CEREBRAL LATERALIZATION OF SPANISH-ENGLISH AND ENGLISH-SPANISH BILINGUALS AS A FUNCTION OF PROFICIENCY IN THE SECOND LANGUAGE

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CHAPTER I

INTRODUCTION

Today, many people speak more than one language. The majority of Europeans are bilingual or multilingual; this is also the case for many Latin Americans, Africans, and Asians. Even in the United States, one of the more monolingual nations of the world, there has been a dramatic increase in bilingualism as more of the population speaks a first language other than English. Yet, until recently, research on the organization of language functions in the brain has provided very little insight into the neurological basis of bilingualism.

It is generally accepted, based on evidence collected over the years, that the left hemisphere of the cerebral cortex is dominant for language in most humans. However, this evidence has been collected mostly from the study of monolinguals. There is no special reason to assume that this is the case for bilinguals or multilinguals. In fact, many recent neuropsychological studies (discussed elsewhere in this monograph) have suggested that the language(s) of bilinguals and multilinguals may be organized differently than in monolinguals.

Interest in the neuropsychological aspects of bilingualism dates as far back as the 1860's with aphasiological studies. Such studies, reviewed in Chapter II, have dealt with the patterns of recovery following neurological damage. The group studies of polyglot aphasics showed that although the majority of aphasics recover their languages in proportion to the premorbid skill in each language, many aphasics have patterns of recovery which could not be explained simply on the basis of extent of prior knowledge of the language (Albert & Obler, 1978; Galloway, 1981). That is, some aphasic patients have been known to recover, to some extent, a second or third language while showing minimal to no recovery in their native language (Minkowski, 1928). Thus, differential impairment or recovery led many investigators to postulate that language(s) may be organized differently in the brains of bilinguals and multilinguals. After reviewing the clinical literature, Albert and Obler (1978) also found that multilingual people showed significantly more aphasia due to lesions to the right side of the brain than monolingual aphasics, and that the brains of non-aphasic multilinguals were anatomically different (greater development of third temporal gyrus) than the brains of non-aphasic monolinguals. The authors concluded that there is greater bilateral representation of language in adult balanced bilinguals (equally proficient in both languages) than in monolingual speakers. However, most of the aphasiological studies are based on a case history approach; as a consequence, a large number of studies are anecdotal and scantily documented. Thus, while the clinical case studies of bilinguals suffering from language disruption following brain damage have been significant in isolating factors such as age of second language acquisition, patterns of second language usage, and familiarity with the second language, that may influence the pattern of hemispheric involvement in the language processing of bilinguals, they are of limited value due to the inadequate data bases and weak hypothesis testing procedures. Unfortunately, until recently, these studies provided the only evidence regarding the neurological relationship between the bilingual's two languages.

Experimental studies on the cerebral lateralization of language in normal bilinguals have used a variety of techniques in the study of the language specific and language acquisitional variables that have emerged from the aphasiological studies. However, the results of these investigations (reviewed below) are, at best, both confusing and inconclusive. Some investigators report greater right hemisphere involvement in the language processing of bilinguals (e.g., Sussman, Franklin, and Simon, 1980), others report greater left hemisphere involvement (Carroll, 1980), while still others report no differences in the lateralization patterns of bilinguals (Galloway and Scarcella, 1979; Piazza & Zatorre, 1981). The discrepancy in findings can be in part attributed to limitations of the techniques used to measure lateralization, a failure to specify the criteria used to determine proficiency, the lack of appropriate control groups, and differences across studies in the hypothesis being tested and the experimental paradigm used (Obler, Zatorre, Galloway, & Vaid, 1982). Most of the experimental studies, however, support the conclusion that different languages may be organized differently in the brain of bilinguals, although the nature of this differential organization is not clear.

Investigations of the lateralization of the bilingual brain have implications both for therapy and for second language teaching. If the right hemisphere does indeed play a major role in learning a second language, then perhaps the monolingual aphasics who do not respond to traditional therapy could benefit by learning a second language or perhaps, by stimulating the right hemisphere, aid in the recovery of the patient's usual language functions. Furthermore, if second language learners make use of "right hemisphere strategies", the case could be made for developing a program of second language teaching that emphasizes music, dance, or the use of visual spatial tasks and other such strategies associated with the right hemisphere (Albert & Obler, 1978).

CHAPTER II

LITERATURE REVIEW

The neuropsychological aspects of bilingualism have been investigated from both clinical observations of case histories of bilinguals and multilinguals who suffered from brain damage, and from experimental studies with neurologically intact individuals. Whereas aphasiological studies have looked at the different forms of behavioral and anatomical distinctions between the two or more languages, most of the experimental studies have concentrated on the differential processing strategies used by multilinguals. The experimental literature assumes that the hemispheres differ in the strategies used for processing stimuli, i.e., to the extent that language functions necessitate different strategies, they will engage the hemispheres differently. This chapter will review results from both clinical and experimental investigations and discuss both language specific factors and language acquisitional factors which might contribute to the functional organization of language in the bilingual brain.

Clinical Studies

On the basis of observations from bilingual and multilingual aphasic patients, researchers over the last 25 years have suggested that a second language might be differentially lateralized (less lateralized to the left hemisphere, or even right hemisphere lateralized) in the bilingual as compared to the monolingual. Patterns of language recovery or restitution following the onset of aphasia have been taken as evidence of the neurological relationship between the patient's languages. In 1977, Paradis reviewed over 138 cases that have been reported in the world literature since 1864. In doing so he identified five different modes of restitution of the patients' various languages. In the case of synergistic recovery, the multiple languages recover simultaneously. Synergistic parallel recovery refers to those cases in which all languages are similarly impaired by the lesion and recover at the same rate. Synergistic recovery is considered differential if each language is impaired differently by the lesion, or if they recover at different rates. Paradis (1977) used the term antagonistic to refer to those cases where one language recovers at the expense of a previously recovered language. Successive recovery of languages occurs when one language begins to recover after another language has fully returned. Recovery is selective if one or more languages do not recover at all or remain permanently and severely impaired. Thus, language dissociation in multilingual aphasics has been known to take many different forms. In the present review, however, there will be no distinctions made between subtypes. Instead, all cases of non-parallel impairment or recovery will be regarded as differential.

Many authors have collected and summarized cases of multilingual aphasia available throughout the literature (Albert and Obler, 1978; Galloway, 1981; Paradis, 1977). In many cases, however, these cases represent unusual rather than typical findings. The incidence of differential aphasic patterns in studies of selected cases is between 45-50 percent. Studies of unselected cases, where more systematic approaches were used, report a much lower incidence of differential recovery patterns. Charlton (1964) studied nine bilingual and multilinguals seen at the Neurological Institute of New York. Only two of the nine cases (22 percent) showed differential impairment. L'Hermite, Hecaem, Dubois, Culioli, and Tobouret-Keller (1966) researched eight cases of multilingual aphasia, none of which showed differential impairment or recovery. Nair and Virmani (1973) studied 33 multilingual aphasic patients at an Indian Hospital and found that only two of these patients showed differential loss of capacity in one of the languages. In their review of multilingual aphasia cases, Albert and Obler (1978) examined the relationship between hemisphere of the lesion and recovery patterns. They found that right sided lesions are more likely to result in non-parallel recovery than left sided lesions. Whereas 88 percent of the patients showing parallel recovery had a left hemisphere injury, only 65 percent of the patients with non-parallel recovery had a left sided injury. Albert and Obler (1978) concluded that differential patterns of recovery in bilinguals are the result of a different organization or degree of organization in the right hemisphere.

A few studies have considered the effects of language therapy on the recovery patterns of the languages of multilingual aphasics. Watamori and Sasauma (1978) reported the recovery process of a 65 year-old English-Japanese bilingual aphasic. At the time of the initial evaluation both languages showed similar impairment consistent with Wernicke's aphasia. Following the initial evaluation, the patient received one hour language therapy sessions, four times a week, in English. Watamori and Sasauma (1978) reported that while the receptive processes (auditory and reading comprehension) improved similarly in English and Japanese, the expressive processes (speaking and writing) showed significantly more improvement in English. Freedman (1976) studied a group of bilingual and multilingual aphasics that received three months of speech therapy in Hebrew, one of their non-native languages. The author hypothesized, based on previous experience, that therapy in Hebrew would aid in the recovery of the native language. Results showed that improvement in Hebrew were paralleled with improvement in the patient's native language, although recovery was generally greater in Hebrew.

Polyglot aphasics have also been known to suffer different aphasic syndromes in each language. Albert and Obler (1978) described the case of a Hungarian-born woman who spoke, in addition to Hungarian, fluent English, Hebrew, and French. After undergoing surgery for a glioma in the left posterior temporal lobe, she suffered Wernicke's aphasia in English, Broca's aphasia in Hebrew, and a mixed form of both types of aphasia in Hungarian and French. Wechsler (1977) also reported a case of differential impairment in specific language modalities. After suffering an infarction in the left occipital lobe, Wechsler's patient had alexia (without agraphia) which was worse in his native English language than in French, which he had learned in high school and college. Wechsler concluded that, as far as reading was concerned, "late" language acquisition led to bilateral representation in the brain.

In an attempt to explain the differential language impairment and restitution in multilingual aphasics, Ribot (1882) postulated that the earliest learned language would recover first, irrespective of language proficiency (Ribot's rule). He based his prediction on the belief, from general memory theory, that earlier memories are more stable and therefore more resistant to "morbid dissolutions." According to Ribot (1882), memories are organized in layers based on linguistic primacy. A problem in testing Ribot's rule is that the earlier learned language is usually the most familiar with the most affectively important, confounding these two variables. After reviewing the literature, Pitres (1895) noted that in cases of selective recovery, it was the most familiar language which recovered first, irrespective of order of acquisition. Based on his observations he postulated, in contrast to Ribot (1882), that familiarity, and not primacy, of the languages involved determined the pattern of restitution (Pitres' rule).

Albert and Obler (1978) collected and summarized neurolinguistic information on 108 polyglot aphasic cases that have appeared in the literature in the last century. They correlated personal factors, language history factors, neurological factors, aphasic disturbances, and recovery patterns. Recovery patterns (parallel vs. non-parallel) could be abstracted from only 47 patients. Twenty of these patients showed parallel recovery in all languages, whereas 27 did not. Twenty-five of the patients examined had their most recently used language returns first (Pitres' Rule), whereas this was not the case for 13 people. Ribot's rule predicted recovery pattern in 26 patients, and it was contradicted by 30 patients. Thus, Pitres' rule predicted the pattern of recovery a significant number of times, whereas Ribot's rule failed to hold more often than chance. There were no correlations between Pitres' rule and sex, age of acquisition, or type of aphasia syndrome. However, age, type of lesion, amount of education, and number of languages spoken (multilinguals vs. bilinguals) did correlate with the rule of Pitres. The younger the subjects, the more likely that the rule of Pitres would predict their pattern of recovery. Obler and Albert (1978) suggested that this may be true because of an impairment in short-term memory in older subjects. Those people who had suffered trauma were more likely to follow Pitres' rule than CVA patients. However, patients suffering from trauma tended to be younger than CVA patients. Thus, age and type of lesion were confounded. Educated subjects were more likely to recover their most frequently used language first. Multilinguals were also more likely to follow Pitres' rule than bilinguals.

In their review of aphasia studies, Albert and Obler (1978) also found that younger multilinguals were more likely to suffer from aphasia after right hemisphere lesions when compared to the data from studies with younger monolinguals. The authors took these findings as evidence for the right hemisphere representation of language in younger multilinguals. However, there was no correlation between type of aphasic disorder and age of learning a second language. Results also showed no significant differences in any of the variable studied between polyglots and bilinguals. Finally, as mentioned before, Albert and Obler (1978) found that right sided lesions were more likely to result in non-parallel recovery than left sided lesions.

In general, case studies of recovery from aphasia in multilinguals show a diversity of recovery patterns. Multilingual aphasics also showed a greater percentage of aphasia following right hemispheric lesions (ten percent) than monolingual aphasics (one to two percent). After reviewing the literature on multilingual aphasic cases, Albert and Obler (1978) concluded that the brains of bilinguals and multilinguals are organized differently than the brains of monolinguals.

Patterns of differential language impairment and recovery have also been associated with affective factors. In 1957, Krapf reported the case of an Englishman who had suffered cranial trauma resulting in sensory aphasia. Besides English, he also spoke fluent Spanish. After the trauma, Krapf noted that his comprehension of English was most impaired when his English-speaking wife visited him. Based on this case, Krapf proposed that the first language to be recovered is the one which produces the least anxiety for the patient, provides him with most security, and strengthens his superego. Minkowski (1928) also noted that affective and emotional factors play a role in the differential recovery of languages in aphasic patients. He reached this conclusion after observing several cases of soldiers from central Asia who recovered Russian, their second language, before and better than their native language when recovering in Russian hospitals.

Researchers have also associated language-specific effects with differential impairment/recovery patterns. It has been argued that some languages require different perceptuo-cognitive processes which depend upon separate cortical systems. Thus, different impairment/recovery patterns will result to the extent that the different languages rely upon separate cortical systems (Critchly, 1974; Peuser & Leischner, 1974). Luria (cited in Critchley, 1974) was among the first to suggest that the writing system of a language may affect the degree of disturbance in reading and writing of multilingual aphasics. Writing systems vary from those in which letters, or characters, correspond closely to sounds (phonetic), to those in which letters, or characters, correspond little to none with the sounds (ideographic). Luria (cited in Critchley, 1974) described a 42-year old patient who spoke fluent French, Polish, German, and Russian before being hit by a shell in the left inferior parietal region. Following an operation to remove bone fragments, he showed severe agraphia in French (high sound-grapheme correspondence), whereas only minimal disturbance in Russian (little sound-grapheme correspondence). Support from Luria's contention also comes from research showing differential impairment of *Kana* and *Kanji* in Japanese patients (Sasanuma, 1975; Sasanuma and Fujimura, 1971). *Kana* and *Kanji* are phonetic and ideographic representations of the Japanese language, respectively. Goldstein (1948) added yet another important factor influencing language recovery following brain damage when he stressed the importance of a writing system in language recovery. He proposed that the literary languages (those with a writing system), as opposed to dialects or non-standard forms, are easier to recover because they are used more systematically and consciously.

Goldstein (1948) explained cases of differential recovery of language functions in bilinguals and multilinguals by postulating a switching mechanism. Impairment of this mechanism responsible for switching between the two languages would result in cases of differential recovery. In support of his contention, Goldstein (1948) reported the case of a Swedish woman who would shift from Swedish to English spontaneously, but who could not translate from either language upon command. Jackobson (in DeReuch and O'Connor, 1964) described his own personal experience after an auto accident. Apparently, Jackobson was aphasic for about two hours during which he translated, automatically, every sentence that he spoke into five different languages. However, in his review, Paradis (1977) found that loss of switching ability and inappropriate switching occur irrespective of locus of the lesion. Thus, localization of the switching mechanism has proven to be an impossible task.

After reviewing the clinical evidence from polyglot aphasics, Paradis (1977) concluded that no single factor could explain the different recovery patterns. Instead, he adopted a "multiple factors view", which stated that language restitution patterns are the result of age, order of learning the languages, context and modality of usage, degree of proficiency, affective attitudes towards the languages, site and size of the lesion, and physiological factors.

More recently, differential patterns of impairment and recovery have been associated with different patterns of right hemisphere involvement in first and second language acquisition. Obler (1980) proposed that the right hemisphere is more involved in the early stages of adult second language learning, as opposed to the left hemisphere, which is known to be specialized for language in monolinguals. Galloway (1981) examined both the linguistic competences and limitations of the right hemisphere based on Zaidel's extensive research with monolingual split/brain patients. She concluded that Obler's (1980) stage hypothesis was consistent with findings on the right hemisphere linguistic capabilities. According to Galloway (1981), the right hemisphere shows superior ability to the left hemisphere on tasks which require the formulation of a concept of the whole from fragmentary data, and to grasp the whole without analysis of the parts. Results of studies with hemispherectomy patients suggests that the right hemisphere may cue in perceptually salient content words such as nouns, verbs, and adjectives, and with the aid of contextual information extract global meaning for an utterance from the fragmentary lexical data. Galloway (1981) has suggested that auditory synthesis is a possible strategy for second language performance. She proposed that with the help of contextual and interactional information, a second language performer may attain the global meaning of the second language utterances. Thus, the primary gestalt strategy of the right hemisphere in conjunction with other right hemisphere nonverbal interactional skills are used to understand and use the second language.

If indeed the right hemisphere is more involved in language in bilinguals, one would expect to find a higher incidence of aphasia due to unilateral right sided lesions in bilinguals than in monolinguals. Galloway (1981) compared nearly 300 cases of polyglot aphasia from which she was only able to use 85 (because of insufficient information) to test this hypothesis. She compared polyglot aphasics with a group of 340 American and British monolingual aphasics. Results from the completed studies showed a higher incidence of aphasia due to right sided lesions in the polyglot sample than in the monolingual sample. Whereas 15 percent of right handed polyglots were aphasic after lesions of the right hemisphere, only two percent of the monolingual sample suffered from aphasia after right hemisphere lesions. Two-thirds of the left handed multilinguals suffered from aphasia after right-sided lesions in contrast to one-third of the monolingual left handers. However, because of the large number of females in the samples, sex was confounded. Galloway (1981) pointed out that because females may be more bilaterally represented, the higher incidence of aphasia after right sided lesions in the polyglot sample could have been due to a higher proportion of females. Galloway's results are similar to those of Albert and Obler (1980) and those of Gloning and Gloning (1965). Albert and Obler (1978) in their review of cases found that right hemisphere lesions led to aphasia in ten percent of the cases. However, not all of the ten percent were right handed. The authors concluded that, as compared to the monolinguals, polyglot aphasics have more language representation in the right hemisphere.

Gloning and Gloning (1965) reviewed 11 published cases of polyglot aphasia and added four more cases of their own. They examined the relationship between type of lesion and type of impairment. They concluded that the type of impairment was not associated with damage to a specific brain area. Instead, the authors suggested that polyglot aphasia was an "overlay" to any aphasia occurring as a result of lesions to the speech region. Gloning and Gloning (1965) also found that of the four left handed patients, only three had a right hemisphere lesion. This percentage, according to the author, is lower than that which is reported for monolingual left handed aphasics. Despite the small sample size, Gloning and Gloning (1965), like Albert and Obler (1978), concluded that fluent bilinguals are less strongly lateralized than their monolingual counterparts, and that their non-dominant hemisphere was involved in their language skills.

Galloway (1981) modified Obler's (1978) original stage hypothesis by suggesting that the right hemisphere will be more involved during the initial stages of adult language acquisition provided that this takes place in a natural setting outside the classroom. In her review of the clinical literature, Galloway (1981) was able to identify four cases with sufficient information to test the modified right hemisphere hypothesis. These were cases in which the persons were clearly in the early stages of second language acquisition and for whom the site of the lesion was known. Three of the four cases provided evidence consistent with this version of the stage hypothesis, which suggests that the right hemisphere is more involved during the initial stages of adult second language performance. As Galloway (1981) pointed out, the small sample size and the possibility of alternate explanations make the results inconclusive.

Most right handed monolinguals show larger structures in the language-related areas of the left hemisphere than in the homologous areas in the right hemisphere (Witelson, 1977a, 1977b). Thus, it is possible that, if the right hemisphere were more involved in the language organization of multilinguals, language homologous areas of the right hemisphere would be as large or larger in the right hemisphere than in the left. Albert and Obler (1978) collected four post mortem studies of polyglot brains and found that they were anatomically different than the brains of non-aphasic monolinguals. The brains of non-aphasic monolinguals showed increased development and furrowing in the first, second, or third convolutions which was not present in the monolinguals' brains. This increased furrowing was not necessarily restricted to the left side of the brain. The authors concluded that knowledge of numerous languages develops the brain and may influence cerebral lateralization. However, it has not been demonstrated that anatomical size reflects functional significance. Furthermore, as pointed out by Albert and Obler (1978), the post mortem data were based on gross generalizations and observations.

Summary

In general, studies of polyglot aphasia cases have shown that although parallel impairment and recovery of all the languages is most probable, differential impairment and recovery occurs in many cases. Attempts to explain differential patterns of restitution have demonstrated the importance of language specific factors (e.g., phonetic vs. ideographic orthographies), language acquisitional factors (e.g., language familiarity), and sociolinguistic factors (e.g., affective value) in polyglots recovery after injury (for review see Vaid, 1980).

Clinical studies of polyglot aphasics led to the suggestion that there is differential cerebral involvement in the cognitive functioning of bilinguals. It has been proposed that bilinguals show greater bilateral representation for language in adult balanced bilinguals as compared to monolingual speakers (Albert and Obler, 1978). Support for this theory comes mostly from findings that there is a higher incidence of right sided lesions among bilinguals than monolingual aphasics. It has also been proposed, based on certain non-verbal, interactional communication skills associated with the right hemisphere, that there is greater right hemisphere involvement in the initial stages of adult second language learning (stage hypothesis) (Galloway, 1978, 1981; Obler, 1980). Clinical support for such a contention comes from a small selection in Galloway's (1981) review.

Unfortunately, it is difficult to make generalizations about the cognitive functions of intact bilinguals and polyglots' brains from case histories of aphasic patients. A large number of the cases reported in the literature are anecdotal and scantily documented. Furthermore, variables such as age of acquisition, proficiency and affective value of the languages, which have been suggested to affect patterns of impairments and recovery are, in many instances, confounded. Finally, the clinical techniques are old and lacked the sophistication of the more modern evaluations.

In general, evidence from case studies in the clinical literature supports the possibility of differential cerebral organization in the functioning of bilinguals and polyglots. However, it is not clear the role that the right hemisphere plays in second language learning. The lack of systematic and reliable information from case reports makes results inconclusive.

Experimental Studies

Experimental studies of neurologically-intact multilinguals have focused on language-specific, and language acquisitional factors. Language-specific factors are those properties unique to a particular language that might give rise to differences in patterns of either interhemispheric or intrahemispheric activity independent of the number of languages known to the speaker. Among the language-specific factors that have been studied in the literature are the following: (1) mode of thinking, (2) vowel characteristics, (3) the linguistic significance of tones, and (4) reading habits. Language acquisitional factors refer to characteristics of the language contexts where the languages are learned. These include age of second language acquisition, manner and modality of acquisition, and stage of second language acquisition.

Language-Specific Factors

Modes of Thought

It has been proposed that some languages differ in the degree to which they elicit "appositional" vs. "propositional" modes of thought, and that these different modes may lead to differences in cerebral lateralization. For instance, Carroll (1978) suggested that the Hopi language is appositional in that it creates involvement with the perceptual field causing the listener to attend to the immediate environment. English, on the other hand, was thought by Carroll to encourage the listener to think abstractly and logically, keeping him from attending to his environment. Since the right hemisphere specializes in the perception of Gestalt relationships, it is possible that it may be more involved in appositional languages that utilize holistic thought processes. The left hemisphere, on the other hand, is thought to specialize in the more logical, abstract thought processes that characterize propositional thought. Based on this rationale, Rogers, TenHouten, Kaplan, & Gardiner (1977) predicted greater right hemisphere participation in the processing of Hopi language (appositional) than for the processing of English (propositional). In their study, the authors monitored EEG activity to measure hemispheric participation in 16 bilingual Hopi-English children while listening to taped folk stories in Hopi and in English. Results showed greater alpha desynchronization, indicating greater activation, over the right hemisphere for listening to Hopi than English stories. Rogers et. al. (1971) concluded that there is greater right hemisphere participation in the processing of Hopi speech. However, there were several limitations to their study: order of language learning was not controlled, the two languages differed in their functions, with Hopi used at home and the community and English used in the classroom, and stories were not equated for such factors as content, concreteness or level of interest.

The Navajo language shares similar characteristics with the Hopi language, and is also considered to elicit a greater appositional mode of thought (Critchley, 1974). Scott, Hynd, Hunt, & Weed (1979) tested the hypothesis that processing Navajo requires greater right hemisphere involvement than the processing of English. Scott et. al. (1979) used a dichotic listening task to present 30 pairs of consonant vowel (CV) syllables to 20 Navajo subjects and 20 Anglos. The authors predicted that Navajo subjects would recognize a significantly greater number of dichotic stimuli presented to the left ear (right hemisphere) than to the right ear as compared to matched Anglo subjects. As predicted the Navajo subjects showed a greater left ear advantage while the Anglo subjects showed a right ear advantage in free recalling the dichotically presented words.

Hynd and Scott (1980) also found differences in the processing of dichotic stimuli between Navajo and Anglo subjects. In one of their studies the authors found a significant right ear advantage for CV syllables in adult acculturated Navajo subjects as well as in the matched Anglo controls. However, there were no significant differences in ear scores between the two groups. Neither unacculturated Navajo-English bilingual adults nor children showed evidence of right hemisphere dominance for the CV syllables. Anglo controls, on the other hand, showed left hemisphere dominance for the same stimuli.

Carroll (1978) studied bilingual Navajo-English subjects that differed in degree of acculturation. The subjects were dichotically presented with Navajo and English words simultaneously to both ears and their task was to report all the words heard. The mean score across all subjects showed a right ear advantage for the processing of both English and Navajo words. However, paired *t*-tests on the ear difference failed to reach significance. Carroll (1978) concluded that bilinguals are less lateralized for the processing of language. Unfortunately, the results of Carroll's (1978) study are equivocal with respect to acculturation since findings varied depending on the acculturation measure used. According to one measure the somewhat acculturated Navajo-English bilinguals showed a significant right ear advantage, whereas with the other measure the same subjects showed no ear advantage.

Thus, although there is no constant evidence that either the Navajos or the Hopis, as a group, are either less lateralized or have more right hemisphere involvement for language, there is evidence suggesting that as they become more acculturated to the Anglo society, their left hemisphere appears to become more dominant for language.

Reading Habits

Some investigators claim that the visual field asymmetry in the processing of verbal information by multilinguals does not reflect cerebral laterality effects, but instead reflects directional and post-directional scanning mechanisms that develop from reading habits (Heron, 1957). Kershner and Jeng (1972) tested 40 Chinese bilingual subjects (20 right-eye dominant and 20 left-eye dominant) for their recall of Chinese and English words. The stimulus words were presented tachistoscopically under conditions of simultaneous and successive presentation. Chinese subjects showed a right visual half-field superiority for verbal stimuli under both simultaneous and successive presentation, and a left visual half-field superiority for nonverbal stimuli presented successively. Right-eyed dominant subjects reported correctly more English and Chinese words than left-eyed dominant subjects. Left-eyed dominant subjects, on the other hand, reported more correct geometric forms than right-eye dominant subjects. The authors concluded that the study supported the validity of the psychophysiological model of asymmetrical cerebral functioning while demonstrating the importance of eye dominance.

As early as 1953, Mishkin and Forgays performed a series of experiments to investigate the accuracy of tachistoscopic recognition of words as a factor of left and right peripheral field of vision. One of these experiments consisted of tachistoscopic presentation of English and Yiddish words to bilinguals. The subjects were all native speakers of English who had learned to read Yiddish (proficiency not reported). The stimulus words were randomly presented to either side of the fixation point. The subjects' task was to read the words aloud. Subjects showed a significant right field advantage in recognizing the English words and an insignificant left field advantage for the recognition of Yiddish words. Since Yiddish words are read left to right the authors concluded that reading trains the left hemiretina selectively and leads to differential patterns of hemispheric involvement. However, Orbach (1953) found visual field effects to be different for English-Yiddish bilinguals than for Yiddish-English bilinguals.

While the former showed a significant right visual field superiority, the latter showed a significant left visual field superiority for Yiddish words. Orbach (1953) suggested that the scanning effect of the first language overrides that of the second language if the two are in conflicting directions. Orbach (1967) replicated the same study with Hebrew-English bilinguals. This time, while the English was better recognized in the right visual field, no significant recognition differential was obtained using Hebrew words.

To minimize the effects of the horizontal presentation of words on the differential recognition of verbal material presented to the right and left of the visual field, Barton, Goodglass, and Shai 91965) examined the cerebral laterality effect in English-Hebrew bilinguals by presenting them with alphabetical material in a vertical orientation. They hypothesized that subjects would show right visual field advantage for both English and Hebrew words after controlling for directional scanning tendencies. Subjects for their experiment were 20 Hebrew-English bilinguals, and ten monolingual English speakers. As predicted, their data showed that all the subjects had a significantly greater right visual field advantage regardless of the language. However, a control group of Hebrew-English bilinguals was not included in the study.

Gaziel, Albert, and Obler (1978) investigated the effects of handedness, history of bilingualism, bilingual proficiency, verbal and non-verbal materials, and the effects of vertical and horizontal presentation in the visual field preference of Hebrew-English bilinguals for visual stimuli. A total of 54 subjects between the ages of 17-30 participated in the study. Subjects were divided into groups according to their knowledge of Hebrew and English (American, Israelis, and balanced bilinguals), and their handedness. A self-assessment scale was used to determine knowledge of the two languages. Stimulus items (words and digits) were presented tachistoscopically. The subjects' task was to press a button when the stimulus appeared in the stimulus list previously shown to them. American bilinguals showed an insignificant tendency towards a left visual field advantage for Hebrew horizontal words and a significant right visual field advantage for Hebrew vertical words. The same subjects showed an insignificant right visual field tendency for English words presented horizontally and a significant left visual field advantage for English words presented vertically. Israeli bilinguals, in contrast to American bilinguals, showed no difference between the two visual fields for English words presented horizontally and almost no difference between the visual fields for English words presented vertically. Balanced bilinguals showed an insignificant right field effect for English words presented horizontally and almost no difference between the two visual fields for English words presented vertically. Whereas American bilinguals showed an insignificant right field effect for numbers presented both horizontally and vertically, balanced bilinguals showed an insignificant left visual field effect for both vertical and horizontal presentation.

Because the authors did not see a reverse pattern of field effect for Hebrew and English stimuli, Gaziel et. al (1978) concluded that reading habits are not the sole factor responsible for the right visual field effect. However, they also concluded that cerebral dominance was not the only factor determining visual field differences. In order to better evaluate the relative influence of reading habits and cerebral dominance, the difference between the two visual fields under both kinds of presentation (vertical and horizontal) were compared for all kinds of stimuli. They concluded that in the condition of horizontal presentation, reading habits and cerebral dominance are operating together. The same effect also exists in the vertical presentation but is less significant than in the horizontal presentation. In summary, bilinguals whose languages are read in opposite directions may have different patterns of visual field asymmetry for each language. This pattern, according to Gaziel et. al. (1978) reflects an interaction of directional scanning tendencies and cerebral laterality. Proficiency and order of language learning are also important factors in that they may act to reinforce certain scanning effects.

Tone Languages

Van Lancker and Fromkin (1973) studied laterality differences in speakers of tonal vs. non-tonal languages. Speakers of Thai, a tonal language, demonstrated a right ear advantage for both tone and consonant words, while hums showed no ear effect. English speaking subjects, in contrast, showed the usual right ear effect for consonant-words, and no ear effects for either tone words or hums. The authors concluded that pitch discrimination is left lateralized when the pitch differences are linguistically processed. However, only native Thai speakers were tested. Thus, whether the same effect of tonality would also arise in non-native Thai speakers remains to be seen. In a subsequent study, Van Lancker and Fromkin (1978) found that Thai speakers had a right ear preference for pitch contrasts which are linguistically significant in their language, but showed no ear advantage for the same pitch contrasts occurring in a nonlinguistic context. American English speakers showed no ear advantage for the same pitch contrast despite musical training. Thus, these studies suggest that tones may be processed differently by the brain depending on whether they are linguistically significant for the language or not.

Vowel Characteristics

Tsunoda (1971) proposed that vowels of different languages may be processed in different hemispheres. He compared Japanese monolinguals to speakers of various Indo-european languages. Using a delayed auditory feedback method to measure laterality differences, Tsunoda found that while monolingual speakers processed vowels in the left hemisphere and pure tones in the right hemisphere, Western subjects processed both vowels and pure tones in the right hemisphere. Tsunoda (1971) also reported that the performance of bilinguals, all of whom were non-native speakers of Japanese, paralleled those of the western monolingual sample. However, the fact that subjects were not systematically tested with stimuli from both languages, and that the proficiency in the second language was not objectively assessed, limits any firm conclusions drawn from the study.

Uyehara and Cooper (1980) compared the performance of Japanese speaking and English speaking subjects using Tsunoda's (1971) procedure. Results were contrary to those predicted by Tsunoda (1971). No differences were found between the two language groups, ears, or tone vs. vowels. Neither Japanese nor English subjects showed a right ear advantage for tone when subjected to an analysis similar to Tsunoda's (1971).

To summarize, thought patterns, reading habits, tonality, and the salience of vowels have been postulated to affect the pattern of cerebral lateralization of bilinguals and second language learners. To the degree that these language specific factors require different perceptual and cognitive processes, they may engage the hemispheres differently. Although limited, the research evidence suggests that such factors may indeed influence language processes and the pattern of hemispheric involvement in bilinguals.

Language Acquisitional Factors

Age of Second Language Acquisition

The neural organization of a second language may differ from that of the first language if the two languages are acquired successively rather than simultaneously (Genesee et al, 1978; Sussman, 1980; Vaid & Lambert, 1979). Differences in the state of the brain maturation during first and second language acquisition may give rise to different patterns of cerebral lateralization. Thus, the effect of neurological age and cognitive maturity have led to the prediction that the pattern of hemispheric involvement in bilinguals will more closely resemble that of monolinguals of the same age the earlier the second language acquisition occurs, and will differ from monolinguals the later second language acquisition occurs (Vaid, 1980).

Genesee, Hamers, Lambert, Mononen, Seitz, and Stark (1978) investigated the processing strategies of three subgroups of adult bilinguals with different histories of language acquisition: bilinguals who were exposed to French and

English since infancy, bilinguals who learned the second language at about five years of age, and adolescent bilinguals who learned the second language at secondary school age. Subjects in Genesee's et. al. (1978) experiment were required to indicate, by pressing a response button, whether each of a series of words, presented monoaurally, was French or English. While the subjects performed the experimental task, left and right evoked potentials activity was monitored. The authors measured latency to the N1 peak (75-150 msecs), latency to the P2 peak (175-250 msecs), and N1-P2 peak-to-peak amplitude. Results showed that whereas infant and childhood bilinguals showed shorter latencies to N1 in the right than in the left ear (faster left hemisphere processing), the adolescent group showed shorter latencies in the left as compared to the right ear suggesting faster right hemisphere processing. In addition, whereas there were no reaction time differences between the groups, the N1 latency was shorter for the adolescent group than for the other subgroups. The authors concluded that there were differences in processing strategies between the adolescent group and early bilingual groups (infant and childhood bilinguals). The adolescent group was thought to rely more on right hemisphere gestalt-like or melodic strategies, while early bilinguals relied more on left hemisphere based, possibly semantic or analytic type of strategy. Unfortunately, results from Genesee's et. al. (1978) study are limited in that they used a small sample size, and failed to use monolingual controls.

Vaid and Lambert (1979) took these factors into account and replicated Genesee's et. al. (1978) results using an auditory version of the Stroop test. They investigated the processing strategies of two bilingual groups: an early bilingual group who became bilingual before age five, and a late bilingual group who became bilingual after age ten. Stimuli for the experiment consisted for the words "high" and "low" and their French equivalents. Each of the words was recorded in a high pitched voice and a low pitched voice for a total of eight possible stimuli. In one condition, subjects were instructed to differentiate low from high pitches, disregarding meaning. In the second condition, subjects were to disregard pitch and respond to word meanings. The stimulus words were presented twice to each ear, with language of stimulus randomized. Subjects responded by pressing a button with their index finger to indicate either the pitch or meaning of the words. Reaction times were taken as a measure of task interference. Results showed significant right ear semantic interference (slower reaction times) for early bilinguals and monolingual controls. However, both early and late bilinguals processed meaning more rapidly in the right cerebral hemisphere and pitch equally rapidly in both hemispheres. Results also showed significant sex differences. Female monolinguals appeared to be less lateralized than male monolinguals for both speech and meaning. The authors concluded that there are hemispheric differences in processing strategies between males and females, early and late bilinguals, and bilinguals and monolinguals in general.

Sussman, Franklin, and Simon (1982) used a concurrent verbal/manual task to test the age hypothesis with subjects of a variety of language backgrounds (English, German, Spanish and French). The task required that the subjects finger-tap while engaging in different kinds of language production behavior: reading out loud passages translated into each of the languages, describing a picture, and reciting automatisms such as saying your name, and counting from one to 20. Subjects were considered early bilinguals if second language acquisition was prior to age six. Late bilinguals had acquired their second language after age six. Results showed that early bilinguals experienced more interference in tapping with their right than with their left hand while concurrently speaking in either their first or second language. Late bilinguals, however, experienced greater right hand than left hand disruption during concurrent speech only in their first language. Late bilinguals showed equivalent disruptions for right hand and left hand tapping while speaking in their second language. The authors concluded that the acquisition of a second language after the native language acquisition leads to greater symmetry of language representation in the brain.

This hypothesis failed to be supported in a concurrent activities study with Portugese-English bilinguals (Soares, 1984), and a tachistoscopic study with the same group of subjects (Soares & Grosjean, 1981). Soares' (1984) subjects were a group of Portugese-English bilinguals who first came into contact with English after age 12, and group of English speaking monolinguals. Bilingual subjects were required to engage in finger tapping while performing the following tasks: talking, reading aloud, and silently reciting automatisms and thinking. The bilinguals performed each task in both Portugese and English, while the monolinguals only performed them in English. Results showed that both bilinguals and monolinguals experienced greater levels of disruption in finger tapping with the right hand than with the left hand while engaging in tasks that required overt speech reproduction. The results were similar for the silent reading and thinking condition except that the overall reduction for finger tapping was significantly lower than for the overt production activities. In a study with the same group of subjects, Soares and Grosjean (1981) used a tachistoscopic word-reading task to examine the effects of bilingualism on hemispheric language dominance. The stimuli were 40 English nouns of medium to high frequency and their Portugese translations. The subject's task was to read the stimulus word as fast as possible. Results showed that both monolingual and bilingual speakers had similar levels of left hemisphere advantage for language. There was no evidence of a greater degree of symmetry in the bilinguals. Thus, both Soares (1984), and Soares and Grosjean (1981) studies showed no lateralization differences across either the bilingual's two languages, or between bilinguals and monolinguals.

Gordon (1980) studied English-Hebrew bilinguals with a dichotic listening test which required subjects to recall the words and digits presented binaurally through earphones. Results showed no differences in the lateral dominance between the first and second language. Lateral dominance was the same regardless of pattern of language usage, proficiency, or sex of the subjects. However, native English speakers who had learned Hebrew after puberty but did not understand it well, according to their own self-rating, showed more reversals in ear preference than any other group. This group lived in, and was learning Hebrew in a Hebrew environment. Furthermore, they did not differ in their overall performance in their native English from the English bilinguals that knew Hebrew better, which suggests that the lower laterality was related to their limited language ability in Hebrew.

In summary, the studies reviewed above suggest that the language lateralization for early bilinguals is similar to that of monolinguals. The data on the effects of late second language acquisition, however, are not so clear. While some studies found greater right hemisphere processing of the second language (Genesee et al., 1978) or less lateralization of language in late bilinguals (Vaid & Lambert, 1979), other studies have found the same pattern of lateral dominance for late bilinguals and early bilinguals or even monolinguals (Gordon, 1980; Soares, 1984).

Manner and Modality of Second Language Acquisition

The manner and modality of second language acquisition has also been studied in relevance to cerebral organization. It has been suggested that there is greater left hemisphere language involvement in the second language than in the first language of adults who are consciously monitoring their performance and applying the second language grammar (Krashen, 1979). Others have hypothesized that there would be greater left hemisphere contribution to the second language than to the first language in adult second language learners who have primarily a reading or writing knowledge of their second language (Wechsler, 1976).

In accordance with these hypotheses, Carroll (1978), in her dichotic listening study with American students studying Spanish in a formal classroom situation, found a significantly greater right ear advantage for words in Spanish (second language) than for English (native language). Data from subjects who were exposed to a 24 hour immersion program in a formal acquisition environment showed no differences in ear advantage between Spanish and English.

Gordon (1980) also found significantly greater laterality for the second language (English) than for the first language (Hebrew) of English-Hebrew bilinguals tested with a dichotic word test. The subjects in Gordon's study had learned English after puberty in school and had spent little time speaking or listening to English.

Albert and Obler (1978) found a greater right ear advantage for English (second language) than for Hebrew (first language). The Israeli subjects in this study had learned English as a foreign language in school where, according to the authors, there was an emphasis on reading skills as opposed to auditory skills. The native English speakers who were acquiring Hebrew in Israel (informally) showed no difference in ear advantage for either English or Hebrew. However, results from studies that have found no difference in laterality between the first and second language (e.g., Gordon, 1980; Walters & Zatorre, 1978) or greater right hemisphere participation in the second language (e.g., Orbach, 1953; Sussman et. al., 1980) would be inconsistent with these hypotheses.

Although results from these studies suggest that the manner and modality of second language acquisition influences the language lateralization in bilinguals, the same studies have also been interpreted as indicative of a greater bilateral representation of language in adult, advanced second language speakers who are in a second language environment (Galloway, 1981). Lower overall language laterality in bilinguals has also been reported in studies by

Sussman, Franklin, and Simon (1982), and Walters and Zatorre (1978), discussed elsewhere.

Stage of Second Language Acquisition

Current psycholinguistic research indicates that second language learners rely more on content than on function words, prosodic rather than phonetic features, and linguistic information in context rather than in isolation (Krashen, 1979). Second language learning is also characterized by the extensive use of verbal routines and formulaic utterances (Scarcella, 1979; Wong-Fillmore, 1979). These language components are consistent with right hemisphere capabilities (Blumstein and Cooper, 1974; Searleman, 1977; Surif, 1974). Zaidel (cited in Campbell, 1982) described the functions of the right hemisphere as follows:

> When a skill or task is new, sometimes the right hemisphere is superior, and this superiority shifts to the left hemisphere when the skill becomes entrenched, better acquired; more conscious, perhaps.
>
> The right does seem to be the one which specializes in processing new information. That's speculation, but it does capture in a single generalization the result of a collection of studies that are available in the literature.
>
> When you present a new symbol to someone, and he has to learn new associations between visual symbols and linguistic material, the right brain is dominant in the beginning. But as he becomes more familiar with the system, the action moves over to the

left brain. Now why that is, is not clear. Perhaps because the right hemisphere provides the context for the new information through its rich associative network (p. 251).

Thus, the aphasiological evidence suggesting greater right lateralization, or weaker left lateralization, together with the apparent compatibility between the right hemisphere processing of language and the strategies adopted by beginning language learners has led to the prediction that the right hemisphere may be more involved during the initial stages of second language performance. The stage hypothesis makes two predictions regarding the lateralization of the bilinguals two languages: (1) that there would be no lateralization differences between the first and second languages in proficient bilinguals, and (2) that the second language would appear more right lateralized in non-proficient bilinguals when compared to their first language, and to the first language in the proficient bilinguals and monolinguals.

Support for the first prediction comes from studies that have found an equivalent right ear advantage or right visual field superiority for both languages of proficient and advanced speakers of the second language. Hammers and Lambert (1977) tested the stage hypothesis with a group of 15 French-English bilingual adults. The subjects were considered equally proficient in both languages (balanced bilinguals) as determined by speed of reaction in a color naming task, global judgment by native speakers of French and English, acquisition before age ten, and personal usage reports. French and English words were tachistoscopically presented to either the left or right from a central fixation point. The subject's task was to press a key when an English word appeared on the screen and a different key when a French word appeared on the screen. The results showed that subjects identified French words as fast as they did English words. Results also showed that bilinguals recognized the language of a word faster when presented to the right visual field than they did when presented to the left visual field regarding of the language of the stimulus. However, three of the 15 subjects in the experiment showed a left visual field effect for both French and English, and two subjects a right visual field effect for English, and a mild left visual field effect in French.

In another tachistoscopic study Walters and Zatorre (1978) also found evidence in support of the stage hypothesis. Subjects for their experiment were 13 native English speakers who had learned Spanish as a second language, and 10 native Spanish speakers who had learned English as a second language. The subjects were considered balanced bilinguals based on a test of reading comprehension, speed of reading, and pronunciation. The experimental task was to report the stimulus words at each side of the fixation point. All the subjects did the task in their native language first. Walters and Zatorre (1978) found a left visual field advantage for the processing of both languages regardless of which was learned first. The mean recognition scores for both groups combined were 7.7 words for the right visual field and 5.4 words for the left visual field. The authors compared the number of bilinguals showing a right hemisphere advantage to a sample of monolinguals subjected to the same procedures. They found significantly more variability in the number of bilinguals showing the expected asymmetry, as compared with the monolinguals. The authors concluded that although both languages of balanced bilinguals tend to be equally lateralized, there may be a trend toward less asymmetry in bilinguals. Unfortunately, Waters and Zatorre (1978) did not control for age of exposure to the second language.

A study by Barton, Goodglass, and Shai (1965), although primarily concerned with investigating other variables (reading scan habits and ocular dominance), proves relevant to the stage hypothesis. Barton et. al. (1965) investigated the effects of reading habits on cerebral lateral dominance on a group of 20 adult, balanced Hebrew-English bilinguals, and ten monolingual English speakers. bilingual subjects were tachistoscopically presented with Hebrew and English words to the left or right of the fixation point. Monolingual speakers were only tested in the English condition. All the subjects showed a significantly greater right visual field advantage regardless of language (despite the fact that the Hebrew, unlike English, is read from left to right), as predicted by the stage hypothesis.

Soares and Grosjean (1981) examined the effects of bilingualism on hemispheric language dominance, while controlling for sex, handedness, and language proficiency. The subjects for the study were ten male Portugese English bilinguals who first came into contact with English after age 12, and ten English speaking monolinguals. Bilingual subjects were determined to be equally proficient in both languages by scores on a reading test, a naming task, and their own rating of overall proficiency. Forty English nouns and their Portugese translations were tachistoscopically presented to the subjects. The experimental task consisted of reading the words out loud as fast as possible. Reaction times to words presented in the right visual field were faster than for words presented in the left visual field for both groups regardless of the language of the words. Furthermore, there was a significant correlation (r=.61) for the lateralization levels of the bilinguals two languages.

Studies of proficient bilinguals who learned their second language in adolescence, however, contrary to predictions of the stage hypothesis, reported less left hemisphere participation in the second language as compared to the first language (Hynd, et. al., 1980; Sussman et. al., 1980). Sussman, Franklin, and Simon (1980) compared bilinguals from several different language backgrounds (English, German, Spanish, French, and Portugese) to a monolingual English speaking group on a verbal-manual interference paradigm. All of the bilinguals were considered fluent in both languages based on self report measures. Index-finger tapping rate was measured during three different language production tasks: (1) reading aloud, (2) describing a picture, and (3) reciting automatisms (e.g., saying your name, counting from one to ten). Each task was performed in both languages. Results showed lesser asymmetries (smaller differences between left hemisphere and right hemisphere disruption rates) for bilinguals as compared to monolinguals. Bilinguals, when performing in their second language, showed increasingly higher left hand disruption rates across tasks as compared to monolinguals who showed a consistently greater tapping decrement for the right hand. The bilingual subjects' performance during their native language and second language tasks was also contrasted. Whereas right hand disruption levels were equivalent for bilinguals' first and second languages performance, left hand disruptions were markedly less for second language performance.

Mishkin and Forgays (1952) tachistoscopically presented English-Yiddish words to native English speakers who had some knowledge of Yiddish. Yiddish words are written from right to left. Subjects showed a significant right visual field preference for English words and a non-significant left visual field preference for Yiddish words. The authors concluded that reading trains limited regions of the left hemiretina selectively. However, Mishkin and Forgays (1952) pointed out the subjects had poorer reading facility in Yiddish than in English; therefore, it is unclear whether the differential proficiency brought about the differential lateralization.

In 1953, Orbach expanded Mishkin and Forgays (1952) study to include two groups of Yiddish-English bilinguals: one group learned English first, and the other group learned Yiddish first or both languages simultaneously. All the subjects were considered equally proficient in both languages. Orbach (1953) tachistoscopically presented English and Yiddish words to one or the other visual field. The results showed that English words were better recognized in the right visual field (M=15.53 right field, M=8.18 left field), whereas Yiddish words were not significantly better recognized in either visual field (M=9.90 right field, M=9.54 left field). Subjects who had learned English as a first language, as in the Mishkin and Forgays (1952) study, showed a significant right visual field advantage for both English and Yiddish words. Subjects who had learned Yiddish first or both languages simultaneously showed a left visual field superiority for Yiddish words (reverse tendency). English scores were not reported. Like Mishkin and Forgays (1952), Orbach (1953) interpreted the results in terms of differential perceptual organization resulting from early reading habits.

Another possible explanation is that the characteristics of Yiddish induced right hemisphere dominance when it was learned as the first language. English, on the other hand, when learned as a first language induced left hemisphere dominance for all subsequent language learning.

In 1967, Orbach performed another tachistoscopic study of differential recognition patterns for Hebrew and English words. Subjects for this experiment were native Israeli students at the Hebrew University who had been required to learn English from the fifth or sixth grade, and were considered proficient speakers of both languages. Hebrew and English words were tachistoscopically presented to the left or right of the fixation point. The subjects were to report the words or letters that they recognized as quickly after the exposure and possible. Results showed that subjects identified English words significantly better in the right side of the fixation point regardless of sex or handedness. Hebrew words, however, were significantly better recognized in the right visual field by right handers, and in the left visual field by left handers. Orbach (1967) pointed out some differences between the English and Hebrew languages in order to explain the results. First of all, the Hebrew alphabet consists of letters which are less differentiable than English letters. There is also less redundancy in the spelling of Hebrew than English words. According to Orbach (1967), English words are much more polarized in the right-to-left direction than Hebrew words. That is, it is possible to identify an English word by seeing only the first and the last letters of the word than it is for its Hebrew counterpart. Finally, Orbach (1967) pointed out that the Hebrew reader does get a certain amount of practice reading material from left to right. He concluded that directional scanning, selective attention, cerebral dominance, and structural factors all influence visual field preferences.

To summarize, the evidence regarding the first prediction of the stage hypothesis, that, in proficient bilinguals, the left hemisphere is dominant for language functioning is inconclusive. Although some of the studies reviewed found support for this prediction (Barton, et al., 1965; Hamers & Lambert, 1978; Soares & Grosjean, 1981; Walters & Zatorre, 1978), others did not (Hynd et al., 1980; Orbach, 1963, 1967; Sussman et al., 1980). Several studies have suggested more right hemisphere involvement in the second language of proficient bilinguals; that is, more right hemisphere involvement in the final stages of second language learning (e.g., Orbach, 1953; Sussman et al., 1980).

Eight studies are relevant to the second prediction of the stage hypothesis, namely, that the first language would appear more lateralized to the left hemisphere than the second language during the early stages of second language acquisition.

In a tachistoscopic study with Israeli students in the seventh, ninth and eleventh grade who were studying English as a foreign language, Gaziel, Obler, Benton, and Albert (1977, as reported by Galloway & Krashen, 1978) found support for the second prediction of the stage hypothesis. Results showed greater right hemisphere processing of English (second language) at the early stages of language acquisition. Right hemisphere participation was found to decrease with exposure and proficiency in the second language. That is, whereas a significant number of students in the seventh grade showed a left visual field advantage, somewhat fewer numbers showed such advantage in the ninth grade, and most showed a right visual field advantage in the eleventh grade.

In a similar study, Silverberg et al. (1979) investigated the lateralization of visual and verbal material to Israeli adolescents in their second, fourth, and sixth years of study of English as a second language. The children were tested by means of a target-word recognition task. They were required to press a switch as soon as possible upon recognizing the target word flashed on the screen. Laterality scores indicated a left visual field preference for English words for children in their second year of second language learning. This advantage decreased with increasing proficiency, becoming a right visual field preference in the oldest group. All subjects showed a significant right visual field advantage for Hebrew words. Although the results are consistent with the stage hypothesis, it is possible that, since the Hebrew children were only exposed to English in a school setting, and mostly through reading, the right hemisphere advantage for English is limited to the initial stages of learning to read. To test this possibility, Silverberg et. al. (1980) studied the visual and auditory lateralization of Hebrew words in Israeli children learning to read their native language. None of the children spoke or read another language. There were 24 second grade students (age seven) and 24 third graders (age eight). Second graders showed a left visual field preference for tachistoscopic words, whereas third graders showed a right visual field preference for the same words. When similar words were presented dichotically, all children showed right ear dominance. Silverberg et. al (1980) suggested that the word stimuli were relatively unfamiliar to the second graders who could not read well, and consequently resulted in poor recognition of the left hemisphere relative to the specialization of this ability in the right hemisphere. Oral presentation of the words resulted in left hemisphere advantage because of the right hemisphere's inability to make grapheme to phoneme connections.

Hynd and Scott (1980) examined the possible developmental trends or effects in the establishment of differential cerebral lateralization using Navajo children of two different grades (second and fifth), and comparable groups of monolingual children. Anglo children were matched according to sex, chronological age, and handedness at two different age levels. All of the children were administered 30 pairs of dichotically presented (CV) syllables. The task was to report either one or both of the stimuli heard. While the Navajo children recognized the stimuli faster when presented to the left ear, the Anglo children showed the expected right ear advantage. Results also showed a significant developmental trend. That is, Navajo fifth graders showed a greater left ear advantage than second graders. Anglo children also showed increased lateralization with age, but it was left hemisphere lateralization.

Gordon (1980) examined laterality differences in Hebrew-English bilinguals with different histories of age of acquisition, years of language use, and proficiency levels. The subjects for the study were native speakers of English who later learned Hebrew, native speakers of Hebrew who later learned English, and native speakers of both English and Hebrew. Proficiency was determined by a self-rating scale. Subjects were dichotically presented with digits followed by words in both English and Hebrew. The task was to write down what they heard through the earphones on a special response blank. Results showed that there were no laterality differences between Hebrew and English for any subject group regardless of language background (age of acquisition, language environment or usage). It was also found that a high lateralization (R-L/R+L) in one language was coupled with a high lateralization in the other language. There were no significant differences in laterality as a factor of age of acquisition; however, there was a nonsignificant trend toward lower laterality of bilinguals who have acquired their second language after puberty. Subjects showed nearly the same laterality regardless of the number of years speaking the second language. Length of usage, however, does not necessarily reflect proficiency. There was a non-significant difference in the degree of lateralization between the groups of subjects who rated themselves as having a low proficiency in the second language and those who rated themselves as high proficiency. However, there was a trend towards lower lateralization in the less proficient group. There were no significant sex differences. Finally, there was a right ear superiority for both native English and Hebrew. The authors concluded that the second language of a bilingual is lateralized to the left hemisphere to the same extent as his native language. In general, cerebral dominance was the same for each language no matter when the second language was learned, how long it had been used, or how well it was know.

However, as Gordon (1980) pointed out, there are hints in the data that the right hemisphere did contribute to semantic processing as suggested by trends towards lower laterality in both languages. This was especially true for those subjects who had learned Hebrew after puberty but still did not understand it well, according to their own rating. These subjects were also described as using

Hebrew frequently because they were living and learning Hebrew in a Hebrew environment. Because the groups did not differ in overall performance in their native English from the English groups that knew Hebrew better, nor did it differ on tests of non-verbal function, it suggests that their lower laterality was due to their reduced proficiency in their second language. However, the comparable native Hebrew speakers who learned English after puberty and rated themselves as low in proficiency (<5 in a scale 1-10), did not show the same reversal in performance, perhaps contributing to the non-significant differences. Gordon (1980) suggested that three major differences between these two groups may have accounted for the results. First, the Hebrew group used English less because they were in a Hebrew speaking environment. Second, it is possible that because the groups used different referent points for comparison, the self ratings did not have the same meaning. That is, the native English speakers, since they compared themselves to the native Hebrew speakers, were more likely to rate themselves lower than native Hebrew speakers who compared themselves with other Hebrew speakers who also spoke English as a second language. Finally, the subjects differed in how they learned their second language. The native English speakers learned Hebrew in Israel in intensive language courses. The native Hebrew speakers, on the other hand, learned English in school in Israel and used it rarely.

Albert and Obler (1978) ran a set of dichotic listening tests on 72 adult Hebrew-English bilinguals: 22 balanced bilinguals (had learned both languages before age 12 and judged themselves equally fluent in both), 24 English speakers who had "fair" knowledge of Hebrew, and 24 Hebrew speakers who had "fair" knowledge of English. In the first half of the experiment, the subjects were dichotically presented with words and numbers in both Hebrew and English. In the second part of the experiment, subjects heard a thread of English words in one ear and a thread of Hebrew words in the other ear. The subjects knew in which ear to expect each language. The word pairs were of different types: one-third of the word pairs were minimally contrasted with part of one word only available in one of the languages, one-third of the word pairs had contrasts occurring in both languages, and one-third of the word pairs contained no contrastive segment. The task for both halves of the experiment was to write down all the words heard in any order. Results showed that all three groups showed a right ear advantage. However, there was a difference between the balanced group and the two dominant groups. The balanced group showed a greater degree of lateralization for Hebrew (consistent right ear advantage for Hebrew), whereas English was almost bilateral. For both the American dominant and Hebrew dominant subjects, English was the strongly lateralized language. Thus, it is not clear whether something about Hebrew results in being more bilaterally represented (a language specific effect), or whether learning a second language results in its being differently lateralized than the first language.

When completing language stimuli were presented to both ears, Hebrew was better processed by the right hemisphere in both balanced bilinguals and the English dominant group. At the time of publication, the tests had not been run in the Hebrew dominant group. These data are consistent with the notion that Hebrew is more bilaterally represented than English. The data on different word pairs indicated that the discrimination of sounds occurs in the left hemisphere.

The largest left-right difference for both balanced bilinguals and English-dominant subjects was between words that contained sounds that occurred only in Hebrew. Albert and Obler (1978) concluded that both language specific effects and second language effects contribute to dominance patterns.

Piazza and Zatorre (1981) also found evidence contradicting the second prediction of the stage hypothesis in a dichotic listening task with two groups of children enrolled in bilingual education classes. The mean age of the younger group was nine years, while the mean age for the older group was 13 years. Both groups of children spoke Spanish as their first language, but were at two different stages of learning English. Subjects were dichotically presented with 60 word pairs in each language. Their task was to write down the words they heard. All of the children showed a significant right ear advantage for the processing of Spanish, as well as English. Furthermore, the total number of correct words did not correlate with the ear difference scores suggesting a possible interdependence between degree of lateralization and language proficiency. The authors concluded that the left hemisphere is primarily and equally involved in the processing of both languages of bilinguals. However, since there was no independent measure of overall proficiency, the results have limited generality.

Using a dichotic listening task, Carroll (1978) studied 54 adults enrolled in beginning, intermediate, and advanced Spanish classes. Contrary to stage hypothesis predictions, he found no significant right hemisphere advantage in the processing of Spanish at any of the three proficiency levels studied. Instead, he found a reliable left hemisphere advantage in the processing of the second language as compared to the processing of the first language, especially for the advanced learners of Spanish. In order to determine the effects of age of first exposure to the second language and learning environment on the mode of processing the second language, an analysis of variance was completed by dividing the subjects into four groups differing in exposure, age and setting. The results showed that those subjects with prior, although limited, exposure to Spanish in a home environment before age six had either a very low degree of left hemisphere lateralization or right hemisphere dominance for Spanish. In contrast, subjects who were first exposed to Spanish in Latin America (naturalistic setting) after age 18, showed the same degree of lateralization as classroom learners. Finally, in an attempt to relate lateralization to language performance, Carroll (1978) estimated proficiency by subtracting the total words recalled in Spanish from the total words recalled in English. Subjects who were exposed to Spanish at home before age six showed the greatest proficiency followed by the subjects who were exposed to Spanish in a naturalistic setting. Subjects with no prior exposure to Spanish showed significantly less proficiency. Carroll (1978) concluded that early exposure, even when it is minimal and there is little use of the second language, may be important to later success and produce a different type of language learning.

Hardych, Tzeng, and Wang (1978) postulated that the lateralization differences found in most experiments reflect a memory process occurring after subjects have learned all the stimuli presented. In an attempt to test this hypothesis, the authors conducted four experiments utilizing tachistoscopic presentations of Chinese and English nouns to visual half fields. Subjects were eight Chinese and English proficient bilinguals (the authors did not report how it was determined that they were proficient). All subjects had learned their second language after age five. The experimental task was to respond "yes" or "no" if the Chinese and English words had the same meaning. The experiments differed only in the ratio of trials to experimental stimuli. No lateralization effects were found when new stimuli were presented on each trial which suggested to the authors that active ongoing cognitive processing is independent of lateralization. The authors concluded that the left hemisphere superiority found in most lateralization studies reflect the lateralization of memory processes and not general cognitive processes.

A modified version of the stage hypothesis was proposed to try to account for some of the inconsistencies in the data (Krashen & Galloway, 1978; Galloway & Krashen, 1980; Galloway, 1981). This modified version suggests that there may be greater right hemisphere contribution to second language performance in adults who are in the initial stages of acquiring a second language in an informal, natural language setting outside the classroom. According to the proponents of the modified version of the stage hypothesis, after a higher degree of language fluency is obtained, the left hemisphere comes to control the second language.

As such, the modified version of the stage hypothesis gives rise to the following predictions: (1) the first and second languages of advanced speakers of a second language should be equally lateralized to the left hemisphere, and (2) the first language would be more left lateralized than the second language in adults who are acquiring the second language in an informal, natural setting, and who are not consciously monitoring their performance with learned second language rules (i.e., classroom learning). According to Krashen (1979) conscious language learning involves the use of grammatical rules in second language performance. Formal language acquisition is characterized by contexts in which there is an emphasis on the structure of language. Such an approach may lead to an awareness of language as a rule governed system. Informal language acquisition, which requires participation in a naturalistic setting, directs the learner toward content and contextual information, the processing of which is consistent with that of the right hemisphere. Since the left hemisphere is usually associated with the processing of sequential information this would suggest that there would be more left hemisphere involvement in second language learning in a classroom setting. Because in some cases there may be more conscious use of rules than for the first language, this hypothesis would also predict greater lateralization of a second language than the first language in adults who are acquiring the language in a classroom setting. Thus, the modified version of the stage hypothesis allows a greater parallel with first language acquisition. It has been suggested that there is greater right hemisphere contribution in early first language acquisition and that as the child begins to learn the grammar and the rules governing the language, the left hemisphere becomes dominant for language function (Witelson, 1977). Others suggest, however, that left lateralization for language occurs at birth or before (Wada, Clarke, & Hamm, 1975).

To test the revised stage hypothesis Galloway and Scarcella (1982) conducted a dichotic listening experiment with Mexican-born men who were acquiring English informally in Los Angeles. She predicted a greater right ear advantage for Spanish words than for English words. The subjects were 32 right handed Mexican-born males. These men had never received formal instruction in English, but were acquiring English informally at a work situation or from people in the streets. There were two monolingual control groups: a group of monolingual Spanish speakers, and a group of monolingual English speakers. Galloway presented subjects with two dichotic listening tapes, one in Spanish, and one in English. Each tape contained 20 word dyads. The subjects were required to repeat the words heard. Results from the study failed to provide evidence in support of the stage hypothesis. The second language acquirers showed a significant right ear advantage in both their languages. This right ear advantage was not significantly different from the right ear advantage shown by monolingual English speakers.

In their study with Israeli children learning to read their native Hebrew, Silverberg et al., (1979) found evidence supporting the modified version of the stage hypothesis. Israeli second and third graders showed a significant right ear advantage in their native Hebrew. However, a tachistoscopic study with the same groups of children showed a shift of visual field from right to left over time. This suggests right hemisphere involvement in acquiring reading skills (early stage) of native language learning.

Bentin (1981) tachistoscopically presented Hebrew and English words to Israeli children (12-13 years old) with basic knowledge of English. According to the author, the subjects experience with English was limited to classroom-related activities. Contrary to prediction of the modified version of the stage hypothesis, results showed a significantly greater right hemisphere preference for Hebrew words and no preference for English words.

To conclude, four studies have produced evidence suggesting no differences in the lateralization of first and second languages of adult balanced bilinguals or advanced second language learners (Barton, Goodglass, & Shai, 1965; Hammers & Lambert, 1977; Soares & Grosjean, 1981; Walters & Zatorre, 1978). This evidence is consistent with predictions of both the original and the modified version of the stage hypothesis. The second prediction of the stage hypothesis, that the left hemisphere is less involved in the processing of a second language in non-proficient bilinguals was supported by three studies (Gaziel et al., 1978; Hynd & Scott, 1980; Silverberg et al., 1979), and refuted by four studies (Albert & Obler, 1978; Carroll, 1978; Gordon, 1980; Piazza & Zatorre, 1978). Thus, the evidence regarding these predictions is contradictory and, therefore, inconclusive.

The revised stage hypothesis predicts that the first language should appear more left lateralized than the second language in adults who are acquiring a second language in an informal naturalistic setting. Evidence supporting this prediction comes from studies by Bentin (1981) and Silverberg et al., (1979). The only study that has directly tested this prediction (Galloway & Scarcella, 1982), however, has failed to provide evidence in support.

The lack of evidence in support of either version of the stage hypothesis should be considered in light of certain factors. First, many of the studies reviewed failed to specify the criterion used to determine proficiency, and others used subjective judgments which may or may not have any validity. Second, even if proficiency were accurately assessed, the studies varied widely in levels of second language proficiency, which could have obscured the results. Finally, the failure to find the predicted differences could rest on the testing procedures, especially since ear or visual asymmetries may be influenced by factors other than degree of cerebral lateralization.

Summary

Recently, there has been an increase in research attempts to determine the neurological organization of language in bilinguals and second language learners (for reviews see Galloway, 1981; Vaid & Genesee, 1980). Clinical studies have mostly dealt with patterns of recovery following aphasia in bilinguals and polyglots. Although the majority of multilingual aphasics lose and recover their languages in direct proportion to the premorbid skill in each language, many aphasics have shown patterns of recovery which cannot be explained on the basis of prior knowledge of the language. Several explanations have been proposed to account for differential recovery patterns. These include age of second language acquisition, affective factors, language usage patterns, and degree of prior skill, among others. No single rule has been able to predict the patterns of recovery in all the individual cases. Autopsies of the brains of some polyglots have shown different patterns of cerebral anatomy when compared to the brains of nonaphasic monolinguals. Evidence from the clinical literature led many researchers to postulate differential patterns of hemispheric specialization for the bilingual's two languages. Obler (1978) suggested that there is a greater bilateral representation of language in adult balanced bilinguals than in monolingual speakers. However, the role of the right hemisphere in second language acquisition cannot be concluded from these studies. The lack of systematic and reliable information from the clinical cases makes generalizations or even comparisons among the different cases difficult.

Experimental studies with intact individuals have used a variety of techniques including tachistoscopic and dichotic presentation of words and concurrent verbal/manual tasks. While the results of some of these studies have shown the typical left hemisphere advantage for the processing of language, others have shown a greater degree of right hemisphere involvement in second language processing. Several theories have emerged about the nature of the organization of language in the bilingual brain. Two types of factors, language specific and language acquisitional, have been implicated in the pattern of cerebral lateralization of second language performers. These two factors represent characteristics of the languages and of the contexts in which the languages are learned. Among the language-specific factors investigated are language related modes of thinking, the salience of vowels, the linguistic significance of tones, and reading habits. Language acquisitional factors include manner, stage, and age of second language acquisition. In general, the experimental studies suggest that different languages may be organized differently in the brain of bilinguals, but that the cerebral lateralization of each language may be influenced by many different factors including age, manner, and modality of second language acquisition, and proficiency in the second language.

Thus, the literature on the lateralization of language is highly contradictory. While some studies report differences in lateralization between bilinguals and monolinguals, others have found no such differences. Unfortunately, many of the experimental studies and the majority of the clinical reports suffer from any methodological problems.

As mentioned before, most studies investigating language processing in bilinguals have used dichotic listening or visual tachistoscopic presentation as part of their experimental paradigm. Both of these techniques have severe limitations. First, the levels of processing assessed by these tasks (e.g., word recognition, word identification, language recognition) are artificial and unlike those found in natural language use. Second, both tachistoscopic and dichotic listening tasks measure mostly perception (visual or auditory), without taking into consideration productive abilities. Thus, further studies should use as an index of laterality a task that more closely resembles real life language processing.

In addition, many tachistoscopic studies have failed to control or did not report a number of variables that may affect language lateralization (eye fixation, stimulus duration, and size of the stimulus). As far as dichotic listening is concerned, the temporal alignment of the stimuli is crucial. A lag in the presentation of a word or set of words in one ear could cancel or interact with ear advantage. Finally, the reliability and validity of dichotic listening tasks may affect comparisons across subject groups and languages. Because bilinguals may simply use different language strategies for each language, bilinguals may be less reliable than other groups if they are more proficient in one language than another.

Many of the bilingual laterality studies reviewed failed to specify the criteria used to determine proficiency and many others have used subjective judgments of little face validity to assess proficiency. Further, many studies have confounded proficiency with age of second language acquisition (Albert & Obler, 1978). The proficient bilinguals have sometimes acquired both languages during early childhood, as opposed to the non-proficient bilinguals who began second language learning in adulthood. Since age of acquisition of a second language has been also associated with differential lateralization, it is difficult to assess what factor is responsible for the results.

Task differences have also varied widely among studies. In many cases, it is not clear that the levels of processing accessed by the different tasks are equal. Whereas some studies have used perceptual tasks that involve recognition or recall, others have required actual production of the language. Finally, the stimuli used for the studies have also varied widely. Stimuli have differed with respect to length, frequency, grammatical class, and abstractness, among other things.

The range of methodological parameters used by many bilingual lateralization studies have made comparisons among studies virtually impossible. Thus, the question of the neurological organization of language in bilinguals and multilinguals remains far from being answered.

CHAPTER III

STATEMENT OF THE PROBLEM

Obler (1980) proposed that the right cerebral hemisphere is more involved during the early stages than in the advanced stages adult of second language learning. The results of studies that have investigated the stage hypothesis appear conflicting and are not directly comparable. As mentioned before, these studies also suffer from many methodological deficiencies and as a consequence have failed to provide a good test of the hypothesis; therefore, they are of limited generality. Thus, the purpose of the present study is to evaluate the stage hypothesis with Spanish-English and English-Spanish bilinguals after taking into consideration the following methodological issues.

In the past, investigators of the stage hypothesis have failed to specify the criterion used to determine proficiency, or have used a subjective judgment (the experimenter's opinion) to assess level of proficiency. This study addresses the question of proficiency by using a cloze test (discussed later), a valid and reliable procedure, to measure the global proficiency in the second language of the subjects in the study. On the basis of scores in the cloze test, subjects were classified into those having low, medium, and high proficiency.

Lack of appropriate controls has also been a problem in the past. The present study included two control groups: a very low proficiency English speaking group, and a very low proficiency Spanish speaking group. Although these groups had been exposed to English or Spanish as a second language, their knowledge of it was minimal. No group of truly monolingual native Spanish speakers could be found in Stillwater, Oklahoma. Thus, both native Spanish speakers with minimal knowledge of English as a second language and native English speakers with knowledge of Spanish as a second language were used in the study.

Finally, probe auditory evoked potentials were used to measure hemispheric involvement. This method involves the recording of brain responses (evoked potentials) to a well defined repetitive yet irrelevant stimulus (probe) during the performance of a cognitive task, in this case, processing verbal passages. It assumes that the area of the brain most involved in processing the task will have less neuronal systems accessible for processing the concurrent irrelevant probe stimulus. Thus, larger amplitude evoked potentials to the probes will be recorded from the hemisphere least involved in processing the ongoing stimuli. The probe paradigm allows the measurement of hemisphere activation during the processing of natural spoken language rather than single words presented auditorily or visually. The probe evoked potential method has been used successfully to study hemispheric differences to verbal and non-verbal information in monolingual subjects (Papanicolaou, 1980; Shucard, Shucard, & Thomas, 1977; Thomas & Shucard, 1983a, 1983b). It has also been successfully used in investigations of lateral dominance for arithmetic vs. visuospatial tasks (Papanicolau, Schmidt, Moore, & Eisenberg, 1983), and the selective processing of linguistic vs. affective cues (Papanicolau, Levin, Eisenberg, & Moore, 1973). These studies showed, in general, that such factors affect differential hemispheric functioning and that the probed evoked potential method is a sensitive index of differential hemispheric electrophysiological activity. In addition, the probe evoked potential method has been applied to a wide variety of areas and experimental situations from the study of attention and distraction to the study of reading disabilities and recovery from aphasia. After reviewing the literature on probe evoked potentials, Papanicolaou (1984) concluded that it is a powerful analytic technique that offers major advantages for the study of complex processes such as reading and information processing.

In the present study, tone probes were superimposed on English and Spanish verbal passages. A baseline condition in which the tone probes were presented with randomly occurring, task relevant clicks, served as a control. Previous studies using auditory evoked potentials with monolingual English speakers have found higher monopolar AEP amplitudes in the right hemisphere for the processing of verbal information, and higher monopolar AEP amplitudes in the left hemisphere for the processing of music. No such laterality effects (amplitude difference between hemispheres) have been found for the baseline condition (Shucard, Cummins, Thomas, & Shucard, 1983b; Shucard, Shucard, & Thomas, 1977). Thus, results from these studies support findings that the probe evoked potential technique is sensitive to the differential hemispheric engagement during ongoing information processing.

The original stage hypothesis makes two predictions in this context: (1) that there will be no lateralization differences between the first and second language of the proficient bilinguals, and (2) that the first language of non-proficient bilinguals will appear more left lateralized than the second language. In accordance with the stage hypothesis, it was predicted that the medium proficiency groups will show greater amplitude responses over the left hemisphere (the less engaged hemisphere) during the processing of the verbal passages in the second language as compared to a greater amplitude of response over the right hemisphere during the processing of the passage in the subjects' native language. In contrast, the high proficiency groups should show a greater amplitude response from the right hemisphere during the processing of both languages. That is, first and second language of the advanced bilinguals should appear equally lateralized. It was also predicted that the low proficiency group would demonstrate the expected left hemisphere asymmetry in the processing of their native language. Since both groups have only minimal knowledge of a second language, they should react to the second language task in a way similar to the baseline condition and show no differences in amplitude between the left and right hemisphere response to tone probes.

CHAPTER IV

METHOD

Subjects

Subjects for the experiment were 48 volunteers, 25 males and 23 females, recruited from O.S.U. Spanish classes, the English Institute for International Students, and the local community. All subjects were right handed, had no known hearing deficits and no known cerebral lesions. The subjects were divided into six groups of eight people each, according to their knowledge of English and Spanish: (1) native English speakers with minimal knowledge of Spanish (F = 3, M = 5); (2) native Spanish speakers with minimal knowledge of English (F = 5, M = 3); (3) native English speakers with medium proficiency in Spanish (F = 6, M = 2); (4) native Spanish speakers with medium proficiency in English (F = 4, M = 4); (5) native English speakers that are highly proficient in Spanish (F = 2, M = 6); (6) native Spanish speakers that are highly proficient in English (F = 3, M = 5). In order to control for age of acquisition, only bilingual subjects who learned their second language after puberty (age 13) were used in the study. Proficiency in the two languages was ascertained by a Cloze test.

Materials

Language Background Questionnaire

A language background questionnaire was given to the subjects before the study in order to ascertain characteristics in language usage and preference (see Appendix A). These included age of second language acquisition, length of second language usage, and manner of second language learning. It also asked for personal data regarding sex, age, and place of second language acquisition, and any presence or history of hearing deficits or cerebral lesions. Included as part of the language background questionnaire was the Edinburgh Handedness Inventory (Oldfield, 1971) to assess the degree of handedness of the subjects. Only right handed subjects participated in the study.

Cloze Test

The cloze procedure was developed in 1953 by W. L. Taylor as a measure of the readability of prose. He used the term "cloze", an intentional corruption of the verb "to close" to denote the natural psychological tendency to fill in grammatical and semantic patterns. Since the cloze technique was developed, it has been used in numerous situations, not only with native speakers, but with non-native speakers as well.

A cloze test is constructed by deleting every *n*th word from a selection, and requiring the examinee to fill in the blanks. This mechanical method of selecting blanks is expected to reflect the frequency of occurrence of grammatical and lexical forms. Cloze tests have two methods of scoring: (1) the exact word method in which only those responses corresponding exactly to the original passage are counted as correct, and (2) the acceptable word method in which responses are counted as correct if they fit the surrounding context. The latter method requires judgments of grammaticality and appropriateness by a native speaker.

More recently, the cloze procedure has been used in second language testing as a measure of second language proficiency or global proficiency. Oller (1980) defined global proficiency as the internalized linguistic competence of language users. He contends that cloze tests provide a measure of global proficiency by utilizing what he calls "expectancy grammar", a system capable of relating linguistic sequences to extralinguistic contexts. According to Oller (1971), cloze tests require the examinee to perform a task similar to that required of native speakers when sending and receiving messages. That is, listening requires that a person anticipate what the speaker will say next, and sometimes even supply the missing words or phrases. These procedures have their counterpart in reading and writing and are accessible through the cloze technique (Oller, 1971). Thus, cloze tests measure both productive and receptive language skills by allowing the examinee to analyze and synthesize the greater whole.

Darnell (1968) used a cloze test as a measure of proficiency in English as a second language. He reported an internal reliability index of .77 and a correlation of .82 with the Test of English as a Foreign Language (TOEFL), a widely used test developed by the Educational Testing Services.

Oller and Conrad (1971) administered a cloze test to two groups of native speakers (n=40) and to various groups of non-native speakers (n=108) at different levels of language proficiency. They correlated scores on the cloze test (using the exact method of scoring) with those of the UCLA English as a Second Language Placement Examination (UCLA ESL); Form 2C. The subjects had already been grouped into five proficiency levels on the basis of prior examination or course graduation: Group I included beginning ESL students, Group II included intermediate ESL students, Group III included advanced ESL students, Group IV included non-native students enrolled in Advanced Composition, and Group V included non-native graduate students enrolled in Teaching English as a Second Language courses. Two control groups of native speakers were also tested. Group VI consisted of native speakers taking a freshman English class, and Group VII included graduate students in Teaching English as a Second Language at UCLA. With the exception of Groups IV and V (non-native subjects enrolled in advance composition or TESL courses), the test rank ordered the groups as expected. The analysis showed significant differences between groups I, II, and VII. However, there were no significant differences between these groups and any other subset. A multiple regression analysis yielded a coefficient of determination of .77, indicating that 77 percent of the variance in the cloze test was present in the UCLA ESLPE. The cloze test correlated .88 with the total score on the UCLA test. The highest product moment correlations were obtained between the cloze test and the dictation section (.82) and the cloze test and the reading comprehension section (.80) of the UCLA ESLPE.

A more extensive comparison between native and non-native performance was made by Oller, Bowen, Dien and Mason (1972). Cloze tests were constructed in English, Thai, and Vietnamese by deleting every sixth word from various passages of prose. There were three original passages, one each in English, Thai, and Vietnamese, and four translations of these passages, one into Vietnamese, one into Thai, and one each into English from Thai and Vietnamese originals.

Mean scores for native speakers on the originals and translations suggested that translating from one language into another yields cloze tests of approximately equal difficulty in both languages. The mean for the American subjects in the English original was 37.2; Thai and Vietnamese subjects scored 35.6 and 34.4 on its respective translations.

Irvine, Atai, and Oller (1974) gave a cloze test to non-native speakers of English in Iran. Their scores on the cloze test were compared to scores on the TOEFL, and a dictation test. The cloze test was scored by both the exact word method and the contextually acceptable method. The correlation between both methods of scoring was .84. Results showed that the cloze (exact word method) correlated .75 with the dictation and .78 with the TOEFL. As in the studies by Oller and Conrad (1971) and Darnell (1968), the cloze correlated better with the listening comprehension section of the TOEFL than with any other subsection.

Stubbs and Tucker (1974) administered a cloze test as part of the English Entrance Examination (EEE) required of all applicants to the American University of Beirut. The EEE was developed and standardized by the Office of Test and Measurements and consists of four parts: (1) structure, (2) vocabulary, (3) miscellaneous test of language aptitude, and (4) reading comprehension. The cloze test was scored by both the exact response and the contextually acceptable response method. The correlation between both methods of scoring was .97. Correlation between the cloze and the EEE was .71 for the exact word scoring and .76 for the contextually acceptable method of scoring. Correlation between the cloze and the sub-sections of the EEE ranged from .60 to .67 for the exact word method and from .65 to .71 for the contextually acceptable method. Stubbs and Tucker (1974) concluded that the cloze technique is a powerful and economical measure of English language proficiency for non-native speakers.

The cloze test used in the present study (see Appendix C) was constructed by deleting every sixth word from a passage excerpted and adapted from a booklet of graded reading materials for elementary school children. It was about 198 words in length and contained 25 blanks. The cloze test was translated into Spanish by the examiner in consultation with two Spanish professors at Oklahoma State University. Due to the impossibility of word-by-word translation, the Spanish version was about 228 words in length and contained a total of 27 blanks, two more than the English version. As customary, the first and last lines of the passage were left intact.

The English version of the cloze test was administered to 27 students of various backgrounds enrolled at the University of Tulsa English Institute. The students at the institute had already been grouped into one of five proficiency levels, from level 1 (the lowest) to level 5 (the highest). The cloze test correlated .76 (using the exact word method of scoring) with the level system used by the

English Institute. Unfortunately, there were no students in level 1 at the time the cloze test was administered.

On the basis of scores on the cloze test, subjects were classified into three proficiency groups prior to testing with the auditory evoked potential procedure. Subjects in the low (minimal) second language proficiency groups scored less than 20 percent in the cloze test. Those subjects scoring between 45 percent and 55 percent in the cloze test were classified as having medium proficiency in their second language. Finally, scores of 85 percent or above were indicative of high proficiency in the second language.

Apparatus

Auditory Evoked Potentials (AEPs) were recorded from two pairs of Grass gold-plated disc electrodes located at homologous sites over the left and right cerebral hemispheres. These were located at C4 and C3 according to the International 10-20 System (Jasper, 1958), and referred to linked ears (A1A2). The forehead served as ground. Electrodes were affixed to the scalp sites with Grass Instruments EC2 paste. Impedances were kept below 5 Kohms and checked by a Grass Impedance Meter at the beginning of the experimental session and after each of three calibrations throughout the session. The EEG was recorded from two amplifier channels of a Grass Model 79 polygraph with band-passes of .3 to 100 Hz with 60 Hz notch filters utilized; sensitivities were set at 5 μv/mm. Outputs from the two amplifiers were sampled and digitized every eight msec by a MetraByte Corporation analog/digital (A/D) converter and stored on a Tecmar fixed disk with all functions controlled by an IBM PC-XT computer. A Coulbourn digital logic system was used for stimulus control.

The stimuli consisted of verbal passages in Spanish and English (read by native speakers), each with a duration of approximately four minutes. Tone probes were superimposed on these verbal passages. The verbal passages were prerecorded on tape and presented over Realistic (Pro-60) stereophonic headphones to the subject who was seated in a reclining chair in an electrically shielded room. The intensity of the verbal passages ranged from 65 to 75 dB sound pressure level (SPL). The tone probes (600 Hz, 200 msec, 72 dB SPL) had an interstimulus interval of no less than 5.0 sec and were generated by a Coulbourn waveform generator. The initiation of A/D conversion (total sweep epoch-2048 msec) occurred 600 msec prior to the onset of each tone. Tones and verbal stimuli were amplified by a Coulbourn audio amplifier/mixer.

Procedure

Auditory Evoked Potentials (AEPs) were recorded to the task-irrelevant tones under three experimental conditions: Baseline, Spanish condition, and English condition.

During the baseline condition, a low level task which presumably does not involve differential hemispheric activation, (Shucard et al., 1977), two 4.0 minute segments of seven randomly occurring clicks were presented to subjects over the headphones. Subjects were instructed to indicate that they detected the clicks by simultaneously pressing two microswitches with the thumbs of both hands whenever a click was heard.

During each verbal condition, subjects heard two verbal passages ranging from 4.12 to 4.25 minutes. Four English passages and their Spanish translations were selected for the study based on their analytical content and lack of imagery. Subjects were required to identify specified "key" words in each of the four passages and were instructed to press the microswitches, as described for the baseline condition, each time a key word was detected. Subjects were also instructed to attend to the content of the passage and to be prepared to answer two written multiple choice questions pertaining to the content at the end of the passage in order to promote attention.

The subjects heard two of the passages in English and the remaining two passages in their Spanish translation. The baseline condition was always presented first. Order of presentation of the verbal conditions was counterbalanced. Half of the subjects heard the passages in their native language first and the other half heard the passages in their second language first. There was a two minute rest period between passages during which the experimenter presented the two multiple choice questions to the subject, and a five minute rest period between the English and the Spanish condition. After presentation of all four verbal passages, the subjects were asked to rate in a scale from 0 (not at all) to 4 (perfectly), how well they understood the passages in the second language.

A total of seven clicks and seven key words occurred during each four minute task segment of the baseline, and the English and Spanish conditions respectively. Thus, the number of required motor responses was minimal and similar across conditions. During each task segment, 45 tone probes were superimposed on the ongoing baseline and verbal conditions. Presentation of the tones began ten seconds after the onset of each task.

Four English passages and their Spanish translations, ranging from 4.12 to 4.25 minutes, were selected for auditory verbal presentation. The passages were chosen from magazine articles and SAT Test practice booklets because of their analytical content and lack of imagery. Seven nouns were selected as "key" words in each of the four passages. The same words were used in both English and Spanish passages. Subjects were instructed to press the microswitches, as described for the baseline condition, each time a "key" word was detected. Subjects were also instructed to attend to the content of the passage and to be prepared to answer two written multiple choice questions pertaining to the content of the passage in order to promote attention.

The subjects heard two of the passages in English and the remaining two passages in their Spanish translation. The baseline condition was always presented first. Order of presentation of the verbal conditions was counterbalanced. Half of the subjects heard the passages in their native language first and the other half heard the passages in their second language first. There was a two minute rest period between passages during which the experimenter presented the two multiple choice questions to the subject, and a five minute rest period between the English and the Spanish condition. After presentation of all four verbal passages, the subjects were asked to rate, on a scale of 0 (not at all) to 4 (perfectly), how well they understood the passage in the second language.

Forty-five tone probes were superimposed on the ongoing baseline and verbal conditions. Presentation of the tones began 10 seconds after the onset of each task. Tones were presented approximately one every five seconds. Auditory Evoked Potentials were reconded to the tone probes. As mentioned before, a total of seven clicks and seven "key" words occurred during each four minute task segment of the baseline, and the English and Spanish conditions respectively. Thus, the number of required motor responses was minimal and similar across conditions.

CHAPTER V

RESULTS

Language Acquisition

A 2 x 3 native language-by-proficiency analysis of variance was performed on the demographic variables of age, years of second language study, years of living in the second language, age of second language acquisition, associations with others, and difficulty ratings of the second language passages. Results showed a significant main effect for language on all the above named variables with the exception of years of second language study (see Table I). These findings revealed some very important differences between the two native speaking groups that were true regardless of proficiency in the second language. First, the native Spanish speakers were significantly older, and started learning the second language at a significantly older age than the native English group. Second, although there were no significant differences in the number of years of second language study, the native Spanish speakers had lived longer in a second language country (U.S.A.) than the native English speakers, most of which had never lived in a Spanish speaking country. Finally, whereas the native Spanish speakers associated on a regular basis with both Spanish and English speakers, the native English speakers related almost exclusively to other

English speakers. The significance of these findings is reflected in the subject's ability to understand the verbal passages in the second language. Native Spanish speakers rated their ability to understand the passages in the second language significantly higher (M=3.13) than the native English speakers (M=2.08), F = 19.10, $p<.001$. This suggests that, as a group, the native Spanish speakers found the verbal auditory passages in English easier to understand than what the native English speakers found the verbal passages in Spanish. The Analysis of Variance also revealed a proficiency effect for the subject's self ratings of their ability to understand the passages in the second language (F=16.54, $p<.001$). Tukey's procedure showed that both the high proficiency group (M=3.31) and the medium proficiency group (M=2.62) rated the passages in the second language significantly higher (understood them better) than the low proficiency group (M=1.87). However, there were no significant differences in the ratings between the high and the medium proficiency groups.

TABLE I

MEAN VALUES OF LANGUAGE ACQUISITION FACTORS FOR NATIVE SPANISH AND NATIVE ENGLISH SPEAKERS ACROSS PROFICIENCY LEVELS

	NATIVE LANGUAGE		
	English	Spanish	*F*
Age	21.58	31.04	20.20 **
Age of L2 Acquisition	16.92	22.17	9.41 **
Yrs. of Living in L2 Country	.05	.78	18.71 **
Yrs. of Study	.08	.17	3.27
Association with Others	4.54	2.25	106.41
Difficulty Ratings	3.13	2.08	19.10 **

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

Finally, the analysis of variance revealed a proficiency main effect for age of second language acquisition (F=6.31, $p<.02$). A comparison between the means using Tukey's procedure showed, as may be expected, that the low proficiency group started learning the second language at a significantly older age (M=23.38) than the high proficiency group (M=15.93). The Medium proficiency group fell somewhere in the middle (M=19.31), not differing significantly from the other two groups. The 2 x 3 native language-by-proficiency analysis of variance revealed no significant interactions between any of the demographic variables.

Auditory Evoked Potentials

Six auditory evoked potential (AEP) peaks were identified for each subject (P1, N1, P2, N2, P3, N3). Table III gives the mean latencies and standard deviations for these peaks across all conditions for all subjects. Four amplitude scores (in microvolts) for each AEP were obtained by computing the peak-to-peak differences for N1-P2, P2-N2, N2-P3, and P3-N3. Thus, the data for each subject consisted of AEP amplitude measures for four peak-to-peak components for each of two hemispheres, in each of three conditions (Baseline, English, Spanish). In addition to these within subjects variables, there were two between subject variables: proficiency (Low, Medium, Hi), and native language (English, Spanish). The data for each language were analyzed separately.

A condition-by-proficiency-hemisphere analysis of variance was done on overall amplitude scores, as well as for the peak-to-peak amplitude differences for native English and Spanish speakers separately. The results for the native English speakers yielded a significant condition effect for N1-P2 ($F(2,42)=133.87$, $p<.001$), P2-N2 ($F(2,42)=16.04$, $p<.001$), N2-P3 ($F(2,40)=7.25$, $p<.002$), and P3-N3 ($F(2,40)=17.80$, $p.001$) peak-to-peak amplitudes. In all cases, peak-to-peak amplitudes were greater for the baseline condition followed by the English condition (native language), and the Spanish condition (second language) respectively. The data for the native Spanish speakers also showed a condition main effect for N1-P2 ($F(2,42)=164.36$, $p<.001$), P2-N2 ($F(2,42)=14.69$, $p<.001$),

TABLE II

MEAN LATENCIES AND STANDARD DEVIATIONS
ACROSS ALL PEAKS AND CONDITIONS

		Native English Speakers						Native Spanish Speakers					
		P1	N1	P2	N2	P3	N3	P1	N1	P2	N2	P3	N3
Baseline	$\bar{X}$	14.17	99	188.5	280	358.17	457.17	16.67	96.17	189.67	283.83	358.67	447
n=16	S.D.	7.69	10.13	20.91	37.31	40.82	56.55	9.35	7.25	18.55	39.47	45.97	63.41
English	$\bar{X}$	26.83	108.83	204.17	300.83	390.83	463.33	30	101	204.17	291	344	442.17
n=16	S.D.	18.42	18.21	21.10	4.155	55.25	60.69	13.98	9.93	66.89	38.54	48.64	54.57
Spanish	$\bar{X}$	30.83	109.50	208	315.67	380.5	465.83	41.67	98.83	191.17	285	358.5	440.83
n=16	S.D.	26.22	16.08	21.25	32.21	36.85	56.15	68.81	13.39	25.55	37.96	42.67	46.67

$p<.001$), and P3-N3 ($F(2,41)=3.65$, $p<.03$). As with the native English speakers, there was a greater peak-to-peak amplitude for the baseline condition followed by the native language and the second language conditions respectively. However, when an analysis of covariance was performed with the baseline condition as a covariate, a main effect for condition was only found for N1-P2 ($F(1,21)=9.64$, $p<.006$), and P2-N2 ($F(1,21)=4.15$, $p<.05$) amplitude differences for the native English speakers. None of the amplitude differences were significant for the native Spanish speakers. Thus, the amplitude effects for N2-P3 and P3-N3 for the native English speakers, and N1-P2, P2-N2, and P3-N3 for the native Spanish speakers were due to the baseline mean being significantly larger than the means for the two language conditions.

In accordance with the stage hypothesis, a proficiency-by-condition-by-hemisphere interaction was predicted. The high proficiency groups were expected to show greater amplitude responses from the right hemisphere during the processing of both English and Spanish. In contrast, the medium proficiency groups were expected to show greater amplitude responses over the left hemisphere during the processing of the second language as compared to greater amplitude responses over the right hemisphere during the processing of the native language. The low proficiency groups were expected to show a greater amplitude response over the right hemisphere in their native language condition and no amplitude difference between the hemispheres for the second language condition. Results of the analysis of covariance, using the Baseline as a covariate, for the native English speakers showed only a significant interaction between condition and hemisphere ($F(1,11)=5.02$, $p<.04$) for the P2-N2 amplitude (see Figure 1). The data showed a greater P2-N2 amplitude in the right hemisphere for the English condition (native language), and a greater amplitude for the left hemisphere for the Spanish condition (second language). Thus, the data for the native English speakers suggest a greater right hemisphere involvement in the processing of the second language when compared to the processing of the first language regardless of proficiency level.

In contrast, the data for the Spanish speakers showed a greater right hemisphere P2-N2 amplitude in their second language (English) condition, and no difference between the P2-N2 amplitude means for the left and right hemispheres in the native language (see Figure 2). However, the results for the native Spanish speakers were not significant. Thus, data for the native Spanish speakers suggest that both the left and right hemispheres were equally active in the processing of English as a second language regardless of proficiency.

A proficiency-by-hemisphere analysis of covariance with the baseline condition as a covariate was done to examine differences between proficiency levels in the second language condition. The results for English as a second language showed a significant main effect for proficiency ($\underline{F}(2,20)=4.86$, $\underline{p}<.02$) for P3-N3 amplitude. The low group exhibited a greater P3-N3 amplitude than the medium proficiency group and the high proficiency group in that order. The effect was not significant for Spanish as a second language group, who showed virtually no P3-N3 amplitude difference in the medium and high proficiency groups, which was lower than the amplitude difference for the low proficiency group.

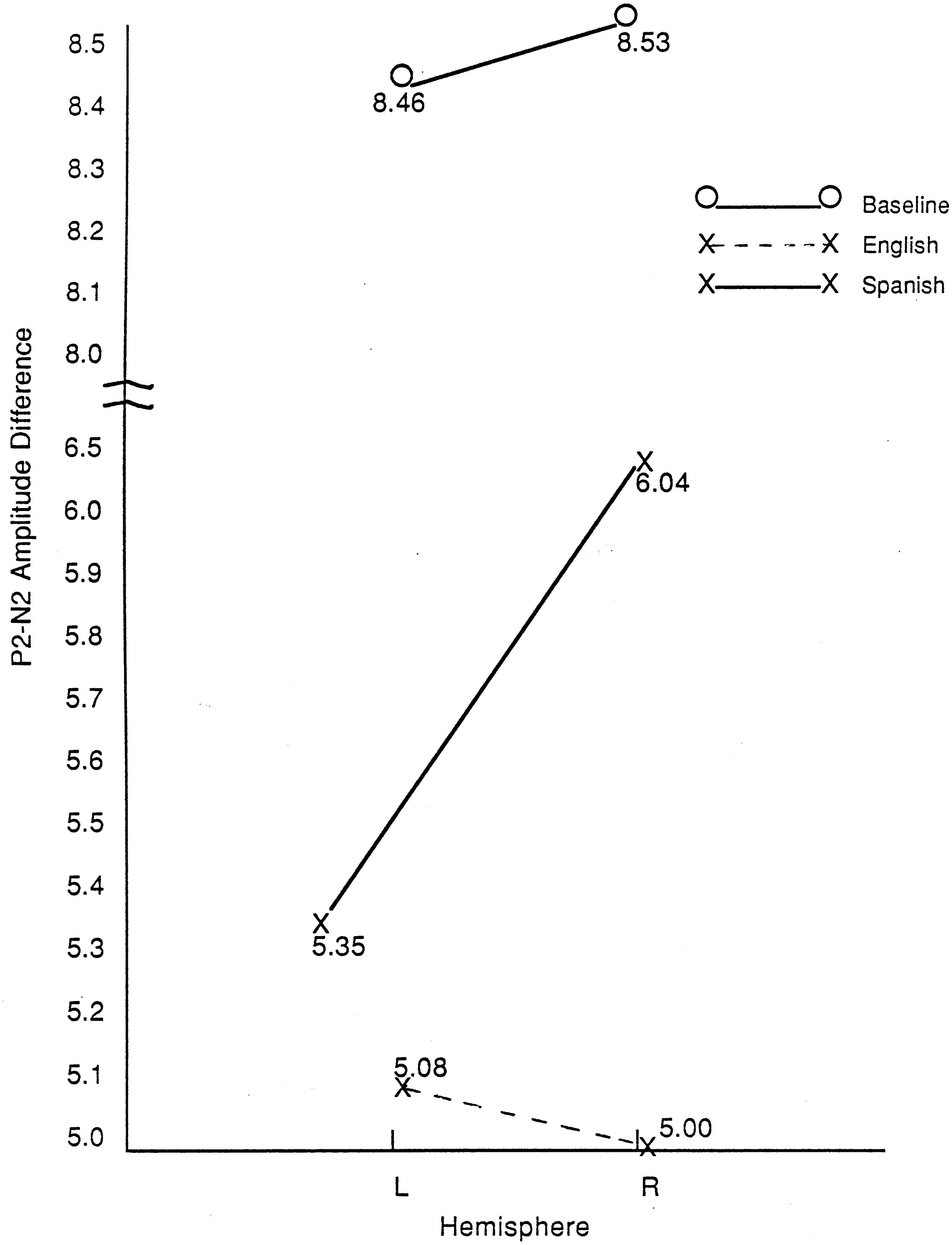

Figure 1. P2-N2 Mean Amplitude Difference for Native English Speakers As Function of Hemisphere and Condition.

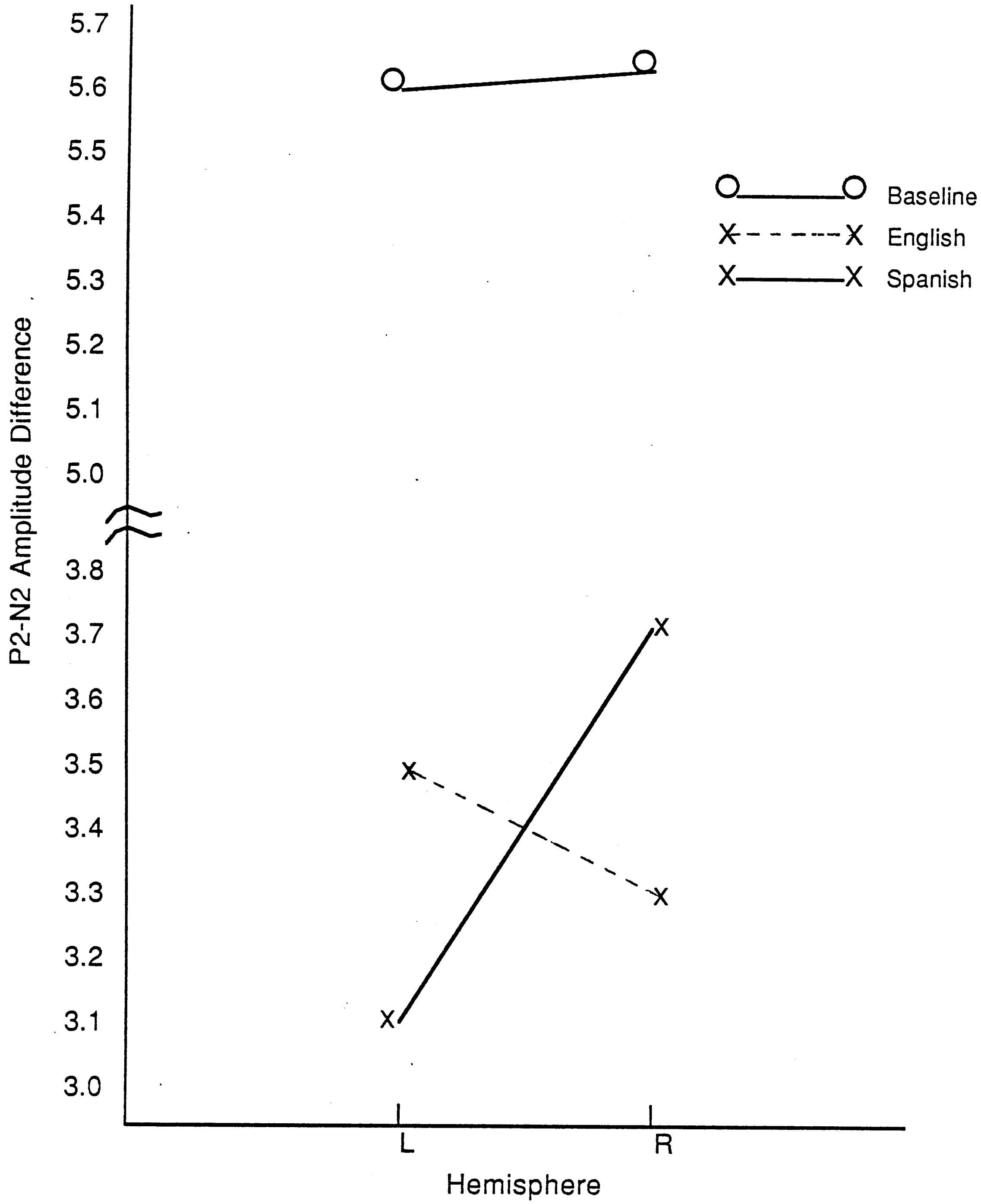

Figure 2. P2-N2 Mean Amplitude Difference for Native Spanish Speakers As Function of Hemisphere and Condition.

CHAPTER VI

DISCUSSION

The purpose of the present study was to examine the neurophysiological organization of language in bilinguals. In particular, it was concerned with the stage hypothesis which proposes that the right hemisphere is relatively more involved during the initial stages of second language acquisition compared to normal processing of the native language. More specifically, the stage hypothesis predicts the following proficiency-by-condition-by-hemisphere interaction: (1) no difference in amplitude between hemispheres for the second language, and greater right hemisphere amplitudes for the native language for the low proficiency group; (2) greater amplitude responses over the left hemisphere for the second language condition as compared to the native language condition for the medium proficiency group; and (3) greater right hemisphere amplitudes for first and second languages in proficient bilinguals. At first glance, however, results did not support the stage hypothesis. Native English speakers did show a greater right hemisphere involvement in processing Spanish when compared to their native language, as measured by a Condition by Hemisphere interaction for P2-N2 amplitude. This, however, was the case for all proficiency levels. The stage hypothesis predicts such an interaction (condition-by-hemisphere) only in the early stages of second language learning.

Results for the native Spanish speakers showed no differential hemispheric involvement in the processing of the first or second language. For the native English speakers the Condition by Hemisphere interaction was significant, indicating that the amplitude relationships between the hemispheres changed from the English to the Spanish conditions; for any single condition, amplitude differences between the two hemispheres did not reach statistical significance. This suggests that there was a lack of measurement sensitivity in the present study when a single condition was examined. Assuming this, adequate sensitivity was achieved only when changes across conditions were examined (e.g., the Condition by Hemisphere interaction). Thus, the lack of significant amplitude differences between hemispheres in each of the two verbal conditions shown by the native Spanish speakers might have been due to this lack of sensitivity. However, there was no evidence of a Condition by Hemisphere interaction for this group, indicating that there was not a change across conditions in the interhemispheric amplitude relationships. The first and second languages appear to have been processed similarly.

There are some major differences between the native Spanish and the native English speaking groups which may have accounted for the results. Although the native English speakers, as a group, had studied the second language as much as the native Spanish speakers, this learning had been limited to the classroom. The native Spanish speakers reported learning English with friends as well as in the classroom. Native English speakers had virtually no exposure to a Spanish speaking community, and therefore little contact with native Spanish speakers. The native Spanish speakers, on the other hand, were living and learning English in an English speaking environment.

In order to understand the difference in the results between the two groups, one must also remember that the verbal passages used in this experiment were presented auditorily as opposed to visually. Because their knowledge of the second language was limited to a classroom setting, where emphasis is usually in grammar, vocabulary, reading, and writing, the task of listening to verbal passages in Spanish may have been considerably more difficult for native English speakers than for native Spanish speakers who listen to native English speakers daily. Evidence of this difference was found when native English speakers rated the difficulty of the passages in the second language significantly higher than the native Spanish speakers in the medium and high proficiency groups. This difference was not significant in the low proficiency groups because neither group understood much of the passages. Thus, as a group, for verbal material presented auditorily, the native English speakers can be considered less proficient in the second language than the native Spanish speakers. If one considers these two groups as representing two different proficiency levels in the second language, the native English speakers being lower in proficiency, then the results show at least partial support for the stage hypothesis. That is, as predicted by the stage hypotheses, there was no lateralization difference in the high proficiency group (native Spanish speakers). In contrast, the low proficiency group (native English speakers) showed greater amplitude responses over the left hemisphere during the processing of the verbal passages in the second language as compared to a greater response over the right hemisphere during the processing of the native language.

The present study shows the effects that increased processing demands and divided attention have on the amplitude of the AEP. Amplitude has been shown to vary with differences in attention. Studies of early auditory selection have bound greater evoked potential amplitude when attention is focused to one channel than when it is divided into two or more channels. Results also show a positive correlation between amplitude and target detection accuracy (Hillyard, 1985). That is, increased target detection is associated with increased attention which in turn is associated with greater peak amplitude. In a 1985 experiment, Picton also found that amplitude increased with increased attention. In the present study, both native Spanish and English speakers showed greater amplitude differences (N1-P2, P2-N2 for native English speakers and P2-N2, N2-P3 for native Spanish speakers) for the baseline condition as compared to the verbal conditions. These amplitude differences reflect greater attentional demands to the verbal passages and away from the probe tones to which AEP's were recorded. During the verbal conditions the subjects were required to listen for both key words and for the content of the passage. The baseline condition required only that the subjects listen for clicks. Thus, the verbal conditions required greater attention and, as a result, subjects showed a decrease in amplitude for these conditions. Results also showed that for native English speakers the N1-P2 and P2-N2 amplitudes were greater for the first language as compared to the second language. There were no such amplitude differences for the native Spanish speakers. These results support the idea that the native

English speakers were less proficient in the second language than the Spanish speakers. The lower amplitude in the processing of Spanish suggests greater attentional demands required by the task than in their native language. The lack of such amplitude differences for the native Spanish group suggests no greater attention in the processing of English over the processing of Spanish.

Amplitude differences within the native Spanish speaking group suggest different strategies for dealing with second language tasks. Due to their difficulty processing the verbal passages in English, it was not uncommon for the low proficiency subjects (self-report) to concentrate on listening for the key words and not to the content of the passage. The native Spanish speakers with high proficiency in English knew enough English to put effort toward listening for content as well as for the key words, resulting in greater attentional demands and significantly smaller P3-N3 amplitude than the low proficiency group. The middle proficiency group fell somewhere in between with some subjects perhaps giving up listening for the content. Results for the native English speakers were similar, but did not reach significance.

Based on the results of this experiment alone, it is difficult to say whether the difference between the native Spanish and the native English speakers was due to the differences in the proficiency level, whether Spanish as a language is more bilaterally represented, or whether learning a second language in a second language environment leads to a different lateralization pattern (greater bilateral representation) than learning a foreign language in a formal classroom environment. Prior research suggests the latter. Gordon (1980) found a trend toward lower laterality (more reversals in ear preference) in those subjects who had learned Hebrew after puberty and who used it frequently because they were living in a Hebrew environment. In contrast, a comparable group of native Hebrew speakers, who had learned English in Israel, did not show the same reversals for ear preference. In their study with native English speakers learning Hebrew in Israel, Albert and Obler (1978) found no differences in ear advantage for either English or Hebrew. Subjects who had learned English as a foreign language in school showed greater left hemisphere involvement in the processing of English (second language) than for Hebrew (first language). The subjects in both the Gordon (1980) and Albert and Obler (1978) studies were considered equally proficient in both languages. Sussman, Franklin, and Simon (1982), in a study that compared advanced (balanced) bilinguals from several different language backgrounds to a monolingual English speaking group in a verbal-manual interference task, found smaller differences between left and right hemisphere disruption rates (lower asymmetries) for bilinguals than for monolinguals. Walters and Zatorre (1978) found a left hemisphere advantage in the processing of both English and Spanish of advanced Spanish-English bilinguals. However, the authors found wide individual differences in the number of bilinguals showing the expected asymmetry when compared to a monolingual sample subjected to the same paradigm. Walters and Zatorre (1978) concluded that there may be a trend toward less bilaterality of language functions in bilinguals.

Results of the present study, as well as the studies discussed above, support propositions of greater bilateral representation of language in adult, advanced second language speakers who are in a second language environment. Since these findings resulted from studies that involved different languages, it is unlikely that it was language specific aspects of Spanish, or any other particular language, that led to the greater bilateral representation. However, propositions of lower laterality in advanced bilinguals do not explain the differential cerebral involvement for English and Spanish in the native English speaking group.

Gaziel, Obler, Benton, and Albert (1977, as reported by Galloway & Krashen, 1978) found differential lateralization of English and Hebrew in a group of Israeli subjects studying English as a foreign language. Results showed greater right hemisphere processing of English when compared to Hebrew. However, results could have been due to the low proficiency of the subjects or to the fact that Hebrew is read from left to right. Similar results were found by Silverberg, Bentin, Gaziel, Obler, and Albert (1979) in a tachistoscopic study with Israel adolescents in their second and third year of studying English. The authors found a left visual field advantage for English words and a right visual field advantage for Hebrew. The results could have been due to the fact that Hebrew children were only exposed to English in a school setting and mostly through reading. This possibility was investigated in another study by Silverberg, Gordon, Pollack, and Bentin (1980). The authors presented words, both visually and auditorily, to Israeli children learning to read their native language. Word stimuli that were relatively unfamiliar to second graders, who could not read, resulted in poor recognition by the left hemisphere. In contrast, third graders, who could read, showed a right visual field preference (left hemisphere advantage) for the same words. When similar words were presented dichotically, both groups of children showed a right ear advantage. Silverberg et. al. (1980) concluded that due to its pattern recognition function, there is right hemisphere involvement in acquiring the reading skills of a native language.

Thus, it is possible that the right hemisphere strategies invoked by the stage hypothesis to predict greater right hemisphere participation in the initial stages of second language acquisition are not so much affected by proficiency but by familiarity with the stimulus material. Although lower proficiency would tend to suggest less familiarity, this may not necessarily be the case. It was the case that some of the native Spanish speaking subjects in the present study, despite their low proficiency in the language, were quite used to listening to English. In contrast because their knowledge of Spanish was restricted to the classroom, the native English speakers with high proficiency in Spanish were unaccustomed to listening to native Spanish speakers.

In conclusion, to say that proficiency in the second language, manner or age of second language acquisition, reading habits, or any single variable leads to differential lateralization in bilinguals is too simplistic. The neurophysiological organization of language in bilinguals appears to be the result of a combination of variables. Further investigations in the area should focus on whether and to what extent a factor leads to a particular mode of information processing, as well as discovering possible interaction effects between these factors, instead of determining whether the two languages are processed in different hemispheres.

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APPENDIX A

LANGUAGE BACKGROUND QUESTIONNAIRE

Language Background Questionnaire

1. Age ___________
2. Sex ___________
3. Native Language ______________________
4. How old where you when you first learned Spanish? ___________
5. How long have you studied Spanish? ___________
6. Number of years spent living in a Spanish speaking country? ___________
7. With whom do you associate in the outside community?

______ 1. Almost exclusively Spanish speaking people.

______ 2. Mostly Spanish speaking people.

______ 3. About equally Spanish and English speakers.

______ 4. Mostly English speaking people.

______ 5. Almost exclusively English speaking people.

8. How did you learn to speak Spanish?

______ 1. In school

______ 2. At home

______ 3. With friends

9. How comfortable do you feel speaking Spanish?

	Not comfortable					Comfortable
	1	2	3	4	5	
At Home						
At School/Work						
With Friends						
In General						

10. Rate yourself on how good you can perform the following activities in Spanish.

	Not at all				Very Good
	1	2	3	4	5
Speak					
Understand					
Read					
Write					

APPENDIX B

CLOZE TEST

CLOZE TEST

FIRST LANGUAGE ______________________________ LEVEL ___________

LAST TOEFL SCORE AND DATE OF TEST ______________________________

You often say to your neighbor, "Nice weather today, isn't it?". But do you know what weather really is? It is nothing (but) the air around us. We (say) that it is warm or (cold) or windy. We say that (it) is raining or snowing. Weather (is) all around us. It is (something) we feel in our body (as) much as something we see.

Air grows warm and rises. Then it cools in the (sky) and falls. It keeps moving (through) the sky in much the (same) way a river moves through (the) land.

Winds, then, are part of what makes up the weather. Another part is the temperature (of) the air. In winter the (air) is cold, while in summer (the) air is warm or hot.

The third thing that makes up the weather is the moisture, or amount of water, in the air. It may be in the (form) of rain, steam, or ice. (A) cloud is a form of (moisture), too. When the sun warms (the) sea and earth, some water (turns) into vapour. The vapour rises (with) the warmer air. It rises (up) in the sky and turns (into) millions of tiny drops and (then) a cloud is formed.

Weather changes constantly. But the main elements that (make) up the weather do not (change). They remain the same -- temperature, winds, and moisture.

VITA

Diana Quintana

Candidate for the Degree of

Doctor of Philosophy

Thesis: CEREBRAL LATERALIZATION OF SPANISH-ENGLISH AND ENGLISH-SPANISH BILINGUALS AS A FUNCTION OF PROFICIENCY OF THE SECOND LANGUAGE

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