speech perception was "due to its possession of a linguistic device" and that "while the general auditory system common to both hemispheres is equipped to extract the auditory parameters of a speech signal, the dominant hemisphere may be specialized for the extraction of linguistic features from those parameters" (p. 579).

The interaction between language performance and the role of the left (dominant) hemisphere have been investigated extensively (see Benton, 1970; Galaburda et al., 1978; Kimura, 1973; Milner, 1971; Schwarz & Tallal, 1980). One method commonly used to investigate hemispheric language processing has been the use of interfering auditory stimuli (Bradshaw, Nettleton, & Geffen, 1971; Dimond, 1972; Kimura,1973; Kinsbourne, 1975). Kimura (1961,b) found that when different digits where presented simultaneously to the two ears through earphones, more digits were accurately reported for the right ear. Her interpretation of this phenomenon is that the right ear has stronger connections with the left hemisphere than does the left ear, and that speech is generally represented in the left hemisphere. Thus, although input from each ear reaches both hemispheres, the contralateral pathway becomes stronger and attenuates the ipsilateral signal. As a result, verbal information received at the right ear is transmitted to, and processed by, the left hemisphere more efficiently than is comparable information from the left ear. Dichotic listening experiments with normal subjects (Curry, 1967; Curry & Rutherford, 1967; Kimura, 1961 b, 1964, 1967, 1973; Kimura & Folb, 1968; O'Neill & Paivio, 1978; Schwarz & Tallal, 1980; Shankweiler & Studdert-Kennedy, 1967; Studdert-Kennedy & Shankweiler, 1970), and brain damaged subjects (Critchley, 1962; Gazzaniga, 1970; Gazzaniga & Sperry, 1967; Geschwind, 1970; Kimura, 1961 a; Milner, Taylor, & Sperry, 1968; Shulhoff & Goodglass, 1969; Sparks & Geschwind, 1968; Sparks, Goodglass, & Nickel, 1970; Sperry, 1974) add support to the suggestion that the specialized neural mechanisms required for the perception of speech are lateralized in the left cerebral hemisphere.

In contrast to these findings, investigators have shown that the reverse is true for melodies and sonar signals (Bryden, 1963; Davidson & Schwarz, 1977; Deutsch, 1970: Doyle, Ornstein & Galin, 1974; Kimura, 1964; Liberman, 1974; McKee, Humphrey, & McAdams, 1973; Tsonuda, 1975). These findings are in accord with the hemispheric specialization of function, with the right hemisphere being more suited for processing melodies and sonar signals (i.e. non-verbal items). These findings are also consistent with clinical observations studies of patients with left hemisphere lesions (see Bartholomeus, 1976; Milner, 1971). These investigators found that while patients with left hemisphere lesions show impaired language processing, those with right hemispheric lesions show impairement in the processing of music and other non-speech sounds.

Evidence for some form of interaction between the two hemispheres during processing is illustrated by Bradshaw et al., (1971) who found that the degree of left hemisphere involvement, as measured by average reading times under conditions of delayed auditory feedback, decreased as meaningfulness and rhythm in a reading task were progressively reduced and increased respectively. Similar evidence was cited by Darwin (1971) who found that for dichotic presentation of vowels a right ear advantage, contrary to the earlier findings in which a different modality was used (see Shankweiler & Studdert-Kennedy, 1967 a, b), occurs when noise is added to the vowels, while a left ear advantage occurs when the same vowels are presented with slow-moving musical pitch contours.

Alternative methods, using interfering tasks to vary stimulus input, have led to further confirmation of hemispheric differences in processing. Bakker (1970), for instance, demonstrated left ear asymmetry could be obtained with monoaural stimulation, using digit series and sound patterns of varying lengths. This researcher required subject to recall rather than recognize up to six digits and up to five different sounds. He found that right ear advantage for verbal material maximized at five items, while left ear advantage maximized at four items. The implications of these findings are that memory load and response requirements may differentially affect response, resulting in most efficient lateralization results with specific component loads, as well as memory and response requirements.

Since each ear appears to be most extensively connected with the opposite hemisphere, Wood, Goff, and Day (1971) set out to investigate the neurophysiological bases for these differences in hemispheric processing. In their study, these researchers measured the electrical activity of the two hemispheres in response to binaural stimuli under two conditions. In the first condition subjects were required to judge whether a stimulus was /ba/ or /da/ (a linguistic judgement), in the second conditions subjects were required to judge whether the stimulus was low or high pitched (a non-linguistic judgement). Their findings indicate that while evoked potentials from the right hemisphere were identical for both tasks, a significantly different pattern of neural activity was produced in the left hemisphere. Further, these differences were not found to be related to differences in the acoustic signal, its presentation probability, the subject's motor responses, or reaction time. These findings generated the conclusion that a unilateral mechanism is specialized to perform those linguistic processes necessary for speech perception.

More recently, Marshall (1975) has criticized such labels as 'linguistic' and 'non-linguistic' on the bases that these labels offer little understanding, in as much as they lack the structural analysis of the hemispheric function they attempt to localize. In an attempt to overcome the need for a fuller understanding of the properties of the hemispheric system, specific components of verbal tasks have been studied separately utilising, for instance, acoustic and phonemic components (Crowell, Kapuniai & Gabarnati, 1977; Liberman, 1974; Tsunoda, 1975), and abstractness and concreteness (Borkowski, Spreen & Stuts, 1965; McFarland et al., 1978; O'Neill & Paivio, 1978; Ranquist & Blackmore, 1973). The relation of verbal and non-verbal factors to hemispheric specialization function is reviewed in the ensuing section, with particular emphasis on the processing of concrete and abstract information.

2.02 The Relation of Verbal and Non-Verbal Factors in Cognition: An Evidential Approach for Hemispheric Specialization

Paivio's (1971) dual-trace hypothesis is a comprehensive attempt to relate verbal and non-verbal factors in cognition. According to this hypothesis any given stimulus can be coded verbally, and, or visually. Exactly which type of code is used depends upon the nature of the information to be coded and the demands of the task.

Paivio distinguishes between concrete items (for instance, apple, horse, newspaper) and abstract items (justice, heaven, belief), and maintains that, although both concrete and abstract items are easily verbally encoded, concrete items are much more likely to be coded visually because apart from their verbal and semantic content they tend to create a visual image. Thus, whereas abstract words can be processed solely in verbal and semantic terms, concrete words can be processed by either or both semantic and imagery based mechanisms. Support for this view comes from a large body of research (eg. Kulhavi & Heinen, 1974; Lutz & Scheirer, 1974; Mondani & Battig, 1973; Nilsson, 1975; Pellegrino, Siegel & Dhawan, 1975; Snodgrass, Wasser & Finklestein, 1974).

A further suggestion by Paivio (1971) is that these two processing systems may be lateralized, the semantic system being in the left hemisphere and the imagery system in the right hemisphere. Das, Kirby and Jarman (1975) provide support for this view. In their 1975 study these researchers found that concrete words are mainly processed via the imagery system, located in the right hemisphere, while abstract words are mediated in a sequential manner by the verbal system in the left hemisphere. Further, this study adds support to the view proposed by Paivio (1971) and to the related approaches of Bower (1972), Cohen (1973), Murdock (1969) and Paivio and Csapo (1969) who found that the visual and auditory systems are respectively specialized for simultaneous (parallel) and successive (serial) processing.

The relationship between the various dimensions of stimulus meaning to hemispheric asymmetry has been the topic of interest in a number of dichotic listening studies. For instance, Borkowski, Spreen and Stuts (1965) and Jones and Spreen (1967) attempted to determine the effect of concrete and abstract words on right ear (left hemisphere) advantage using a dichotic listening task. These investigators found recall to be better for concrete than abstract words, but failed to report an ear advantage as would be expected if differing processes were involved. Similar results were obtained by Ranquist and Blackmore (1973) in two separate studies involving aurally presented words. Although they did establish that auditory presentation can produce imagery codes, these researchers also failed to report a hemispheric advantage. More recently McFarland et al., (1978) investigated ear differences under various competitive stimulation conditions. These investigators, although failing to detect ear differences under various competitive stimulation conditions, did report a right ear advantage for abstract words when the competitive stimulation was speech (expt. II). This suggests that a dual-processing theory cannot be based solely on the evoking qualities of the stimuli but must take into account the varying demands that such variables as the physical characteristics of the input, the processing and response requirements, place on the degree of hemispheric activity involved. Moscovitch (1976) suggests that the left hemisphere exerts an inhibitory control over language function in the right hemisphere, which can be removed when some left hemispheric task is imposed, such as, for instance McFarland's et al., (1978) speech interference condition. Moscovitch (1976) further suggests that the lack of right ear differentiation may be the result of overloading, and that hemispheric differences may become evident only under conditions where a minimum processing load is imposed. This assumption is supported by Norman and Bobrow (1975), Posner (1975) and Schneider and Shiffrin (1977) who found that when a limited capacity system is required to perform simultaneous processing performance deteriorates.

This view is reflected in the findings by Hellige(1978) and Hellige and Cox (1976) which showed that when both laterality and concurrent memory tasks required left hemispheric verbal processing, the left hemisphere performance deteriorated in relation to the right hemisphere. For instance, Hellige and Cox (1976) found a laterality shift from a 'right visual field/left hemisphere' advantage when a concurrent two-word load, requiring verbal processing, was imposed, whereas no influence on laterality patterns was found when concurrent memory tasks did not require verbal processing (Hellige, Cox & Litvac, 1979, expt I). In the latter case concurrent verbal loads produced complex and variable changes in the performance of both hemispheres. It appears from these results that the left hemisphere functions as a typical capacity system that can be influenced separately from the right hemispheric system.

Recent work by Moscovitch, Scullion and Christie (1976) indicates that only higher order processes, such as visuo-spatial memory comparisons, are more specialized in the right hemisphere, and that lower level of processing, such as acoustic signals, is maintained in echoic memory and can be handled equally well by either hemisphere. According to this view, hemispheric contributions to cerebral processing are such that differences in performance do not become apparent until the task reaches a certain level of difficulty. In contrast to these interpretation, Hellige et al., (1979) found no differences in laterality effects for higher and lower order processing and suggested that the laterality effect could be attributed to differences in task demands. Several investigators have suggested that the laterality pattern may be quite different for the same stimuli when the coding strategy demands of the laterality task are changed (eg. Cohen, 1973, 1975 a, b; Patterson and Bradshaw, 1975; Seaman & Gazzaniga, 1973). Egeth and Epstein (1972) have further suggested that with verbal stimuli the left hemisphere tends to be biased towards the perception of sameness, whereas the right hemisphere tends to be biased towards the perception of differences. Moscovitch (1976) however speculates that, as in same/different judgement experiments, this effect could be due to subject's checking of information in both hemispheres (i.e. the subject's decision-making process) before responding different and not having to check the information before responding same.

Research manipulating the strategies prefacing decision-making have been found to affect cerebral processing and offer additional support for the above evidence. Evidence for such dual coding of verbal and non-verbal material has been put forward by a number of authors (eg. Cohen, 1972; Geffen, Bradshaw & Wallace, 1971; Klatzky, 1970; Klatzky & Atkinson, 1972; Moscovitch, 1973, 1976; O'Neill & Paivio, 1978; Seaman & Gazzaniga, 1973). A short-term recognition memory paradigm involving two types of instructional strategies, relational and imagery, was employed by Seaman and Gazzaniga (1973) in order to test subjects' use of these strategies. They found that subjects' responses were faster for probes to the right ear than the left ear when employing the rehearsal strategy, and significantly faster when signal detection methods were employed indicating that the observers may have some degree of control over allocation of processing capacity.

O'Neill and Paivio (1978) investigated dichotic recognition performance under conditions of a reduced memory load and controlled order of report. These researchers departed from the premise that factors affecting perceptual processing would contribute significantly to performance, and that a higher order dependence between verbal stimuli presupposes a limited processing capacity that must be distributed over the two inputs (see Kahneman, 1973; Massaro, 1975). They hypothesized, further, that if ear asymmetry occurs at a primary coding level, and if word attributes can only be elicited after the completion of primary processing, any effect due to ear of input would be independent of attribute effects. Results from their experiments indicated that the effect of concreteness of an attribute as a determinant of dichotic word discrimination was contrary to the findings of Borkowski, Spreen and Stutz (1965) who found recall to be higher for concrete than abstract words. Further, these researchers found a right ear advantage for recognition of all stimulus words. However, ear asymmetry was found to be greater for pairs low (abstract) rather than high (concrete) in meaningfulness (expt. 1). Moreover, they found (expt. 2) that order reporting of the material had little if any effect on the processing relationship, suggesting that interstimulus dependence occurs during encoding rather at some later stage of information proceesing involving short-term memory and decision-making factors.

In addition to the evidence they provide on the dependence phenomenon, the above experiments contribute substantially to ear asymmetry literature. They attest, generally, to the robustness of the right ear (left hemisphere advantage) and have further generated a number of different theoretical approaches to the concept of hemispheric specialization. These approaches and related studies are reviewed below.

2.03 Theoretical Perspectives on Hemispheric Specialization of Function and Related Studies

Semmes (1968) has offered a theoretical explanation for a possible mechanism underlying hemispheric specialization consistent with much data on lateral differences. Her basic assumption of diffuse-focal specialization rests on the premise that sensory and motor capabilities are more focally represented in the left hemisphere. Semmes interpretation is primarily based on evidence derived from physio-sensory experiments which indicate that left hemispheric damage to a specific cortical area results in a specific functional impairment (for example, speech dysfunction). Clinical data (eg. Humphrey & Zangwill, 1952; Milner, Branch & Rasmussen, (1964) suggest that left-handers more frequently than right-handers sustain language deficits with unilateral cerebral disease; these deficits are less severe and more transient than those with right-handers.

Data collected from dichotic listening studies tend to support this perspective. For instance, the original dichotic listening data of Kimura (1961 a) show a significant loss in the number of digits recalled when comparison is made between pre and post-surgery scores for patients who had undergone left hemisphere temporal lobectomies. Similar evidence was cited by Schulhoff and Goodglass (1969) from their study involving patients with unilateral temporal damage. These patients were 'matched' with patients with right temporal lobe damage and a control group of normal subjects. Three types of material were dichotically presented in an auditory modality.

These involved digits, tonal sequences, and clicks. Results indicated a right ear advantage for digits for the normal group, a bilateral deficit for digits for patients with damage to the left temporal lobe, and a bilateral deficit for tonal sequences for patients with damage to the right temporal lobe. These deficits were attributed to damage to the specific mechanisms for speech and tonal sequences, and was termed by these researchers as the 'dominance effect'. Further, on the click counting task, a marked deficit occured for patients with left temporal lobe damage when clicks were presented to the contralateral ear, than with right temporal lobe patients. As lesions on the temporal lobes for both groups of patients were of comparable size, dominance deficits for the right temporal lobe damage could reflect, in accordance with Semmes (1968) theory, more diffuse representation in the right hemisphere (with lesions in the right hemisphere producing less of an effect than the same size lesions in the left hemisphere). Further, and in accord with the above findings, Semmes' theory does account for left hemisphere superiority for verbal tasks.

An alternative explanation, based on hemispheric competition, has been proposed by Kinsbourne (1975). This model, congruent with Milner's (1971) model of verbal/nonverbal distinction, hypothesizes that lateralized cerebral activity biases attention towards the contralateral side of the body such that performance of a task on that side is enhanced. Kinsbourne's suggestion, thus, implies a system whereby the specialized function of one hemisphere inhibits the specialized function of the other hemisphere.

Support for this theory has come from Spellacy and Blumstein (1970), and Morais and Bertleson (1974, 1975). In their studies involving the identification of dichotically presented language and non-language stimulus sets, a task that has been found to result in small, if any, lateral differences (see Shankweiler & Studdert-

Kennedy, 1970 b), Spellacy and Blumstein (1970) found that the language set (vowels) resulted in significant right ear superiority, while the non-language set (humming melodies) in left ear superiority. Additional support comes from a study by Morais and Bertleson (1975) who found a right ear advantage with three types of presentation of speech messages involving time differences, intensity differences, and dichotic presentation. The results of these studies suggest that the relative strength of contralateral and ipsilateral signals is not sufficient to account for these data as interpreted by Kimura (1961 b).

Evidence in contrast with the above is provided by Goodglass, Shai, Rosen and Berman (1971) who attempted to extend Kinsbourne's idea by using material with known lateral dominance effects. These researchers carried out a study using three groups of subject under three conditions with three types of material. The former included a verbal set consisting of sound shadowing, a non-verbal set consisting of humming along with a tape, and a no-set condition. The latter comprised of nonsense figures as neutral, two-letter words as right field dominant, and dot-localization as left-field dominant. Results revealed minimal shifts toward set conditions with only one of six shifts reaching significance, and led these authors to conclude that the Kinsbourne effect is not sufficient to reverse known perceptual lateral asymmetries. Kinsourne's attentional stance has also been contrasted by findings by Cohen (1972) and Moscovitch (1973) who found that the detection of stimuli in the right and left visual field are not affected by the subject's foreknowledge of the verbal and non-verbal nature of the stimulus material to be detected.

A theory of selective attention has been proposed by Moray (1975) who suggests that the stimulus messages are processed simultaneously in both channels until a response is made. This theoretical perspective places emphasis on the decision-making process leading up to the response, at the same time taking into consideration that subjects' expectations of target probability may affect his or her likelihood of making a particular response. The significance of Moray's model is reflected in the premise that when stimulus materials are held constant, changes in the response requirements will elicit observable changes in hemispheric interaction. Further, this model appears to be an extension of those attentional models of hemispheric dominance which focus on such variables as the mechnisms responsible for the limitations in information processing (see Broadbent, 1958; Norman, 1968; Triesman, 1964), and the nature of these mechanisms (see Broadbent, 1971, 1974; Welford, 1968).

The above theories and related studies provide further evidence for the concept of hemispheric specialization. Indeed, although different theoretical interpretations of the phenomenon have emerged, all converge on the same basic notion of hemispheric specialization of function. That is, that the left hemisphere is better suited for linguistic processing while the right hemisphere for non-linguistic processing.. In the ensuing section evidence relating to the physiological aspect of cerebral asymmetry will be reviewed, with special emphasis on the relationship of the two hemispheres to language and handedness.

2.04 Left-Right Asymmetries in the Brain and Their Relation to the Concept of Cerebral Dominance

The concept of cerebral dominance, descriptive of the functional asymmetry of the two hemispheres of the human brain, dates from the apparently independent observations of Dax (1836) and Broca (1865) that language disorders followed left hemispheric damage (Critchley, 1962). The most comprehensive body of evidence for the different abilities of the two hemispheres has been obtained by Sperry and Gazzaniga (1970) from their observation of a number of split-brain patients who had undergone surgical section of the major links between the hemispheres (namely, the corpus collossum and the anterior commissure) in an effort to control epileptic seizures. These investigators found that the hemispheres of these patients functioned independently, each specialized in its own function. While the right hemisphere was found to specialize in spatial tasks, the left hemisphere was found to be predominant in verbal tasks, controlling speech, writing, and arithmetic abilities. This interpretation is consistent with a number of clinical analyses of language disorders following brain damage (see Geschwind, 1970), and may be related to anatomical differences between the left and right temporal lobes (Geschwind & Levitsky, 1968). In their study, Geschwind and Levitsky (1968) examined for anatomical differences between the right and left temporal lobes in one hundred human brains, and confirmed the presence of asymmetries in the planum. Their report revealed that the left planum was larger than that of the right side in 65 percent of the brains, approximately equal in 24 percent of the brains, and smaller in only 11 percent of the brains examined. Further, the left planum was found to exceed the right planum in length by nearly one centimeter and to be on average one-third larger in area that the right planum, while in the more striking cases five or more times larger. These gross asymmetries on the upper surface of the temporal lobe have been interpreted as potentially of major significance in that 'damage in the posterior and superior part of the temporal lobe on the left side leads to distinctive disturbances in language function'(Galaburda et al, 1978, p. 853).

A further assumption on the function of cortical asymmetries was based on the premise that most asymmetries of functional significance would be reflected in differences of the cytoarchitetonic regions of the two sides. These differences were recently reported by Bogen and Bogen (1976) who reiterated that the major difference between the two sides of the brain is reflected in the greater volume of the temporo-parietal cortex on the left side. The volume in this area was found to be approximately seven times larger than on the right side. This was also confirmed by Galaburda et al., (1978) who reported that the relative volumes (in planimetric units) of auditory cytoarchitetonic areas for one brain, measured 35 versus 254 planimetric units for the right and left sides respectively, in the temporo-parietal cortex.

Based on the premise that the crossing fibres in the pyramidal tract connect with the arm and hand areas of the spinal cord, Keretsz and Geschwind (1971) attempted to correlate asymmetries in the crossing of the pyramidal tract with the handedness of the individual. In a study of 158 medullas, these researchers found that for right handed individuals there was a more rostral crossing of the left pyramid to the right in 82 percent of the cases. In a more recent study of hemispheric asymmetry and individual handedness LeMay (1976) found that in the right handed a wider left occipital lobe is nearly nine times more common than a wider right, and that the left occipital petalia and right frontal petalia (that is, identations in the inner and outer tables of the skull) are also more common in the right handed. Galaburda et al., (1978), report further, that a majority of the right handed individuals display a larger left planum than do left handed individuals.

Based on the above context, a general pattern appears to emerge. Although there is a scarcity of information about the relationship of anatomical asymmetries and function, it is possible to speculate on the bases of the available data. It is possible that the functions of areas usually found to be larger on the right side of the brain are generally different from those areas which are generally larger on the left side of the brain. It is conceivable but unlikely that such striking asymmetries are of no functional importance.

THE PRESENT STUDY

The present study is based on, combines elements of, and extends experiments II and V in the Moton et al., (1971) series. In the following experiment the stimulus suffix is investigated in a monoaural presentation paradigm as in experiment II, with meaningful word information as in experiment V of the original work.

This study differs and extends from that of Morton et al. (expt. V) in that meaningful information consists of both concrete and abstract nouns as compiled by Paivio et al. (1968). The original experiment (Morton et al., 1971, expt. V) included only concrete nouns which were restricted to two sets comprising only of 'utensil' and 'animal' categories. Concrete and abstract nouns were selected because of their differential effect on hemispheric processing as reported by McFarland et al. (1978) and O'Neill and Paivio (1978). These researchers reported greater ear asymmetry for abstract information, with the right ear showing an advantage in the processing of abstract information. No differences for the processing of concrete information were reported. In addition, O'Neill and Paivio reported a right ear advantage for all information (i.e. concrete and abstract combined). These findings are consonant with what is known of hemispheric processing (i.e. that the left hemisphere shows an advantage for the processing of speech information) and with Paivio's (1971) dual-trace model which presupposes differential hemispheric processing for abstract and concrete information (abstract information being thought to be of a more verbal nature since it lacks the imagery content associated with concrete information and is therefore more likely to be processed by the left (speech processing) hemisphere).

This study also differs and extends from Morton et al's experiment V, in that apart from incorporating the presentation of concrete and abstract stimuli in a stimulus suffix paradigm, it incorporates monoaural (left/right ear) presentation (expt. II). It was reasoned that if hemispheric processing differences operate for concrete and abstract information, then detection of these differences may be possible with left and right ear presentation of equal numbers of these two categories of information. Further, such a design would allow investigation of some of the properties pertaining to the stimulus suffix effect: namely, the effect of these two categories of information on the magnitude of the stimulus suffix effect, and the effects of using different and similar suffixes to the list items could be investigated.

It was the experimenters intention to use monosyllabic words in this study as per Morton et al. (expt.V), however, as a result of scarcity of monosyllabic concrete and abstract words needed for the compilation of 40 word-lists, two and three syllable words were used. As syllable length has been found not to affect the effect of the stimulus suffix, even when syllable length ranged from one to four syllables (Watkins & Watkins, 1973), no confounding was expected to arise due to this factor. Similarly, because of the scarcity of two and three syllable words in the Paivio et al. noun list, it was not possible to control for word length. It was believed, however, that as stimulus words were read on tapes, sound rather than word-length was the more crucial variable.

In keeping with Morton et al. (expt. V), seven-word lists plus stimulus suffix were compiled. This is well within the normal ability to remember. The stimulus lists contained words from one of two clearly defined semantic classes (concrete and abstract), and the stimulus suffix events were words either from the same class or from the other class of the to-be-remembered items. It was reasoned that, given the right ear advantage for abstract information, right ear presentation of an abstract suffix following an abstract list should yield a reduced suffix effect as compared to all other list and suffix combinations. It was further presumed that, given right ear advantage for all linguistic information, a reduced suffix effect would occur with right ear presentation for all list and suffix combinations as compared to the left ear.

In order to avert confounding due to poorly defined concreteness-abstractness levels, an effort was made to include in the pools of concrete and abstract words, from which the stimulus lists were compiled, nouns which were considered to be significantly high (concrete) and low (abstract) in meaningfulness value. That is, only nouns rated 3.9 or below in abstractness and 5.7 and above in concreteness in accordance with Paivio et al. (1968) 0 - 7 ratings, were used. These nouns were further divided into pools containing either 2-syllable concrete, 2-syllable abstract, 3-syllable concrete, and 3-syllable abstract words. According to their syllable length and concreteness-abstractness value, all words were then randomly assigned to lists. In order to avert order presentation effects, in terms of both list and ear of presentation, a 4 x 8 Latin Square design was used. Lists were randomly assigned to squares.

Further, although several experimenters investigating for left-right ear processing differences have availed themselves of dichotic listening tasks using interference conditions and running memory span paradigms based on stimulus recognition (eg. Kimura, 1964, 1976, 1973; McFarland er al., 1978; O'Neill & Paivio, 1978), a number of experimenters have obtained significant left-right ear differences using monoaural stimulus presentation based on serial recall (eg. Bakker, 1970). As a serial recall paradigm is typically used in stimulus suffix effect experiments, and as this pattern of presentation and recall has been found to yield significant left-right ear difference, the use of such a paradigm was considered appropriate. In order to ensure that no time was given to subjects to fully process the incoming information, and therefore possibly confound probable left-right ear differences, our recall paradigm was closely based on a running memory span presentation in that it involved rapid stimulus presentation. It was reasoned that with the use of a recall rather than recognition paradigm, a prerequisite for testing the suffix effect, the 'guessing' element typically associated with stimulus recognition paradigms, where subjects are required to respond whether a stimulus word is 'old', 'new', or take a 'guess', would be eliminated.

Against this general background aim the following hypotheses were investigated.

1. Given that both concrete and abstract words fall into the speech category, and that speech is processed more efficiently by the left hemisphere (connected to the right ear), one would predict:
   a) a greater right ear advantage for both word categories, and,
   b) a reduction in the stimulus suffix effect with right ear presentation.

2. Based on evidence that there are processing differences for concrete and abstract information, and that abstract information, being of a more verbal nature, is processed more efficiently by the left hemisphere, one would predict:
   a) a right ear advantage for abstract information, and,
   b) a reduction of the stimulus suffix effect with right ear presentation when both stimulus list and stimulus suffix are abstract.

The concern of this study is also with the effects of delaying the stimulus suffix item. The available evidence on this matter is at present somewhat inconsistent. For instance, whereas Crowder (1969) found that the stimulus suffix had no selective effect when it was delayed by two or more seconds, Routh and Mayes (1974) found a typical suffix effect with delays of up to 3.2 secs, and Watkins and Todres (1980, expts. I and III) found a suffix effect, although reduced, with delays of up to 16 and 20 secs. The present study closely follows experiment I by Watkins and Todres (1980) and investigates the suffix effect with delays of 2, 4, and 8 secs, as well as incorporating a no-delay conditions as per Crowder (1969). Based on the above evidence our final hypothesis predicts that:

3. Given the assumption that the stimulus suffix effect is due to the erasure of echoic memory, and further, that echoic memory persists for up to 20 secs, then it should be possible to demonstrate a stimulus suffix effect under all delay conditions.

METHOD

Design: A between-subjects factorial design was used with all subjects receiving all combinations of variables. The design involved the presentation of two stimulus categories (concrete/ abstract) to the left and right ears in four types of word-list and stimulus suffix combinations (concrete list - concrete suffix; concrete list - abstract suffix; abstract list - concrete suffix; abstract list - abstract suffix) at four delay conditions (0.5, 2, 4, 8 secs). Correct recall of the stimulus words was evaluated at all seven serial positions.

Materials: A sequence of 40 seven-word lists plus stimulus suffix (20 abstract and 20 concrete) was constructed, four of which were used for practice and four as baseline control. All stimulus lists and suffixes were either semantically similar or semantically dissimilar. These lists are presented in Appendix A. Words were selected from the Paivio et al., (1968) norms with abstractness - concreteness being decided on the basis of their 0 - 7 ratings. For each list words were randomly sampled, without replacement, from a pool of 340 words. The mean value for concrete words was 6.62, and the mean value for abstract words 2.42. There was a significant difference between concrete and abstract word lists (Mann-Whitney U-test, $u = 0$, $p. < .005$, Appendix B). Syllable length was controlled by using only 2 and 3 syllable words with the mean syllable length for concrete and abstract words being 2.5. The stimulus lists were recorded into a Sony TC 330 tape recorder by a female speaker. Each list being recorded on a separate tape and channelled to play to the appropriate ear. The delays between list and stimulus suffix presentation were determined by using a chronometer. Both channels of the tape recorder were matched for subjective loudness before testing began. Stereophonic Idex HD 124 DX headphones were used to present the stimuli to the two ears. In order to obliviate ceiling effects in recall performance an appropriate volume level was determined pre-experimentally, using pilot subjects. *

Subjects: The subjects were 21 undergraduate psychology students (10 males and 11 females) who volunteered to take part in the experiment. Their ages ranged between 18 - 26. All were self-declared right handers with no hearing difficulties.

Procedure: Testing was carried out in a small interview room over a three week period during March - April 1981. Subjects were tested individually after listening to instructions read by the experimenter (for verbatim instructions see Appendix A). Each subject was seated at a desk on which the testing apparatus was set up and was informed that he or she would be listening to a number of word lists on tape. Subjects were further instructed that prior to each tape being played they would be given a cue word. This cue word would appear at the end of each list and was to act as indicator that the list had ended. Recall had to be commenced immediately the subject heard the cue word. There was a stipulation calling for ordered recall. It should be noted that the requirement for the subjects to recall the items in the list in order of presentation (serial recall) is essential when the effects of the suffix are being investigated (Morton & Chambers, 1976). Stimulus list tapes were presented in accordance with a Latin Square technique with subjects' sequences commencing at randomly determined

* Note: In a preliminary study it was established that a) subjects had no difficulty in recalling seven-word lists, and b) that recall of the stimulus list items was in accordance with that of a typical 'auditory curve' with primary and terminal items being more frequently recalled than items in the middle of the list.

positions. This was done in order to avert order presentation effects in terms of both lists and ear of presentation. Recall was written on a response sheet with the appropriate number of spaces by the experimenter. Only correct responses recalled in the correct serial position were recorded. Each session commenced with a practice run of 4 lists incorporating all variables. This session typically lasted 8 mins (with a typical list sequence lasting approximately 10 secs). The first experimental trial commenced at the conclusion of the practice run. Each trial varied depending on the duration of the delay condition with the total session lasting 90 mins. There was approximately a 1 min interval between each trial and a 10 min rest at the end of the 20th trial. At the conclusion of the experimental session subjects were administered four lists (2 concrete and 2 abstract) from which the suffix word was omitted. Subjects were instructed as per the experimental condition but without reference to the cue word (see Appendix C). This condition typically lasted 8 mins and served as a baseline control against which the effect of the suffix could be measured.

RESULTS

The number of words correctly recalled at each serial position was calculated under all combinations of ear of presentation, list type, suffix type, delay condition, and serial position. These scores were then subjected to a five-way analysis of variance, a summary of which is shown in Appendix F.

The analysis of variance showed that the number of words correctly recalled varied as a function of ear of presentation $F\ (1,20) = 14.17$, $p < .01$, list type $F\ (1,20) = 27.08$, $p < .01$, the delay condition $F\ (3,60) = 3.16$, $p < .01$, and serial position $F\ (6,120) = 18.54$, $p < .01$. For ease of interpretation, data on the relationship between ear of presentation and number of words correctly recalled is illustrated in Figure 1, which shows a right ear advantage (REA) for all information. This advantage, however, appears to be due to the right ear superiority for the recall of abstract information. This is exemplified in Figure 2 which shows a marked REA for abstract list information, and to a much smaller degree the reverse occuring for left ear presentation of concrete information. This two-way interaction was significant $F\ (1,20) = 21.63$, $p < .01$.

Multiple comparisons of means utilizing Newman-Keuls technique confirmed the REA for abstract information and revealed a significant difference $q\ (1,20) = .0918$, $p < .05$ for right ear recall of abstract information as compared to the left ear. Similar differences were apparent between mean recall frequencies for left ear abstract and right ear concrete $q\ (1,20) = .1045$, $p < .05$, and left ear concrete and abstract information $q\ (1,20) = .1224$, $p < .01$. All other comparisons, including mean recall frequencies for concrete information from left and right ear presentation, were not significant $p > .05$.

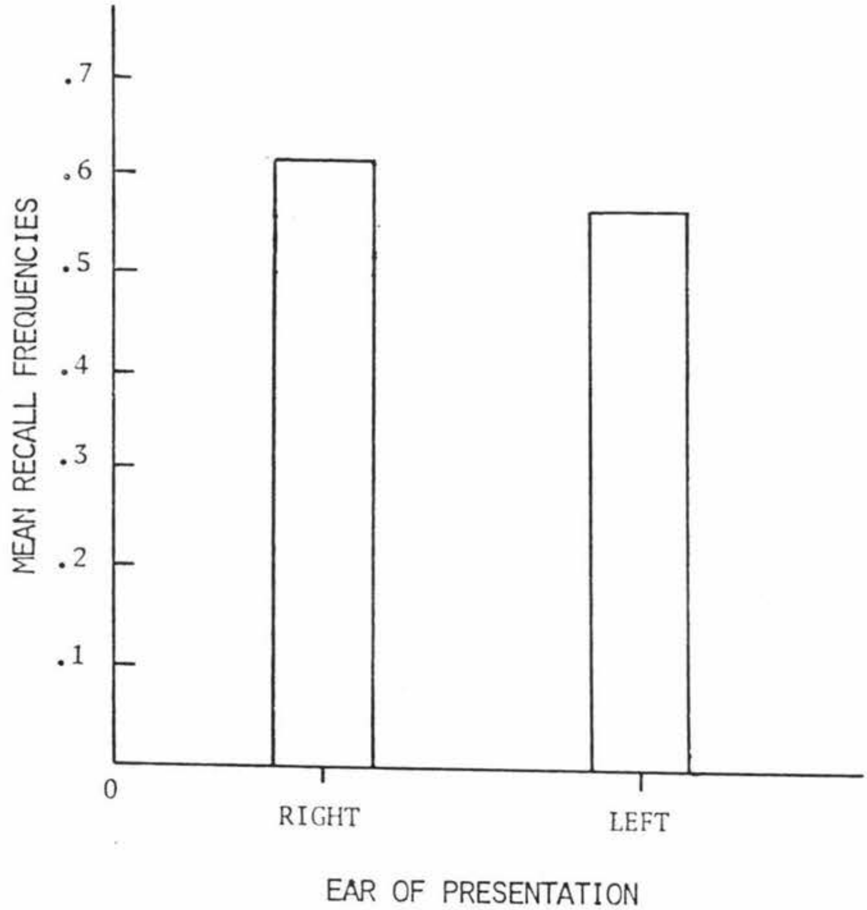

Figure 1. Proportion of words correctly recalled as a function of ear of presentation.

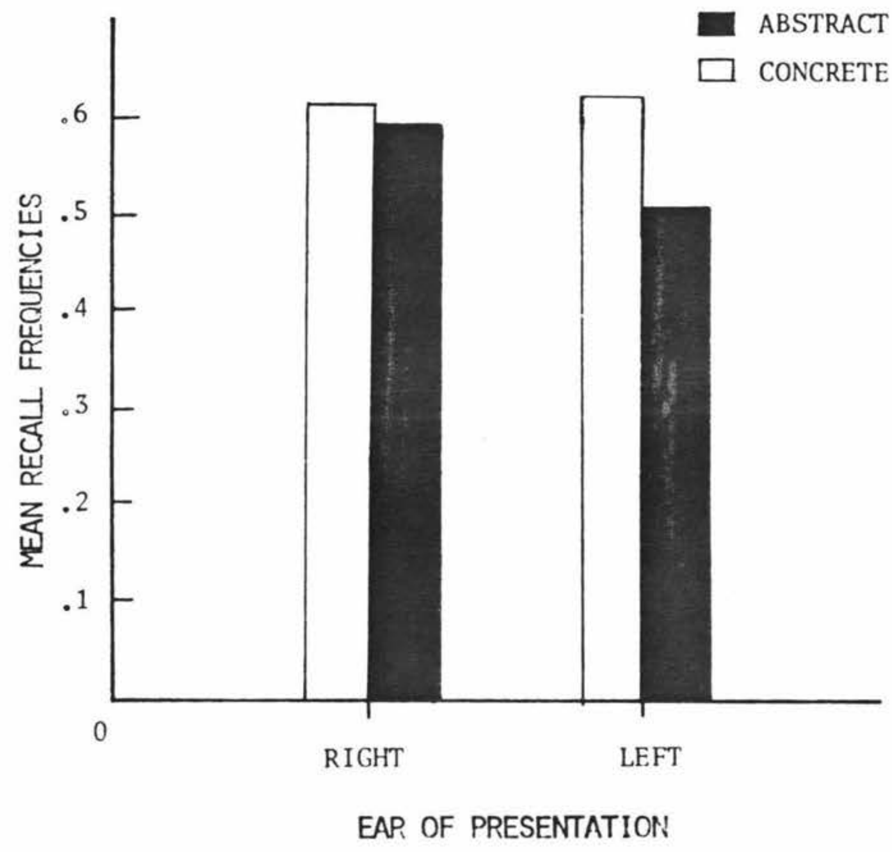

Figure 2. Proportion of words correctly recalled as a function of type of information and ear of presentation.

The suffix type failed to exert a significant effect $F(1,20) = < 1.0$, as did the two-way interaction between both ear and suffix types $F(1,20) = < 1.0$, and list and suffix types $F(1,20) = < 1.0$. The three-way interaction between ear, list and suffix types was not significant $F(1,20) = 2.13$, $p > .05$, nor was the interaction between suffix, delay, and serial position $F(18,360) = 1.49$, $p > .05$. All other interactions were significant $p < .05$, including the five-way interaction between all variables $F(18,360) = 2.06$, $p < .01$.

In order to isolate specific interactive effects between list and suffix types and ear of presentation, a further series of analyses were performed. In the first of these, the number of words correctly recalled were pooled over list type and suffix type, to yield a variable which reflected the four combinations of list and suffix information. The analysis of variance (see Appendix G), showed that the number of words correctly recalled varied as a function of ear of presentation $F(1,20) = 13.85$, $p < .01$, the stimulus list and suffix combinations $F(3,60) = 13.59$, $p < .01$, the delay condition $F(3,60) = 3.46$, $p < .05$, and the serial position $F(6,120) = 18.44$, $p < .01$.

The two-way interaction between list and suffix types with ear of presentation was significant $F(3,60) = 9.31$, $p < .01$, and is shown in Figure 3. Inspection of Figure 3 reveals that recall of all list and suffix combinations was similar for the right ear. For the left ear, recall was reduced for all the abstract combinations. Multiple comparisons of means utilizing Newman-Keuls technique for left and right ear recall of word lists and suffix types, revealed a significant REA for abstract list - abstract suffix (AA) combinations $q(3,60) = .0965$, $p < .01$, and for abstract list - concrete suffix (AC) combinations $q(3,60) = .0850$, $p < .05$ when compared to the left ear. Comparisons of means for recall of concrete list - concrete suffix (CC) and concrete list - abstract suffix (CA) combinations, revealed no

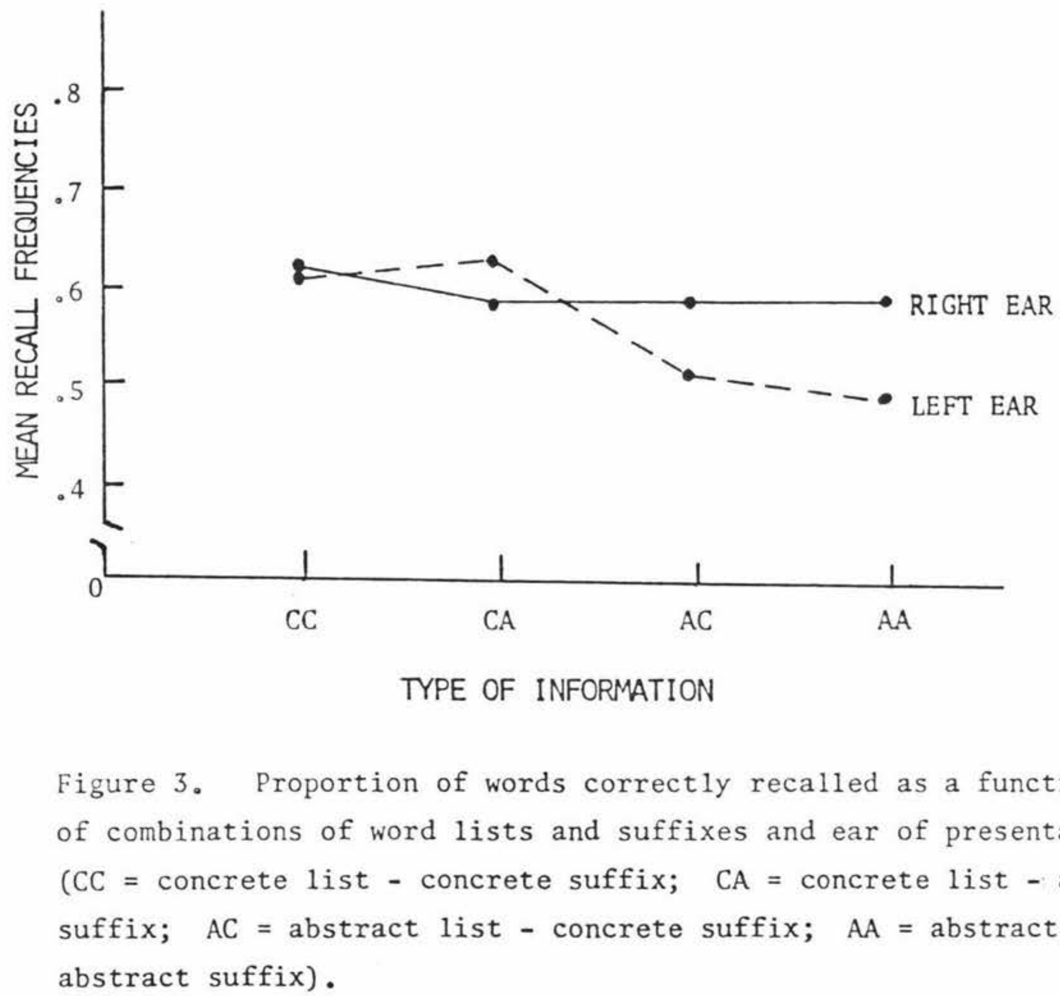

Figure 3. Proportion of words correctly recalled as a function of combinations of word lists and suffixes and ear of presentation (CC = concrete list - concrete suffix; CA = concrete list - abstract suffix; AC = abstract list - concrete suffix; AA = abstract list - abstract suffix).

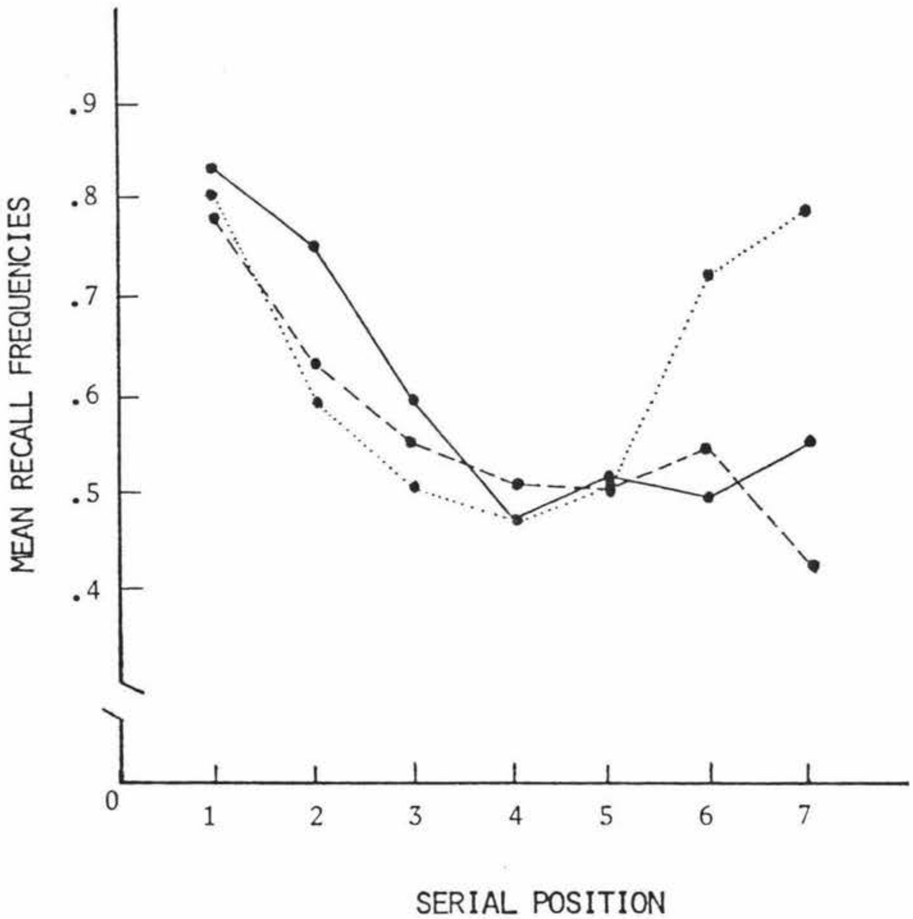

Figure 4. Proportion of words correctly recalled as a function of ear of presentation and serial position (•———• right ear; •– – –• left ear; •·········• control - no suffix).

significant differences $p > .05$. Separate comparisons of means for left and right ear data revealed no differences in right ear recall of any of the list and suffix type combinations. For the left ear, significant differences were evident between the CC and AA combinations $q(3,60) = .1190$, $p < .05$, the CC and AC combinations $q(3,60) = .1054$, $p < .05$, the CA and AA combinations $q(3,60) = .1395$, $p < .05$, and the CA and AC combinations $q(3,60) = .1259$, $p < .05$. The differences between the means in the CA and CC combinations were not significant $p > .05$.

The two-way interaction between ear of presentation and serial position was significant $F(6,120) = 3.24$, $p < .01$, and is shown in Figure 4. In this figure there is a decline for both ears in the number of words recalled as a function of serial positions as compared with the control condition. A marked suffix effect occured for both ears, with that for the left ear being more pronounced. The suffix effect extended over the last two serial positions for both ears. A significant two-way interaction was also found between ear of presentation and delay $F(3,60) = 4.23$, $p < .01$. This interaction, illustrated in Figure 5, shows that while there was a systematic increase in the number of words recalled for left ear presentation with increasing delay, with the right ear the number of words recalled decreased with the 8 sec delay.

The two-way interaction between delay and serial position was significant $F(18,360) = 2.86$, $p < .01$, and is shown in Figure 6. Inspection of the terminal serial positions of this figure generally reveals an increase in the number of words recalled as the delay between list and suffix presentation increases, but this increase is not systematic with delay. The stimulus suffix disrupts recall in the last serial position with delays of 0.5, 4, and 8 secs, but in the 2 sec conditions more severe disruption occurs over the last two

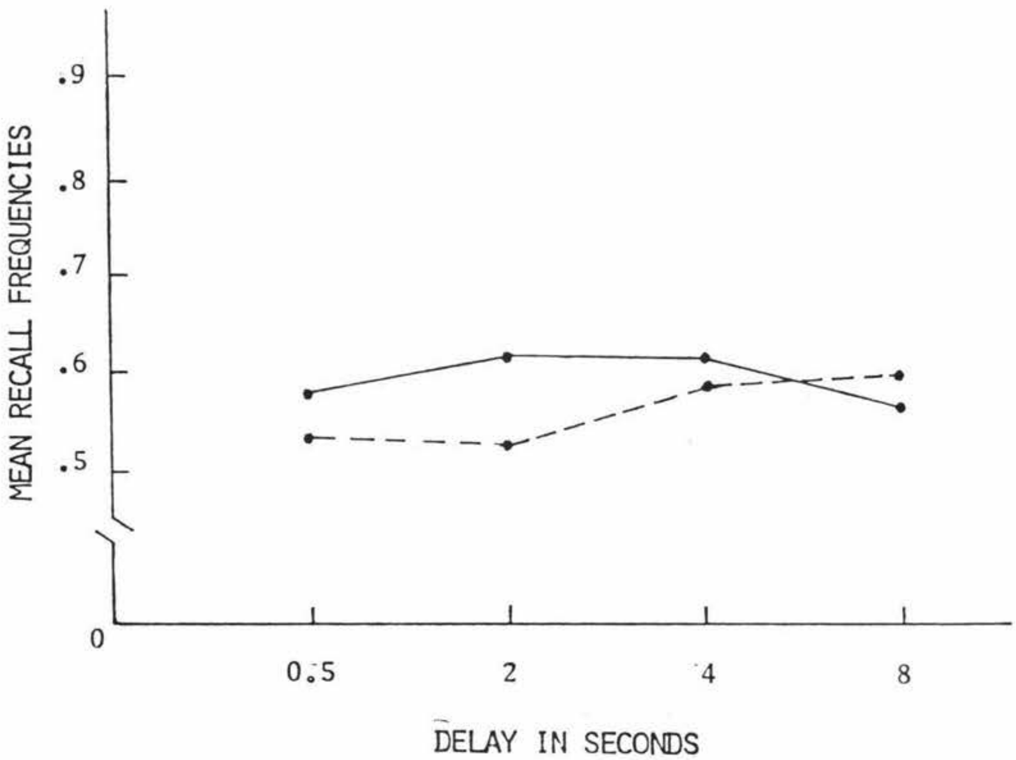

Figure 5. Proportion of words correctly recalled as a function of ear of presentation and delay (•– – – – –• left ear; •————• right ear).

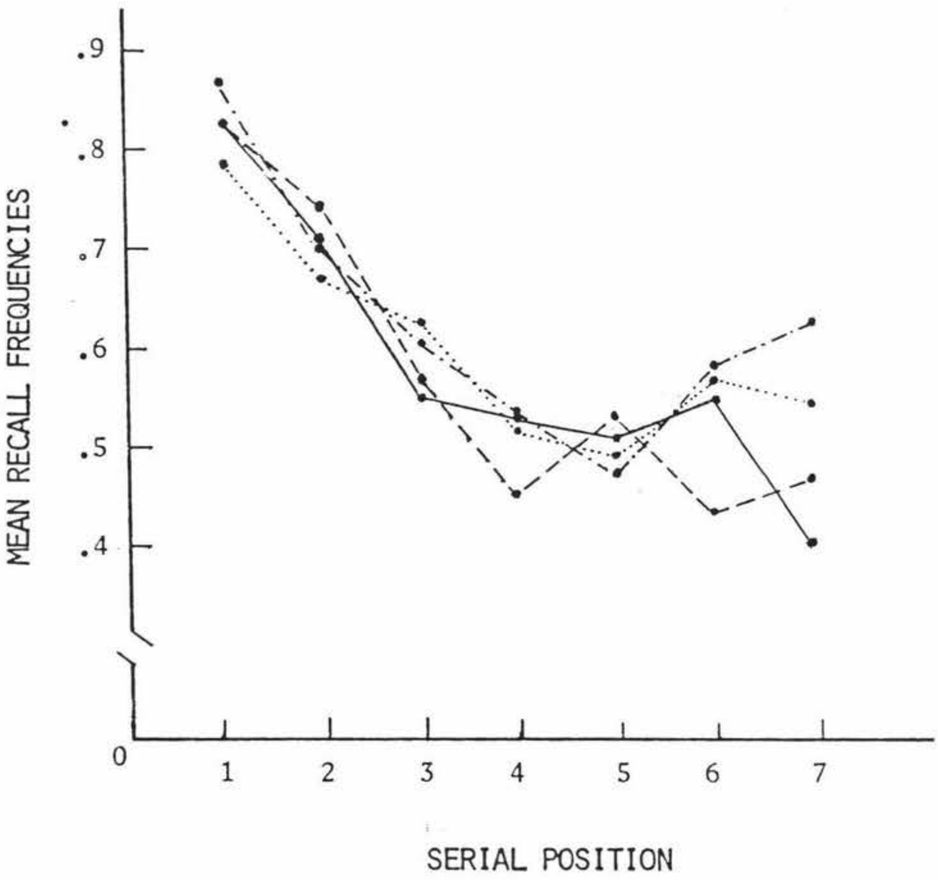

Figure 6. Proportion of words correctly recalled as a function of delay and serial position (•———• no-delay; •– – – –• 2-sec delay •–·–·–• 4-sec delay; •··········• 8-sec delay).

serial positions. All remaining two and three-way interaction were also significant $p < .01$, as was the four-way interaction $F(54,1080) = 3.20$, $p < .01$.

In order to isolate recall frequencies specific for each ear of presentation, the four-way interaction of Appendix G was decomposed in two further analyses (left ear, Appendix H; right ear, Appendix I). For the left ear the analysis of variance (Appendix H) showed that the number of words correctly recalled varied as a function of the list and suffix combinations $F(3,60) = 16.64$, $p < .01$, the delay condition $F(3,60) = 5.08$, $p < .01$, and serial position $F(6,120) = 14.33$, $p < .01$. All two-way interactions between these variables were significant as was the three-way interaction $F(54,1080) = 3.00$, $p < .01$. For the right ear, the analysis of variance (Appendix I), showed that the number of words correctly recalled varied as a function of serial position $F(6,120) = 13.56$, $p < .01$. However, the list and suffix combinations did not exert a significant effect $F(3,60) = 1.32$, $p > .05$, nor did the delay exert a significant effect $F(3,60) = 2.40$, $p > .05$. All the two-way interactions between these variables were significant $p < .01$, as was the three-way interaction $F(54,1080) = 2.02$, $p < .01$.

The significant two-way interactions between delay and serial position for the left ear, $F(18,360) = 2.64$, $p < .01$, and the right ear, $F(18,360) = 2.57$, $p < .01$ are shown in Figure 7. For both ears, under most conditions, there was a suffix effect, with the effect being more pronounced for information presented to the left ear than to the right. Again, the suffix effect was not systematic with delay, and there was no difference between the ears for the recall of information in the no-delay condition.

The significant two-way interaction between list and suffix

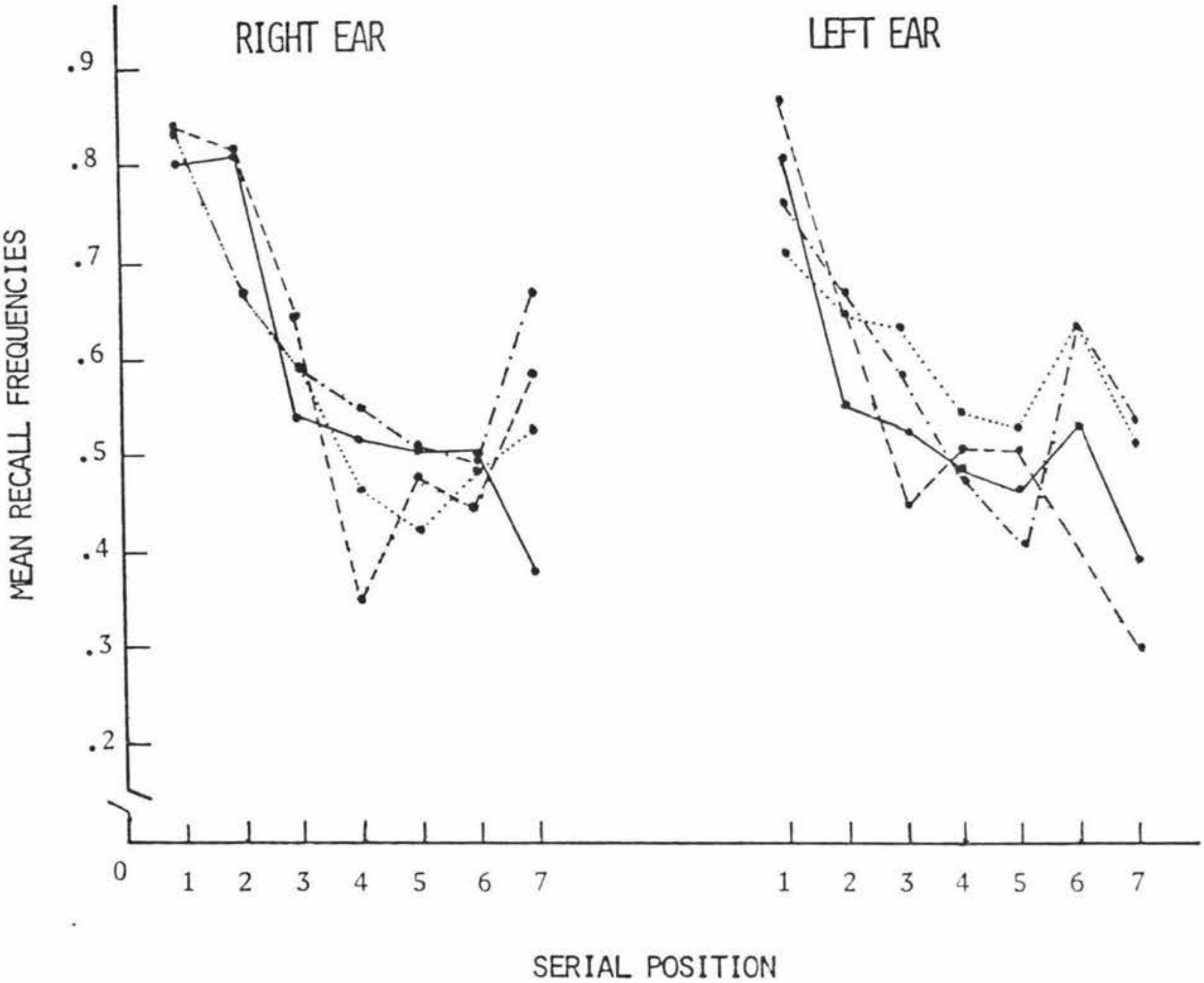

Figure 7. Proportion of words correctly recalled as a function of ear of presentation, delay, and serial position (•———• no-delay; •— — — —• 2-sec delay; •— · — · —• 4-sec delay; •··········• 8-sec delay).

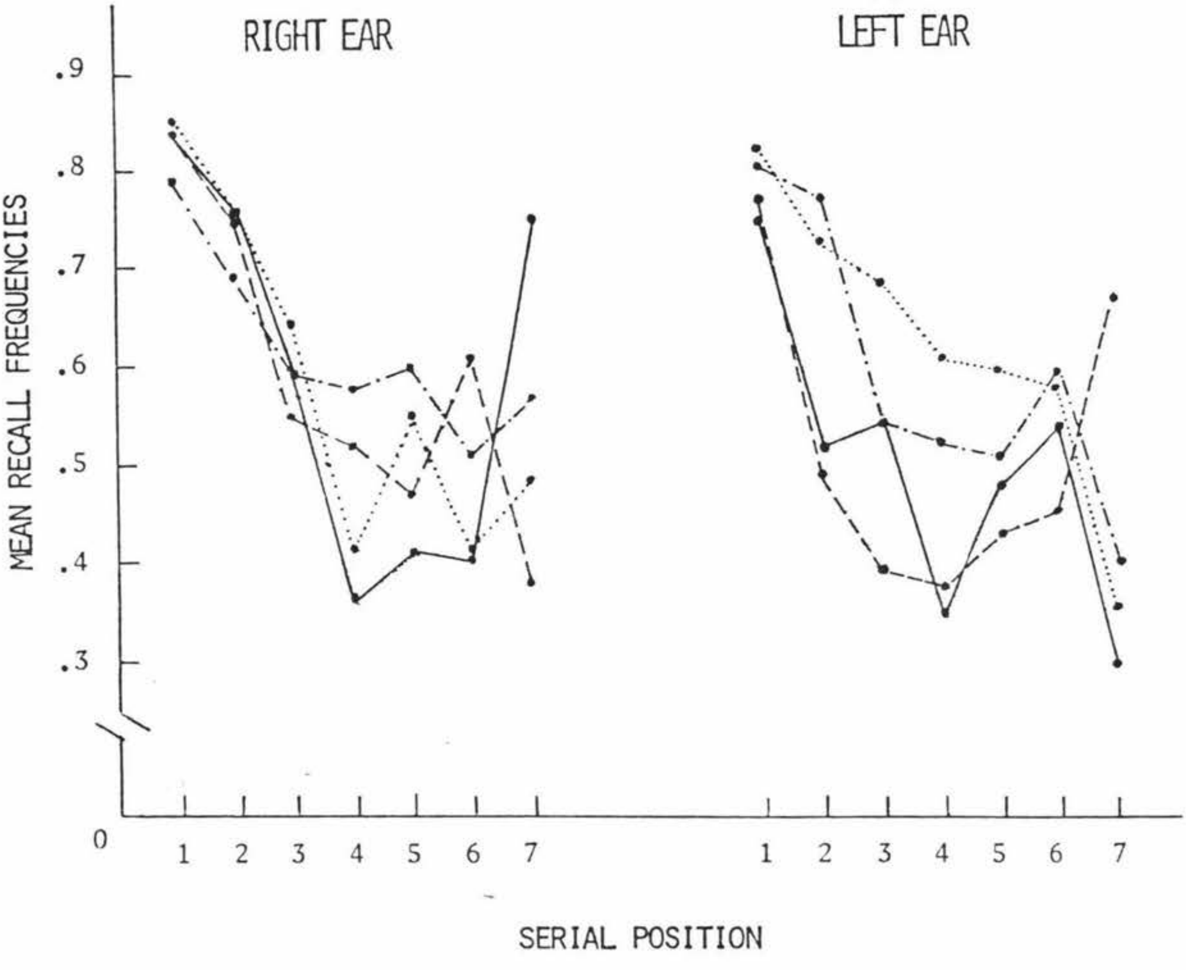

Figure 8. Proportion of words correctly recalled as a function of combinations of word lists and suffixes, serial position, and ear of presentation (•——• abstract list - abstract suffix; •— — —• abstract list - concrete suffix; •—·—·—• concrete list - concrete suffix; •·········• concrete list - abstract suffix).

combinations and serial position for the left ear F (18,360) = 5.24, $p < .01$, and the right ear F (18,360) = 3.44, $p < .01$, is shown in Figure 8. Inspection of Figure 8 reveals the presence of a suffix effect for both ears. This effect was reduced for the right ear when both list and suffix combinations were abstract, and for the left ear when the word lists were abstract and the suffix concrete.

In all cases, except where stated, the higher order interactions from the five and four-way analyses were significant beyond the 0.01 level of significance. In all cases these interactions were studied but were found not to be directly related to the hypotheses under investigation in the present study. In addition the large number of degrees of freedom associated with these interactions generally, did not allow graphical interpretation in terms of the lower order effects.

In summary, the major findings of importance which have emerged from these results are: a) the REA for abstract information; b) the diminished effect of the suffix for abstract information when presented to the right ear; and, c) the reduced effect of the suffix with increasing delay.

DISCUSSION

The predictions made in the hypotheses are supported by the results of this experiment. Firstly, a right ear advantage (REA) for all information (concrete and abstract combined; Fig. 1) as well as a marked REA for abstract information was obtained (see Fig. 2). The REA for all information appears to be due to the superiority of the right ear for the recall of abstract information, particularly since there are minimal differences between the two ears in the recall of concrete information, with the left ear showing only a small advantage as compared to the right ear (Fig. 2).

The findings of REA for abstract information, as predicted in the second hypothesis, concur with Paivio's (1971) dual-trace model which hypothesizes the availability of two coding processes: a system based on semantic storage and a system based on both imagery and semantic storage, with each system functionally related to cerebral asymmetries. According to this model, abstract words are processed solely in verbal or semantic terms, while concrete words can be processed by both (or either) the semantic and imagery mechanisms. Since abstract words are said to be processed solely by the verbal mechanism located in the left hemisphere, the findings of the present study support this explanation for hemispheric specialization. In contrast, however, with concrete word presentation, there was no difference in the number of words recalled by both ears, suggesting that concrete information is not processed by the same semantic mechanism as is abstract information. As both word classes fall into the speech category, and since speech has been found to be processed better by the left hemisphere than the right (eg. Critchley, 1962; Gazzaniga, 1970; Sperry, 1974), REA for abstract information can be regarded as evidence for hemispheric specialization, since abstract information has a more verbal or semantic content.

These findings, thus, provide further evidence for hemispheric specialization and are consonant with studies which suggest that verbal information presented to the right ear is transmitted to, and processed more efficiently by the left hemisphere, than comparable information presented to the left ear connected to the right hemisphere (eg. Curry, 1967; Curry & Rutherford, 1967; Kimura, 1961 b, 1964, 1967, 1973). Further, since information presented to the right ear was processed more effectively than information presented to the left ear, these findings lend support to Kimura's (1961) explanation of hemispheric processing based on the premise that the right ear has stronger connections with the left (speech-processing) hemisphere than does the left ear.

The findings of the present study are also consonant with Semmes' (1968) interpretation that sensory-motor capabilities are more focally represented in the left hemisphere. Semmes' theory is based on, and supports, evidence derived from studies with normal and brain damaged subjects (eg. Bartholomeus, 1976; Milner, 1971; Sperry and Gazzaniga, 1970), as well as those studies involving clinical (eg. Humphrey & Zangwill, 1952; Milner, Branch, & Rasmussen, 1964) and anatomical investigations of cerebral asymmetries (eg. Galaburda et al., 1978; Geschwind & Levitsky, 1968; Keretz & Geschwind, 1971), which suggest that speech is processed better by the left hemisphere.

The results of the present study cannot be adequately explained by either Kinsbourne's (1975) theory of hemispheric competition, or Moray's (1975) theory based on selective attention, as both of these theories are based on dichotic listening experiments. The present study involved the presentation of two types of word categories (concrete and abstract) in monoaural presentation involving no decision-making as would be expected with dichotic presentation. Similarly, as each word category was represented in an identical number of word-lists for each ear of presentation (10 concrete and 10 abstract lists), with subjects being unaware as to which ear the word list would play, any effects due to differences in the materials and mode of presentation were to a great degree averted. In the absence of variables which may have influenced the outcome, such as competitive stimulation (Kinsbourne, 1975; Moscovitch, 1976), the subjects' expectations of target probability (Moray, 1975), and the decision-making requirements of the task (Moray, 1975; Moscovitch, 1976), neither Kinsbourne's, nor Moray's theories are adequate in explaining these findings as are Kimura's (1961) and Semmes' (1968) explanations based on the physiological aspect of hemispheric processing. Further the latter theorists provided explanations which can be related to studies involving both dichotic listening and monoaural presentation paradigms.

Studies involving a visual presentation paradigm (eg. Seamon & Gazzaniga, 1973; Hines, 1976), where a left visual-field advantage for the recognition of abstract words was obtained, offer further evidence in support of the present finding that abstract information is processed more efficiently by the left hemisphere. These findings, as well as those of the present study, are also consonant with those of O'Neill and Paivio (1978) who found a REA for all information in a study involving an auditory recognition paradigm, and with findings by these authors and McFarland et al. (1978) who found a REA for abstract information.

As processing differences were obtained in the present study using a recall rather than recognition paradigm, it appears, contrary to the suggestion by Cohen (1973, 1975 a, b) and Patterson and

Bradshaw (1975), that the response requirements of the task do not influence performance. Further, as monoaural rather than dichotic presentation was employed, without the use of competitive stimulation for subjects to contend with as per McFarland et al. (1978), it is also clear that these processing differences are independent of the type of presentation paradigm used, and the conditions under which stimulus items are presented.

The findings of REA for abstract information in the present experiment, however, do not account for the failure by Borkowski et al. (1965), Jones and Spreen (1976), and Ranquist and Blackmore (1973) to find a REA under dichotic presentation conditions as would be expected if differing processes were involved. As the dichotic mode of presentation is generally found to yield significant left/right ear differences in the processing of concrete and abstract information (eg. O'Neill & Paivio, 1978; McFarland et al., 1978), there is the possibility that the absence of such an effect may be related to the meaningfulness value of the concrete and abstract stimulus words used by these researchers, as smaller or no processing differences may be expected with unclearly defined level of difference between the two word categories. That is, processing differences for these two categories of information may become apparent only if high concrete and low abstract words, as defined by Paivio et al. (1968) 0 - 7 ratings of meaningfulness value, are used.

Bakker (1970), Hellige (1978), Hellige and Cox (1976), and Moscovitch (1976) provide another explanation for the failure of the above researchers to obtain REA for abstract information. These authors suggest that the lack of REA may be the result of overloading, and that differences may become evident only under minimal load conditions. This view is also supported by Norman and Bobrow (1975), Posner (1975), and Schneider and Shiffrin (1977), who found that when a limited category system is required to perform simultaneously, processing performance deteriorates. This explanation would also account for the differences in the results between the present findings and those by the above researchers, as in the present study stimulus items presented were will within the normal ability to remember (7 items per list) thus, effects due to memory load requirements were minimized. Further, with monoaural presentation, unlike dichotic presentation, the necessity for simultaneous processing leading to deterioration in performance is also averted.

A comparison of the results obtained for concrete and abstract word-list and suffix combination and ear of presentation modality, reaffirms REA for all information as well as REA for abstract information, irrelevant of the semantic category of the stimulus suffix item (see Fig. 3). REA for abstract information occurs whether the suffix item is similar to the word-list (abstract) or dissimilar (concrete). Very small differences are evident in terms of recall frequencies between the two ears of presentation with concrete information. These results reaffirm evidence derived from studies which indicate differential hemispheric processing for the two types of information (eg. O'Neill & Paivio, 1978; McFarland et al., 1978).

Separate analysis of the results for each of the two presentation modalities as a function of list and suffix type combinations and serial recall position (see Fig. 8), reveals marked differences in the number of words recalled in the abstract-abstract and abstract-concrete combination conditions respectively for the right and left ear. This marked increase in the number of words recalled in the abstract-abstract condition for right ear presentation, is in accord with Paivio's (1971) dual-trace model which hypothesizes a right ear left hemisphere advantage for abstract information, and supports the hypothesis made in this study that a smaller suffix effect would occur when both list and suffix items are abstract and presented to the right ear. Apart from being based on Paivio's model, this hypothesis was based on the premise that the right ear has an advantage for abstract information as proposed by O'Neill and Paivio (1978) and McFarland et al. (1978). Consonant with the view of REA for all speech information, the right ear showed a marked advantage for the recall of most stimulus list and suffix combinations as compared to the left ear. Of particular importance are the higher recall frequencies of abstract - abstract, and concrete - concrete combinations for the right ear, and the higher recall of the abstract - concrete combinations for the left ear. This finding is consistent with Egeth and Epstein's (1972) suggestion that with verbal stimulus information, the right ear (left hemisphere) tends to be biased towards the perception of sameness, while the left ear tends to be biased towards the perception of difference. However, Salter and Colley's (1977) and Salter et al. (1976) suggestion that the magnitude of the stimulus suffix effect can be affected by the semantic relationship between list and suffix items is only true to a degree. These authors contend that recall is generally higher with synonymic rather than non-synonymic suffixes. In the context of the present results, this explanation can only be applied to results yielded with right ear presentation, as no such effect occurs in the left ear modality.

Analysis of the relationship between ear of presentation and serial position indicates that despite REA for abstract information, the stimulus suffix does affect recall of terminal items in the list for both ears of presentation (Fig. 4). This effect was particularly evident when recall frequencies for both ears of presentation were compared to the recall frequencies in the no-suffix condition. Although, for the latter condition, recall of items followed a typical 'acoustic' curve function (see Control Condition, Fig. 4; Morton & Chambers, 1976; Morton et al, 1971; Murdock, 1974), that is items recalled in the terminal positions approximated the recall frequencies of items in the primary positions in the list, in the suffix condition a depression in the recall scores restricted to the last items in the list occured. Although disruption by the suffix item was restricted to the terminal positions of the word lists for both ears of presentation, the disruption was slightly greater with left ear presentation as compared to right. This greater disruption was however, not significant, and a marked suffix effect occured for both ears of presentation, indicating the independence of the suffix effect on the ear of presentation and its independence of the type of information used for both stimulus list and suffix items. These results provide further support for, and are in accord with Morton et al. (1971) who found a suffix effect with meaningful information, and reported further, that this effect does not depend on ear of presentation.

Comparisons between ear of presentation and delay conditions generally support the prediction of REA for all information (see Fig. 5). This is true for delays of up to 4 secs, where the delay between the stimulus list and suffix presentation had a smaller effect on subjects' recall of items with right rather than left ear presentation. However, in the 8 secs delay condition, a reversal in recall frequencies occured, with subjects recalling more information from left ear presentation, suggesting that there may be some differential processing effects between the two ears as the delays between list and stimulus suffix presentation increase. However, in view that this effect occurs in the last delay condition, not even a tentative interpretation of these results would be in order since it is not possible to predict that this pattern would persist with delays exceeding 8 secs. This effect may be better exemplified with a design involving delays between stimulus list and suffix presentation which exceed the 8 secs utilized in this experiment, such a design may, indeed, yield some interesting results if this pattern of left ear increase persists for longer than 8 secs, for they would indicated that processing differences obtained between the two hemispheres may be a function of delay.

Recall frequencies for all data (left and right ear combined) as a function of serial position revealed that a significant suffix effect had occured under all delay conditions (see Fig. 5). Although recall frequencies for the terminal positions in the list increased as a function of delay, this increase had little influence on the effects of the suffix and was not systematic with delay. The latter finding is contrary to the results obtained by Watkins and Todres (1980) who found that as the delay between the stimulus list and suffix presentation increased so did the number of terminal items recalled.

It is difficult to interpret these results as indicative that some rehearsal had taken place during the delay period between list and suffix presentation as proposed, albeit tentatively, by Watkins and Todres (1980) since if this were the case a systematic increase in the number of terminal items recalled could have been expected to occur as: the longer the delay period between stimulus list and suffix presentation, the longer the rehearsal time available to subjects, therefore the higher the probability that the subject may recall the last items in the list, leading to a systematic increase in the recall frequencies for terminal items.

Watkins and Todres (1980) used their results to hypothesise that the delay period may be used by the subjects as a means for establishing a more durable, suffix-resistent non-echoic memory, one which will persist after echoic memory has faded. However, since the suffix effect is said to be a function of echoic memory (Crowder, 1969, 1971, 1976; Morton, 1969), and further, since echoic memory is said to persist for up to but no longer than 2 secs (Crowder, 1971, 1976;

Morton, 1969), the appearance of a suffix effect with delays exceeding 2 secs, irrelevant of whether the increase in the recall of terminal items is or is not systematic with delay, must be interpreted as indicating that echoic memory persists longer than 2 secs. Thus, in view of the findings in the present experiment, as well as those by Watkins and Todres (1980), the suggestion that echoic memory does not persist longer than 2 secs cannot be equated with findings of a suffix effect with delays exceeding those delay parameters: and, as the suffix effect is said to be a function of echoic memory, these findings must support the assumption (eg. Routh & Mayes, 1974 b; Watkins & Todres, 1979, 1980; Watkins & Watkins, 1980) that echoic memory persists longer than the 2 secs suggested by earlier experiments. Further, since the PAS is said to operate for up to 2 secs, and since the suffix is said to eliminate or overwrite the information from this memory storage for the last item in the list, than one would logically expect the stimulus suffix effect to be more pronounced with shorter delays (i.e. up to 2 secs) than with longer delays since with longer delays the information in PAS is no longer available to the subject. Thus, findings of a characteristic suffix effect with delays exceeding 2 secs can no longer be attributed to PAS but must be interpreted as being the result of echoic memory function.

The PAS explanation of the suffix effect, in view of the present findings, which in accord to those of Routh and Mayes (1974 b), Watkins & Todres (1979, 1980), and Watkins and Watkins (1980) show a suffix effect with delays exceeding 2 secs, must be regarded as inadequate in the present context. Since, however, the design of this study did not incorporate the various delay conditions ranging from no delay to 2 secs, which would have allowed investigation of PAS, no operational interpretation on the properties of PAS is possible.

The pattern of results obtained in this study was interpreted to mean that echoic memory persists for at least 8 secs. This interpretation is in accord with findings by Watkins and Todres (1979, 1980) and Watkins and Watkins (1980) who found a substantial suffix and modality effect with delays of up to 16 and 20 seconds. Since the findings in the present study of a suffix effect with delays of up to 8 secs is well within the period postulated by these experimenters, then these findings support the prediction made in the hypothesis that given that echoic memory persists longer than 2 secs then it should be possible to demonstrate a suffix effect with delays exceeding that period. However, the suggestion for a longer echoic persistence is made with some caution and not without some reservation about the 'true' duration of echoic memory. The differential effect of the stimulus suffix on the terminal items of the lists between the no delay condition and the three delay conditions, with the suffix effect being more pronounced in the former, suggest that echoic memory in its 'total' form may, indeed, persist for up to but not including 2 secs as implied by Crowder (1969, 1971, 1976), and Morton (1969). Evidence for this assumption might have been obtained by incorporating in the present experimental design delays ranging from 0 to 2 secs which would have allowed direct comparison of suffix effects obtained with shorter delays with the longer delays as implemented in the present study.

The decline in the suffix effect with increasing delay, seems to support the common assumption by the above researchers that echoic memory decays relatively rapidly, since the more echoic memory has faded away the less will remain to be erased by the suffix. Equally viable, in view of the above explanation, would be an interpretation which takes into consideration both sets of results, since it is possible that, although echoic memory persists in its total form for up to 2 secs, this memory also endures in an ever weakening form for up to 20 secs, and that the gradual weakening of echoic memory is responsible for the decreasing suffix effects with longer delays. Such an explanation would account for the findings of the present study and those obtained by Watkins and Todres (1979, 1980) and Watkins and Watkins (1980), since in both the latter cases as the delay exceeded 2 secs, the effect of the suffix decreased as compared to the no-delay conditions. Further, this explanation would also account for the paradox which arises from the postulation (eg. Crowder, 1969, 1971, 1976) that the suffix effect is a function of echoic memory, a statement which simultaneously implies that if echoic memory was not involved no suffix effect would occur. Since a suffix effect does occur with longer delays, the results of the present study must be interpreted as evidence that echoic memory persists for at least 8 secs.

From a theoretical viewpoint, Kahneman's (1973) suggestion that the suffix effect may reflect attentional grouping, is not untenable in the light of the present results, since presentation of the suffix item out of rhythm with the stimulus list items, as suggested by Kahneman, might enable subjects to group the suffix separately from the memory list items of the to-be-remembered list, thereby reducing the effect of the suffix. In as much as in the no-delay condition of the present experiment, the stimulus suffix was presented in accordance with the inter-item rate of presentation, and in as much as this condition yielded a more pronounced effect than did conditions where the delay between stimulus list and suffix presentation was longer (and therefore out of rhythm with the inter-item presentation rate), then a conclusion in support of Kahneman's interpretation may be in order. However, since Kahneman's interpretation is based on experiments incorporating a visual presentation paradigm, such a conclusion would fail to take into consideration the modality effect (i.e. the recall advantage for terminal items in a memory list with auditory versus visual presentation), which is said to be a function of echoic memory.

In contrast to Kahneman's explanation, Massaro's (1972) interpretation based on STM, takes into consideration both the modality and suffix effects. While in the former effect information is said to be present in STM, making terminal items accessible for recall, in the latter case the suffix is said to either eliminate the codes constructed for the terminal items in the list or to interfere with the construction of these codes. This explanation has its merits, since it describes both the modality and suffix effects. However, this explanation does not account for the differential effect of the suffix arising from the associative relationship between the stimulus list and suffix items as found by Salter and Colley (1977) and Salter et al. (1976) and which is supported to a degree by similar findings in the present experiment with right ear presentation. Further, it is difficult to equate this interpretation with findings (see Fig. 8) which suggest that the magnitude of the suffix is differentially affected not only by the relationship between the semantic content of stimulus list and suffix items, but also by the ear of presentation modality in as much as the disruption for terminal items for left ear presentation are greater than for right ear presentation.

A separate analysis of these results for left and right ear presentation as a function of delay (see Fig. 7), further support the findings for combined left/right ear presentation data. A marked suffix effect occured for both ears of presentation under all delay conditions. However, the effect of the suffix was more pronounced with left ear presentation, suggesting that REA for verbal information may affect the recall of items even under suffix effect conditions. However, and interesting finding is, that the effect of the suffix is exactly the same for both ears of presentation in the no delay condition.

This effect does, to a degree, support Crowder's (1969, 1971, 1976) contention that echoic memory may persist for up to 2 secs. In the present experiment, the absence of delay conditions incorporating the period between 0 to 2 secs (with the exception of the 0.5 condition), makes it difficult to establish that such an effect would occur under all delay conditions up to 2 secs. However, were such an effect to occur, then one would have to conclude that echoic memory in its 'total' form persists for up to but not including 2 secs. Findings of such an effect would not, however, negate evidence for longer echoic persistence as obtained in the present experiment and related studies (eg. Watkins & Todres, 1979, 1980; Watkins & Watkins, 1980), since as the suffix effect is said to be a function of echoic memory, any evidence of a suffix effect must be necessarily regarded as evidence that some traces of echoic memory persist long after the 2 sec period as implied by Crowder

CONCLUSION

The present study has been primarily concerned with two major areas of research: namely, the concepts of cerebral asymmetry and echoic memory have been investigated. The experimental design used has allowed the integration of elements from two areas of interest to be investigated within the framework of a single experimental design. This approach has had both advantages and limitations. Specifically, this design has allowed the examination of the differential processing of the two hemispheres, the effect of the stimulus suffix on meaningful information, and the nature of echoic memory via the utilization of two semantic categories in a monoaural stimulus suffix presentation modality, over four delay conditions. In addition, the presentation of these two categories of information in four types of stimulus list and suffix combinations, at the various delay intervals, has allowed for further distinctions to be introduced into the analyses of these results.

Overall findings suggest hemispheric asymmetry not only as a function of the verbal information to be processed, but also as a function of the semantic value of these items. The stimulus suffix effect occurs independently of the type of information presented but its magnitude is dependent on the semantic relationship between the stimulus list and the suffix items, the ear of presentation of these items, and the delay conditions between stimulus list and suffix presentation. The findings of this research generally support findings by other researchers in the areas, and suggest that the variables involved are not totally independent of one another, and that the effect of one variable is partially dependent on the level of the other. The design of this experimental study has, however, not allowed the effect of increasing delay as a function of the category of information and ear of presentation to be adequately investigated. An extension of the present study addressed to this question may be of interest.

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APPENDIX A

Word Lists

EXPERIMENTAL SET

C-A = Score on Concreteness-Abstractness Scale

S-L = Syllable length

ASS = Abstract Stimulus Suffix

CSS = Concrete Stimulus Suffix

LEFT EAR PRESENTATION

Concrete 2-S-L Word Lists - No Delay Condition

	Word	C-A			Word	C-A	
1.	rattle	6.60		2.	saloon	6.70	
	damsel	6.58			garden	6.83	
	fabric	6.55			robber	6.25	
	boulder	6.96			pudding	6.63	
	salad	6.83			engine	6.76	
	python	6.42			hurdle	6.65	
	dollar	6.62			clothing	6.63	
	hotel	6.80	CSS		mischief	2.90	ASS

Abstract 3-S-L Word Lists - No Delay Condition

3.	quantity	3.32		4.	distinction	2.20	
	incident	3.00			idiom	3.44	
	reaction	2.93			fantasy	2.03	
	abasement	2.38			happiness	1.94	
	wistfulness	1.83			clemency	1.97	
	magnitude	3.03			deduction	2.94	
	irony	2.10			agony	3.13	
	umbrella	7.00	CSS		intimate	2.03	ASS

Concrete 2-S-L Word Lists - 2-Second Delay Condition

	Word	C-A			Word	C-A	
5.	garments	6.59		6.	sheepskin	6.83	
	moisture	6.24			banner	6.83	
	lobster	6.96			reptile	6.65	
	bottle	6.94			locker	6.96	
	monarch	6.40			pupil	6.63	
	storeroom	6.73			guardhouse	6.69	
	nectar	6.41			college	6.38	
	leaflet	6.62	CSS		hatred	1.59	ASS

Abstract 3-S-L Word Lists - 2-Second Delay Condition

	Word	C-A			Word	C-A	
7.	intellect	1.83		8.	history	3.03	
	vocation	3.26			insolence	1.93	
	inducement	2.34			occasion	3.22	
	disclosure	2.51			jeopardy	2.00	
	quality	2.13			reminder	3.48	
	direction	3.19			misery	2.28	
	gratitude	1.59			illusory	2.03	
	vestibule	6.73	CSS		gaiety	2.15	ASS

Concrete 2-S-L Word Lists - 4-Second Delay Condition

	Word	C-A			Word	C-A	
9.	letter	6.94		10.	river	6.83	
	corner	6.65			barrel	6.94	
	butter	6.96			stagecoach	6.90	
	steamer	6.94			flower	6.96	
	mantle	6.76			metal	6.76	
	elbow	6.94			cottage	6.90	
	mammal	6.31			hardwood	6.90	
	banner	6.58	CSS		forethought	1.83	ASS

Abstract 3-S-L Word Lists - 4-Second Delay Condition

10.	blasphemy	2.88		12.	amazement	2.18	
	distraction	2.35			dalliance	2.83	
	perception	2.33			opinion	2.29	
	evidence	3.45			devotion	1.48	
	exertion	2.88			victory	2.95	
	memory	1.78			attribute	2.00	
	attitude	1.83			vanity	1.77	
	avenue	6.48	CSS		sentiment	1.83	ASS

Concrete 3-S-L Word Lists - 8-Second Delay Condition

	Word	C-A			Word	C-A	
13.	committee	6.35		14.	furniture	6.83	
	passageway	6.28			pianist	6.55	
	cerebrum	6.59			utensil	6.58	
	policeman	6.69			animal	6.78	
	vehicle	6.45			islander	6.28	
	attendant	6.07			caravan	6.15	
	colony	5.87			gallery	6.49	
	avalanche	6.38	CSS		miracle	2.25	ASS

Abstract 2-S-L Word Lists - 8-Second Delay Condition

15.	moral	1.39		16.	hindrance	2.97	
	onslaught	3.34			conquest	3.11	
	passion	1.66			virtue	1.46	
	menace	3.70			method	2.20	
	knowledge	1.56			phantom	2.50	
	limelight	3.06			power	2.73	
	blessing	1.75			instance	2.87	
	apple	7.00	CSS		amour	2.65	ASS

RIGHT EAR PRESENTATION

Concrete 3-S-L Word Lists - No Delay Condition

	Word	C-A			Word	C-A	
17.	barnacle	6.20		18.	orchestra	6.55	
	daffodil	7.00			strawberry	7.00	
	industry	5.76			factory	6.87	
	officer	6.32			belongings	5.85	
	tobacco	6.87			acrobat	6.38	
	fireplace	6.96			elephant	7.00	
	sovereign	5.94			headquarters	5.94	
	alcohol	6.87	CSS		loyalty	1.56	ASS

Abstract 2-S-L Word Lists - No Delay Condition

19.	present	3.88		20.	vigor	2.60	
	pleasure	2.10			context	2.73	
	sadness	2.47			impact	3.73	
	encore	3.62			series	3.88	
	boredom	1.94			foible	3.07	
	glory	1.77			satire	2.33	
	blandness	2.03			deceit	1.66	
	hairpin	6.96	CSS		effort	2.22	ASS

Concrete 3-S-L Word Lists - 2-Second Delay Condition

	Word	C-A			Word	C-A	
21.	prisoner	6.45		22.	thistledown	6.14	
	opium	6.44			gentleman	6.42	
	potato	7.00			lemonade	6.93	
	fisherman	6.52			photography	6.56	
	brassiere	6.96			newspaper	6.56	
	physician	6.59			ambulance	7.00	
	insect	6.80			glacier	1.65	
	musician	6.53	CSS		obsession	2.80	ASS

Abstract 2-S-1 Word Lists - 2-Second Delay Condition

	Word	C-A			Word	C-A	
23.	demon	2.56		24.	fortune	3.82	
	namesake	3.53			heaven	2.75	
	event	3.72			devil	2.13	
	welfare	2.35			figment	1.90	
	amount	3.62			spirit	1.86	
	mercy	1.59			cleanness	3.63	
	savant	3.02			belief	1.55	
	cotton	6.90	CSS		outcome	2.80	ASS

Concrete 3-S-L Word Lists - 4-Second Delay Condition

	Word	C-A			Word	C-A	
25.	racketeer	6.07		26.	volcano	6.83	
	tablespoon	6.90			hospital	6.80	
	scorpion	6.93			wholesaler	6.15	
	cranium	6.45			sonata	5.73	
	revolver	6.96			nursery	6.45	
	building	6.94			mosquito	6.96	
	retailer	5.88			kerosene	6.87	
	property	5.99	CSS		discipline	2.17	ASS

Abstract 2-S-L Word Lists - 4-Second Delay Condition

27.	science	3.05		28.	honor	1.75	
	advice	2.08			panic	2.18	
	crisis	2.81			session	3.62	
	nonsense	1.90			hardship	2.93	
	silence	3.09			malice	1.73	
	upkeep	2.50			moment	2.52	
	rating	2.66			array	3.60	
	cabin	6.96	CSS		concept	1.97	ASS

Concrete 2-S-L Word Lists - 8-Second Delay Condition

	Word	C-A			Word	C-A	
29.	body	6.58		30.	horsehair	6.80	
	blossom	6.62			spinach	6.90	
	headlight	6.90			shotgun	6.96	
	cradle	6.94			meadow	6.69	
	arrow	7.00			casement	6.24	
	mountain	7.00			goblet	6.24	
	chloride	6.28			leggins	6.90	
	forehead	6.93	CSS		chaos	2.50	ASS

Abstract 3-S-L Word Lists - 8-Second Delay Condition

31.	mastery	2.20		32.	gravity	2.56	
	discretion	1.34			sensation	1.99	
	ownership	3.07			bereavement	2.49	
	hankering	1.83			hurricane	2.25	
	comradeship	2.75			agreement	2.93	
	suppression	2.35			diffusion	3.18	
	advantage	2.25			tragedy	2.59	
	performer	6.01	CSS		tendency	1.78	ASS

CONTROL SET

	Left ear Concrete 3-S-L			Right ear Abstract 3-S-L	
	Word	C-A		Word	C-A
33.	grandmother	6.94	34.	bravery	1.93
	instructor	6.45		origin	3.25
	restaurant	6.83		poverty	3.17
	professor	6.52		ignorance	1.75
	piano	6.85		affection	2.18
	admiral	6.35		afterlife	1.77
	abdomen	6.83		betrayal	1.77

	Right ear Concrete 2-S-L			Left ear Abstract 2-S-L	
35.	footwear	6.58	36.	vacuum	3.87
	doctor	6.62		folly	2.63
	maiden	6.10		freedom	1.98
	bullet	7.00		courtship	3.22
	abode	6.31		safety	2.25
	diamond	6.94		humour	2.31
	blister	6.67		gender	2.90

PRACTICE SET

	Concrete 3-S-L No-Delay Condition				Abstract 3-S-L 2-sec Delay Condition		
	Word	C-A			Word	C-A	
37.	falconer	5.59		38.	aptitude	2.60	
	cattle	6.79			fallacy	1.89	
	cobblestone	6.58			perjury	2.70	
	residue	5.72			reflection	3.12	
	tomahawk	6.87			genius	2.76	
	beverage	5.96			interest	2.20	
	instrument	6.25			interim	2.67	
	butterfly	6.93	CSS		competence	1.86	ASS

	Concrete 2-S-L 4-sec Delay Condition				Abstract 2-S-L 8-sec Delay Condition		
39.	landscape	6.20		40.	franchise	3.57	
	slipper	6.94			goddess	3.04	
	hammer	6.96			hearing	3.57	
	baby	6.90			prestige	1.73	
	money	6.43			justice	2.18	
	railroad	6.76			proxy	3.72	
	forrest	6.69			impulse	2.08	
	essence	1.66	ASS		juggler	6.45	CSS

APPENDIX B

Mann-Whitney U-test for differences in rank for abstract and concrete lists based on concreteness-abstractness mean scores for each list.

All scores	All ranks	A ranks	B ranks
6.84	1	1	
6.82	2	2	
6.76	4	4	
6.76	4	4	
6.76	4	4	
6.73	6	6	
6.68	7	7	
6.66	8	8	
6.65	9.5	9.5	
6.65	9.5	9.5	
6.64	11	11	
6.61	12	12	
6.59	13	13	
6.54	14	14	
6.52	15	15	
6.51	16	16	
6.44	17.5	17.5	
6.44	17.5	17.5	
6.33	19	19	
6.10	20	20	
3.02	21		21
2.89	22		22
2.86	23		23
2.76	24		24
2.69	25		25
2.62	26		26
2.57	27		27

(CONTINUED)

2.55	28	28
2.53	29	29
2.52	30.5	30.5
2.52	30.5	30.5
2.42	33	33
2.42	33	33
2.42	33	33
2.34	35	35
2.31	36	36
2.28	37	37
2.21	38	38
2.20	39	39
2.09	40	40

$\Sigma Ra=210$ $\Sigma Rb=610$

$$Ua = nanb + \frac{nb(nb + 1)}{2} - \Sigma Rb$$
$$= 400 + \frac{20(20 + 1)}{2} - 610$$
$$= 400 + \frac{420}{2} - 610$$
$$= 400 + 210 - 610$$
$$= 610 - 610$$
$$= 0$$

$$Ub = nanb + \frac{na(na + 1)}{2} - \Sigma Ra$$
$$= 400 + \frac{20(20 + 1)}{2} - 210$$
$$= 400 + \frac{420}{2} - 210$$
$$= 400 + 210 - 210$$
$$= 610 - 210$$
$$= 400$$

$Ua + Ub = nanb$

$0 + 400 = 400$

$U = 0$

APPENDIX C

INSTRUCTIONS

EXPERIMENTAL CONDITION

"You will hear a number of word lists on tapes. Before playing each tape I will tell you what the last word in the list is. This word will act as cue that the list has ended. When you hear this word you are to begin recall of the words in the list in the same order as you heard them. Ignore the cue word. Your are not required to recall it. Before we begin are you quite sure as to what you are expected to do?"

CONTROL CONDITION

"You will hear a number of word lists on tapes. When the list has ended you are to begin recall of the words in the list in the same order as you heard them. Before we begin are you quite sure as to what you are expected to do?"

APPENDIX D

Frequencies for Recall Responses from Left-Ear Input Given for Each Item in the Word Lists as a Function of Serial Position

Word Lists	Serial Positions 1	2	3	4	5	6	7	Totals
1 CC	19	16	7	10	9	11	8	80
2 CA	19	21	20	18	10	11	5	104
3 AC	17	5	3	10	12	8	11	66
4 AA	13	5	14	3	8	15	8	66
5 CC	19	15	10	9	14	11	6	84
6 CA	18	15	10	9	14	11	6	87
7 AC	14	10	9	7	10	5	9	64
8 AA	13	14	7	13	16	7	4	74
9 CC	17	19	15	18	10	15	12	106
10 CA	17	13	16	11	11	15	8	91
11 AC	18	15	10	4	3	12	17	79
12 AA	18	9	8	7	10	11	8	71
13 CC	13	15	14	20	9	13	8	92
14 CA	15	13	12	10	17	14	11	92
15 AC	13	11	11	10	11	13	19	88
16 AA	19	15	16	6	7	13	5	81
				Total Number of Responses				1325

CC = Concrete Word List - Concrete Stimulus Suffix

CA = Concrete Word List - Abstract Stimulus Suffix

AC = Abstract Word List - Concrete Stimulus Suffix

AA = Abstract Word List - Abstract Stimulus Suffix

APPENDIX E

Frequencies for Recall Responses from Right-Ear Input Given for Each Item in the Word Lists as a Function of Serial Position

Word Lists	Serial Position 1	2	3	4	5	6	7	Totals
17 CC	15	15	12	12	14	15	11	94
18 CA	17	16	14	14	13	11	8	93
19 AC	19	21	15	10	8	9	2	84
20 AA	17	17	5	8	8	8	11	74
21 CC	17	19	10	10	16	9	11	92
22 CA	17	16	15	5	14	8	11	86
23 AC	17	15	11	12	9	13	10	87
24 AA	21	19	19	3	12	8	18	100
25 CC	17	7	16	14	10	8	12	84
26 CA	17	17	9	8	12	10	13	86
27 AC	20	17	11	12	11	17	13	101
28 AA	17	15	14	12	10	7	19	94
29 CC	18	17	12	13	11	11	14	96
30 CA	21	15	16	8	8	6	9	83
31 AC	15	11	10	10	12	13	7	78
32 AA	17	13	12	8	5	11	15	81
					Total Number of Responses			1413

CC = Concrete Word List - Concrete Stimulus Suffix

CA = Concrete Word List - Abstract Stimulus Suffix

AC = Abstract Word List - Concrete Stimulus Suffix

AA = Abstract Word List - Abstract Stimulus Suffix

APPENDIX F

SUMMARY OF ANALYSIS OF VARIANCE FOR THE TOTAL DATA

A = LEFT-RIGHT EAR

B = LIST TYPE (CONCRETE-ABSTRACT WORD LISTS)

C = SUFFIX TYPE (CONCRETE-ABSTRACT STIMULUS SUFFIXES)

D = DELAY CONDITIONS

E = SERIAL POSITIONS

SOURCE	S.S.	D.F.	M.S.	F	
BETWEEN SUBJECTS	1.6091	20			
WITHIN SUBJECTS					
A	1.6091	1	1.6091	14.174	**
ERROR 2	2.2704	20	0.1135		
B	5.3744	1	5.3744	27.079	**
ERROR 3	3.9694	20	0.1985		
AB	3.5376	1	3.5376	21.634	**
ERROR 4	3.2704	20	0.1635		
C	0.0478	1	0.0478	0.398	
ERROR	2.4031	20	0.1202		
AC	0.1125	1	0.1125	0.823	
ERROR 6	2.7313	20	0.1366		
BC	0.0002	1	0.0002	0.003	
ERROR 7	1.4507	20	0.0725		
ABC	0.2604	1	0.2604	2.134	*
ERROR 8	2.4405	20	0.1220		
D	1.2898	3	0.4299	3.157	*
ERROR 9	8.1701	60	0.1362		
AD	2.2098	3	0.7366	4.125	**
ERROR 10	10.7143	60	0.1786		

SUMMARY OF ANALYSIS OF VARIANCE FOR THE TOTAL DATA (CONTINUED)

SOURCE	S.S.	D.F.	M.S.	F	
BD	2.0432	3	0.6811	4.696	**
ERROR 11	8.7024	60	0.1450		
ABD	2.4819	3	0.8273	5.379	**
ERROR 12	9.2279	60	0.1538		
CD	1.4989	3	0.4996	3.157	*
ERROR 13	9.4966	60	0.1583		
ACD	1.3425	3	0.4475	5.104	**
ERROR 14	5.2602	60	0.0877		
BCD	1.5772	3	0.5257	4.607	**
ERROR 15	6.8469	60	0.1141		
ABCD	0.6945	3	0.2315	1.444	*
ERROR 16	9.6224	60	0.1604		
E	61.2343	6	10.2057	18.539	**
ERROR 17	66.0604	120	0.5505		
AE	4.6662	6	0.7777	3.276	**
ERROR 18	28.4855	120	0.2374		
BE	6.8414	6	1.1402	5.768	**
ERROR 19	23.7211	120	0.1977		
ABE	4.4043	6	0.7341	2.758	**
ERROR 20	31.9439	120	0.2662		
CE	3.9418	6	0.6570	3.389	**
ERROR 21	23.2636	120	0.1939		
ACE	8.8295	6	1.4716	6.998	**
ERROR 22	25.2330	120	0.2103		
BCE	0.3227	6	0.0538	0.323	
ERROR 23	20.0077	120	0.1667		

SUMMARY OF ANALYSIS OF VARIANCE FOR THE TOTAL DATA (CONTINUED)

SOURCE	S.S.	D.F.	M.S.	F	
ABCE	6.7768	6	1.1295	6.288	**
ERROR 24	21.5536	120	0.1796		
DE	11.2504	18	0.6250	2.852	**
ERROR 25	78.8835	360	0.2191		
ADE	7.9275	18	0.4410	2.301	**
ERROR 26	68.9821	360	0.1916		
BDE	3.2113	18	0.1784	0.874	
ERROR 27	73.5119	360	0.2042		
ABDE	12.2844	18	0.6825	3.980	**
ERROR 28	61.7245	360	0.1715		
CDE	5.1008	18	0.2834	1.487	
ERROR 29	68.6224	360	0.1906		
ACDE	13.1144	18	0.7286	3.440	**
ERROR 30	78.2517	360	0.2118		
BCDE	12.6416	18	0.7023	3.304	**
ERROR 31	76.5281	360	0.2126		
ABCDE	6.6671	18	0.3704	2.056	**
ERROR 32	64.8597	360	0.1802		

** $p. < .01$

* $p. < .05$

APPENDIX G

SUMMARY OF ANALYSIS OF VARIANCE FOR THE TOTAL DATA (POOLED OVER LIST AND SUFFIX COMBINATIONS)

A = LEFT-RIGHT EAR

B = CONCRETE-ABSTRACT WORD LISTS AND STIMULUS SUFFIXES

C = DELAY CONDITIONS

D = SERIAL POSITIONS

SOURCE	S.S	D.F.	M.S.	F	
BETWEEN SUBJECTS	1.5359	20			
WITHIN SUBJECTS					
A	1.5359	1	1.5359	13.846	**
ERROR 2	2.2185	20	0.1109		
B	5.4241	3	1.8080	13.591	**
ERROR 3	7.9821	60	0.1330		
AB	3.9411	3	1.3137	9.311	**
ERROR 4	8.4651	60	0.1411		
C	1.3884	3	0.4628	3.463	*
ERROR 5	8.0179	60	0.1336		
AC	2.2285	3	0.7428	4.231	**
ERROR 6	10.5349	60	0.1756		
BC	5.1312	9	0.5701	4.067	**
ERROR 7	25.2304	180	0.1402		
ABC	4.4407	9	0.4934	3.792	**
ERROR 8	23.4209	180	0.1301		
D	61.1841	6	10.1973	18.442	**
ERROR 9	66.3516	120	0.5529		

SUMMARY OF ANALYSIS OF VARIANCE FOR THE TOTAL DATA (POOLED OVER LIST AND SUFFIX COMBINATIONS)-(CONTINUED)

SOURCE	S.S.	D.F.	M.S.	F	
AD	4.6263	6	0.7710	3.237	**
ERROR 10	28.25880	120	0.2382		
BD	11.1101	18	0.6172	3.334	**
ERROR 11	66.6399	360	0.1851		
ABD	19.9741	18	1.1097	5.087	**
ERROR 12	78.5259	360	0.2181		
CD	11.2054	18	0.6225	2.862	**
ERROR 13	78.2946	360	0.2175		
ACD	7.9843	18	0.4436	2.317	**
ERROR 14	68.9086	360	0.1914		
BDC	20.7453	54	0.3842	1.889	**
ERROR 15	219.6118	1080	0.2033		
ABCD	32.43.58	54	0.6007	3.201	**
ERROR 16	202.6713	1080	0.1877		

** $p. < .01$

* $p. < .05$

APPENDIX H

SUMMARY OF ANALYSIS OF VARIANCE FOR LEFT EAR DATA (POOLED OVER LIST AND SUFFIX COMBINATIONS)

A = ABSTRACT-CONCRETE WORD LIST AND STIMULUS SUFFIX COMBINATIONS

B = DELAY CONDITIONS

C = SERIAL POSITIONS

SOURCE	S.S.	D.F.	M.S.	F	
BETWEEN SUBJECTS	8.9932	20			
WITHIN SUBJECTS					
A	8.9932	3	2.9977	16.638	**
ERROR 2	10.8104	60	0.1802		
B	2.6361	3	0.8787	5.078	**
ERROR 3	10.3818	60	0.1730		
AB	4.8061	9	0.5340	3.464	**
ERROR 4	27.7474	180	0.1542		
C	26.6352	6	4.4392	14.332	**
ERROR 5	37.1684	120	0.3097		
AC	17.7866	18	0.9881	5.238	**
ERROR 6	67.9099	360	0.1886		
BC	10.2628	18	0.5702	2.641	**
ERROR 7	77.7194	360	0.2159		
ABC	32.1046	54	0.5945	3.003	**
ERROR 8	213.8418	1080	0.1980		

** $p < .01$

APPENDIX I

SUMMARY OF ANALYSIS OF VARIANCE FOR RIGHT EAR DATA (POOLED OVER LIST AND SUFFIX COMBINATIONS)

A = ABSTRACT-CONCRETE WORD LIST AND STIMULUS SUFFIX COMBINATIONS
B = DELAY CONDITIONS
C = SERIAL POSITIONS

SOURCE	S.S.	D.F.	M.S.	F	
BETWEEN SUBJECTS	0.3720	20			
WITHIN SUBJECTS					
A	0.3720	3	0.1240	1.320	
ERROR 2	5.6369	60	0.0939		
B	0.9809	3	0.3270	2.401	
ERROR 3	8.1709	60	0.1362		
AB	4.7657	9	0.5295	4.560	**
ERROR 4	20.9039	180	0.1161		
C	39.1752	6	6.5292	13.562	**
ERROR 5	57.7713	120	0.4814		
AC	13.2976	18	0.7388	3.442	**
ERROR 6	77.2560	360	0.2146		
BC	8.9269	18	0.4959	2.569	**
ERROR 7	69.4838	360	0.1930		
ABC	21.0765	54	0.3903	2.022	**
ERROR 8	208.4413	1080			

** $p < .01$