Neuropsychological Approaches to Bilingualism: A Critical Review*

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ABSTRACT

Clinical and experimental studies which have examined the neuropsychological bases of language processing in bilinguals are reviewed and evaluated. Evidence from case studies of polyglot aphasics suggests that the neuropsychological organization of their languages is the same for most bilinguals but that cases of dissociation do occur. Two main factors – language specific and language acquisitional – which might account for dissociation are defined and empirical evidence relevant to each is considered. It is argued that while clinical case studies of bilinguals suffering language disruption following brain damage have been significant in isolating these factors, they have failed to establish their explanatory power, due in part to inadequate data bases and in part to weak hypothesis-testing procedures. A review of the experimental studies provides preliminary evidence that such factors may influence the pattern of hemispheric involvement in the language processing of bilinguals. The variables of age, stage and manner of second language acquisition are discussed in some detail. A theoretical framework integrating the available evidence is proposed and guidelines for further research are suggested.

RÉSUMÉ

Les études cliniques et expérimentales qui ont examiné les substrats neuropsychologiques du traitement du langage chez les bilingues sont passées en revue et évaluées. Les données provenant d'études de l'aphasie chez les polyglottes suggèrent que chez la plupart des bilingues l'organisation neuropsychologique de chacune des langues est la même, mais il y a des cas de dissociation.

Deux facteurs principaux, l'un spécifique à la langue et l'autre dépendant du contexte d'acquisition, qui pourraient rendre compte de la dissociation sont définis, et les données empiriques relatives à chacun de ces facteurs sont considérées.

Bien que les études de cas cliniques de bilingues souffrant de troubles du langage à la suite de lésions cérébrales aient joué un rôle significatif dans la découverte de ces facteurs, elles n'ont pas réussi à établir leur valeur d'explication, d'une part à cause du fondement inadéquat des données et d'autre part à cause de la faiblesse des procédures de vérification des hypothèses.

Les données provenant des études expérimentales sur la latéralisation cérébrale dans lesquelles ces facteurs ont été considérés chez des bilingues neurologiquement intacts sont examinées. On constate que les données relatives à la latéralisation différentielle du langage associées aux variables spécifiques aux langues (par ex. 'mode de pensée,' direction de l'écriture, caractéristiques et tonalité des voyelles) sont équivoques à cause des contrôles inappropriés des sujets et des stimulus. L'examen des études concernant les variables dépendant des contextes d'acquisition (par ex. âge, stade de développement et mode d'acquisition de la deuxième langue) procure des données préliminaires en faveur de l'hypothèse selon laquelle de telles variables pourraient influencer le mode de participation hémisphérique dans le traitement des langues chez les bilingues. Un cadre théorique intégrant les données disponibles est proposé, selon lequel, toutes autres choses demeurant égales, la participation de l'hémisphère droit du bilingue sera d'autant plus probable que la deuxième langue aura été acquise plus jeune, que l'exposition à la langue aura été informelle, et que le stade d'acquisition sera primitif. Inversement, la participation de l'hémisphère gauche sera d'autant plus probable que l'âge à l'acquisition sera plus avancé, que l'exposition sera plus formelle, et que le stade d'acquisition sera plus avancé.

Des recherches fondées sur des idées plus complexes et utilisant des procédures méthodologiquement plus rigoureuses sont nécessaires.

Interest in the neuropsychological aspects of bilingualism has a long history in apha-

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siological studies, dating from the time of Broca in the early 1860s. By now, there is a rich and extensive body of published literature on individual aphasic cases. Until recently, the study of language disruption following neurological insult was the only source of evidence concerning brain-language relations in bilinguals and monolinguals alike. With the development of sophisticated electrophysiological techniques and neuropsychological testing procedures, it has now become possible to carry out investigations of neurologically-intact individuals. These procedures are being used increasingly for experimental investigations of bilingualism – of all the experimental studies to be reviewed here, almost half were conducted in the last three years. At the same time, there has been a renewed interest in clinical studies of polyglot aphasia, as evidenced by the number of recently published reviews on this topic (cf. Albert & Obler, 1978; Paradis, 1977; Whitaker, 1978). Thus, it seems timely to summarize and assesss the state of these two complementary approaches.

What has distinguished both aphasiological and experimental studies of bilinguals from those of monolinguals has been the search for evidence regarding the relationship of the bilingual's two languages, and, particularly, whether they involve the same or distinct neuropsychological processes. This, then, will be the focus of our review. Since the clinical studies have already been summarized thoroughly by others, our review of them will be selective. Furthermore, unlike extant reviews, which have excused methodological inadequacies of the clinical studies in favour of their results, the present one will focus on methodological issues in order to assess the implications of this research. Since experimental neuropsychological studies of bilingualism are less numerous, and more recent, our discussion of this literature will be comprehensive, constituting both a summary and a critique of all relevant studies.

FINDINGS FROM STUDIES OF POLYGLOT APHASIA: PARALLEL OR DIFFERENTIAL LANGUAGE IMPAIRMENT

Researchers of polyglot aphasia have sought evidence for the neuropsychological relationship of the patient's languages in the patterns of language impairment and/or restitution following the onset of aphasia. Differential impairement and/or recovery of the bilingual's languages following brain damage has been taken as prima facie evidence for distinct neuropsychological processing of the languages, or what may be termed language dissociation. Conversely, parallel language impairment and/or recovery has been taken as evidence for common neuropsychological processing.

Evidence regarding language dissociation has been sought primarily in studies of selected cases of bilingual aphasia (cf. Albert & Obler, 1978; Galloway, Note 1; Leischner, 1980; and Paradis, 1977 for reviews of such cases). Other sources of evidence include studies of groups of unselected cases of bilingual aphasia, which are much fewer in number (Charlton, 1964; L'Hermitte, Hécaen, Dubois, Culioli & Tabouret-Keller, 1966; Nair & Virmani, 1973), and investigations of language restitution in bilingual aphasics undergoing therapy in one language (Fredman, 1975; Voinescu, Vish, Sirian, & Maretsis, 1977; Watamori & Sasanuma, 1976, 1978).

Findings from all three sources indicate that language dissociation does occur among bilingual aphasics, and that it may take several different forms (Paradis, 1977). In the present review, no distinction will be made between subtypes; all instances of non-parallel impairment/recovery will be referred to simply as differential. Estimates of the incidence of differential aphasic patterns based on studies of selected individual cases are generally high: Albert and Obler – 53%, and Paradis – 45%. These estimates are probably inflated due to the overinclusion of unusual and, therefore, interesting cases, as the authors themselves point out. In contrast, estimates derived from studies of unselected cases are much lower, and probably more realistic – Charlton (1964) reported that only 2 of the 9 cases he examined evinced differential impairment; L'Hermitte et al. (1966) reported that none of their 8 cases showed differential impairment or recovery; and Nair and Virmani (1973) reported that 2 of the 33 bilingual cases in their study manifested differential symptoms. Charlton and Nair and Virmani did not report on recovery patterns.

Estimates of differential recovery following therapy are not available although evidence of dissociation is reported by Watamori and Sasanuma (1978) who found that, while recovery was comparable for both the treated and non-treated languages of a Broca's aphasic, it was selective, favouring the treated language, in the case of a Wernicke's aphasic. Since these observations are based on individual cases, it remains to be demonstrated more convincingly that type of aphasia was the critical factor mediating these effects. Fredman has also noted that therapy in one language had beneficial effects on even the non-treated language, although recovery was generally greater for the treated one. The implications of this observation are unclear because of the lack of non-treated control patients; thus, the impact of language usage outside therapy could not adequately be taken into account. Moreover, because the follow-up assessment was carried out within months of the onset of aphasia, spontaneous restitution, which is most likely at this time, may have had a significant influence on the results.

It is difficult to establish valid estimates of differential aphasic patterns in bilinguals for psychometric reasons. In principle, assessment of the patient's linguistic condition following the onset of aphasia should reflect a broad range of linguistic skills and should be carried out longitudinally until stable language behaviour is achieved (Lebrun, 1976) in order to determine whether initial impairment is truly parallel in all relevant linguistic aspects and whether subsequent recovery proceeds in a parallel manner. Moreover, language assessment instruments should be standardized in some fashion so that valid comparisons between languages can be made. In fact, this has often not been the case. Owing in part to the lack of linguistic sophistication of early investigators, who were usually neurologists, and in part to the lack of appropriate tests in different languages, assessments have often been fragmentary and impressionistic. The use of more sophisticated and thorough language testing than has been the practice to date could provide evidence that *all* bilingual aphasics present some differential language patterns following aphasia. In the meantime, the consensus of opinion, as well as the results of the few extant studies of unselected cases, is that differential language impairment and restitution is probably an exception to the more frequent parallel pattern, and by implication, therefore, that both or all languages are usually processed by common neuropsychological mechanisms.

EXPLANATIONS OF LANGUAGE DISSOCIATION IN BILINGUAL APHASIA

Patterns of differential language impairment and recovery have been associated with a number of different factors. For the sake of convenience, they can be classified in terms of language specific, language acquisitional, and sociolinguistic factors. Although these factors will be discussed separately, it is not our intention to suggest unitary independent explanations. Indeed, as will become evident in our discussion, a multidimensional explanation is probably necessary.

Language-specific factors. Differential language impairment might be expected in bilingual aphasics to the extent that their languages require different perceptuo-cognitive processes which, in turn, may depend upon separate cortical systems. A distinctive characteristic of a given language would presumably be processed similarly in monolinguals and bilinguals, so that a language-specific effect would not be unique to bilinguals. Language-specific effects may, however, differ between bilinguals and monolinguals, or between different bilingual subgroups, because of the fact of language combination per se, or because of the effects of particular language combinations. To that extent, a given effect would be unique to bilinguals.

Language-specific effects have often been reported in the clinical literature for bilinguals whose languages differ in the extent to which their orthographies are phonetic or ideographic. Lesions in the temporal cortex have been associated with greater impairment of reading and/or writing of scripts which are phonetically based (de Agostini, 1977; Hinshelwood, 1902; Luria, 1960; Peuser & Leischner, 1974; Sasanuma & Fujimura, 1971) whereas lesions in the posterior, occipito-parietal cortical areas have been associated with greater impairment in reading and/or writing of scripts with an ideographic or irregular phonetic basis (Lyman, Kwan, Chao, 1938; Newcombe, in Critchley, 1974; Sasanuma, 1975). It is argued that damage to temporal cortical regions impairs the acoustic analyzers which underlie processing of phonetic writing systems whereas occipito-parietal damage impairs the visuo-spatial analyzers implicated in processing ideographic scripts.

All of the above cases are thought to reflect the importance of different sensory modalities, or combinations of sensory modalities, and of their underlying neurophysiological substrates in the processing of different languages. Intra-modality differences across languages might also be expected to reveal differential neuropsychological involvement to the extent that languages differ in the particular perceptual elements that convey meaning. Jakobson (1955) cites cases of bilingual aphasics who appeared to have lost the ability to use intonation (as in Norwegian), vowel length (as in Czech), and stress (cf. Pick, in Jakobson, 1955, p. 70) to represent linguistic distinctions. Lesion sites were not, however, reported for any of these cases.

With the exception of the study by de Agostini (1977), an examination of the writing patterns of two groups of aphasics, language-specific effects have been used as post hoc explanations of differential impairment in single, selected aphasic cases with no serious attempt to test out their predictive power in non-selected cases. Explanations of differential impairment based on language-specific effects would require that samples of aphasics whose languages are thought to depend upon different cortical processes be identified, irrespective initially of their aphasic symptoms, and subsequently examined for evidence of dissociation in the relevant aspect of their languages, taking locus of lesion into account. Until such tests are carried out, one can only conclude that differential language impairment in bilinguals can be associated with languages that appear to require different perceptuo-cognitive analyzers. At present, we do not know what conditions are necessary and/or sufficient to produce language-specific effects.

Language acquisitional factors. Explanations of differential impairment/recovery have also been sought in variables associated with language acquisition. In fact, the earliest attempts to explain differential language recovery in bilingual aphasics were based on the notions of primacy of language acquisition and familiarity. Ribot (1881) hypothesized that languages learned early in ontogenetic development would be more resistant to impairment caused by brain damage and would, therefore, recover before languages which have been acquired subsequently, irrespective of language proficiency. Despite its intuitive appeal, Ribot's hypothesis is conceptually weak since there seems to be no evidence to support the notion of layers of memory on which the principle of linguistic primacy depends. Moreover, it is difficult to find cases which provide a clear test of the hypothesis since primacy of language acquisition is often confounded with other factors – the first learned language may be the language which is most familiar and/or affectively most important to the patient at the time of injury. Both familiarity (Pitres, 1980) and affective value (Minkowski, 1980) have been proposed by others as explanations of differential language impairment. In fact, there has been very little empirical support in the aphasiological literature for Ribot's hypothesis (Albert & Obler, 1978; Galloway, Note 1; Paradis, 1977).

In contention with Ribot, Pitres (1980) hypothesized that the language that was most familiar to the patient prior to neurological insult would be the first to recover, irrespective of its order of acquisition. While attempts to support Pitres' hypothesis have fared better than similar efforts on behalf of Ribot's rule, there still has been no convincing demonstration of its validity. It is not sufficient, as has been done to date, simply to compare the number of cases with differential language impairment that support Pitres's hypothesis with those that do not (cf., for example, Albert & Obler, 1978; pp. 142, 147, 153). The postmorbid language symptoms of unselected bilingual aphasics should be assessed and correlated with their premorbid levels of language familiarity. The necessity for indices of premorbid linguistic familiarity compounds psychometric problems outlined earlier because of the obvious difficulty of obtaining systematic, objective measures of premorbid language competence after the onset of aphasia. This difficulty will necessarily characterize any study related to language acquisitional factors.

Differential patterns of impairment and/or recovery have been postulated to occur in bilinguals to the extent that different patterns of hemispheric involvement are implicated in first and second language acquisition. Specifically, it has been hypothesized that the right hemisphere is specialized for second language acquisition (Ovcharova, Raichev & Geliva, 1980; Vildomec, 1963) in contrast to the assumed specialization of the left hemisphere in first language acquisition. It follows from this hypothesis that there should be a higher incidence of right-sided lesions among bilingual than monolingual aphasics. In an exhaustive test of this prediction, Galloway (Note 1) re-examined nearly 300 cases of polyglot aphasia from which she was able to identify some 85 whose records included sufficient information to test the hypothesis. As well, she included a comparison group of some 340 monolingual aphasics who had been carefully selected to insure their monolinguality. In support of the prediction, she noted that 13% of the right-handed polyglot cases in contrast to 2% of the right-handed monolingual cases and 58% of the left-handed polyglot cases in contrast to 32% of the left-handed monolingual cases had right-sided lesions. These findings corroborate those of Albert and Obler (1978) based on a similar re-examination of published individual cases and of Gloning and Gloning (1980) based on 15 unselected cases of polyglot aphasia.

A refinement of the hypothesis of right hemispheric involvement in bilinguals holds that the right hemisphere will be more involved only in the initial stages of second language acquisition, with the left hemisphere assuming control in advanced stages (Krashen & Galloway, 1978; Obler, 1980). In her survey of the clinical literature, Galloway (Note 1) was able to identify only five cases who were clearly reported to be in the early stages of second language learning and for whom side of lesion was indicated or inferable, information necessary to test the stage hypothesis. Although the patterns of first and second language impairment and/or restitution of these were consistent with the hypothesis, the evidence is inconclusive, as Galloway herself conceded, owing to small sample sizes, the possibility of biased reporting, and, as is always the case in polyglot aphasia, the possibility of alternate explanations for the observed recovery patterns. Moreover, a direct test of the stage hypothesis would entail comparison of second language impairment patterns of bilinguals at early versus advanced stages of acquisition rather than, as has been done to date, comparisons of first and second language impairment within the same individuals or between different groups of aphasics.

Any attempt to establish a special relationship between bilingualism and right hemispheric language processing must (1) take into account the incidence of right hemispheric linguistic competence in monolinguals; (2) rule out extenuating circumstances, such as early left hemisphere damage or language-specific effects that might predispose to right hemispheric involvement; (3) rule out the possibility that the right hemisphere has been instrumental in reacquiring the language; and, in the case of the stage hypothesis, (4) establish that the patient was in the initial stages of acquiring the second language and had not yet fully mastered it. With the exception of Galloway's analysis, which she points out was inconclusive, attempts to address this issue so far have fallen far short of these criteria.

Sociolinguistic factors. The last category to be considered emphasizes aspects of the patient's pre- or postmorbid social milieu and/or affective values associated with each language (see Lebrun, 1976, and Minkowski, 1980a, for reviews). Cases of differential polyglot aphasia have been reported in which the language that was selectively recovered either was the language of the patient's entourage following injury (Bychowski, 1980; Halpern, 1980) or was associated with positive affective value premorbidly (Minkowski, 1980b, Krapf, 1980; Winterstein & Meier, 1980) or postmorbidly, for example, in order to communicate with family members (Halpern, 1980) or for professional reasons (case J.L. in Lebrun, 1976; van Thal, 1960). The significance of cases of the first type may also reside in the role of affective variables, namely, the patient's desire to communicate with those around him/her.

The importance of affective variables in language restitution, as in the case of recovery from any neurological injury, is likely to be considerable. Halpern (1980), for example, reports the case of an aphasic who achieved extensive recovery of philosophical vocabulary in order to complete a scholarly treatise that he had begun prior to injury, even though he had difficulty with many common, day-to-day terms. Research with neurologically-intact individuals has also demonstrated the importance of affective variables; in particular, positive attitudes towards and motivations underlying second language learning (Gardner & Lambert, 1972; Gardner, Gliksman & Smythe, 1978). While such factors may be particularly influential in certain cases of polyglot aphasia, they are probably present to some extent in all cases. In order for systematic investigations of these factors to be profitable, they would have to respect previously mentioned psychometric, subject selection and hypothesis-testing standards. Unless these standards can be met, it seems questionable whether sociolinguistic factors should be considered separately. They may, nevertheless, be useful as ad hoc clinical explanations of otherwise enigmatic cases.

Summary

Studies of single, selected cases of polyglot aphasia, of unselected cases, and of cases undergoing systematic therapy indicate that impairment and/or recovery may not be comparable in both, or all, languages of the patient, although the consensus of opinion, as well as the results of the few extant studies of unselected cases, is that differential impairment/restitution is probably an exception to the more frequent parallel pattern. These same studies have amply demonstrated the possible significance of a number of factors in accounting for the differential aphasic patterns that occur. However, systematic attempts to establish whether these factors, either in isolation or in interaction with other factors, provide necessary and/or sufficient explanations of these patterns are sorely lacking. More rigorous linguistic assessment, subject selection and hypothesis-testing are necessary if understanding of differential aphasia in bilinguals is to go beyond its current speculative, case history state. At the same time, it is fully recognized that judicious investigation of individual cases may be heuristic in isolating variables that are susceptible to more systematic or experimental investigation.

FINDINGS FROM EXPERIMENTAL STUDIES OF BILINGUALS

While clinical neuropsychological investigations of bilingual aphasia have directed attention to intra- and/or interhemispheric organization of language, experimental studies of neurologically-intact individuals (see Table 1 for a summary) have typically been limited to an investigation of differential inter-hemispheric language specialization. The present conception of cerebral lateralization, derived mainly from the experimental literature, differs from an earlier, clinically-derived view in two important respects. First, rather than emphasizing stimulus characteristics, it accords a greater importance to stimulus-task interactions. The cerebral hemispheres, in this view, are presumed to differ not so much in the type of stimuli that they process, but in their manner of processing any stimulus (Tomlinson-Keasey & Kelly, 1979). The left hemisphere is thought to process information analytically and serially, while the right hemisphere is believed to process information in a gestalt, simultaneous manner (Cohen, 1973; Levy-Agresti & Sperry, 1968). To the extent that language functions vary in their reliance on serial vesus simultaneous modes of information processing, one would expect differential hemispheric involvement in the processing of different linguistic skills. Secondly, in contrast to the earlier view, in which language was regarded as undifferentiated and subserved mainly by the left hemisphere, the current view holds that language consists of an aggregate of perceptual and mnemonic processes, some of which may be better subserved by the left hemisphere, and others by the right. Both hemispheres would, thus, contribute to language processing.

Turning to the issue of language lateralization in bilinguals, it would thus appear that an appropriate question would be whether, or to what extent, factors in the bilingual experience differentially favor a particular hemispheric mode of information processing, and not whether the two languages are processed in different hemispheres (cf. Hamers & Lambert, 1977; Walters & Zatorre, 1978). In the following sections, two types of factors will be discussed. One focuses on language-specific variables and the other on variables related to language acquisition, specifically, age, stage, and manner of second language acquisition. After the available studies bearing on each factor have been reviewed separately, an attempt will be made to integrate them and to suggest ways in which they may interact.

Language-Specific Factors

As has already been discussed, different languages may require different perceptuo-cognitive processes which, in turn, may depend upon intra- or interhemispherically distinct cortical systems. The language-specific factors that have been investigated in the experimental literature include differences in language-related thought patterns, direction of

TABLE I
Cerebral lateralization in bilinguals: Experimental studies

Author(s)	Subjects	Sex	Age	Stimuli	Method	Results
Mishkin & Forgays 1952	b:19 (N) En-Yi	?	12–14	24 bw	T:150 h,U l-r vf-r v-acc	%Subjects En Yi RVF* LVF 40 25
Orbach 1953	b1:4 En,Yi b2:20 En-Yi b3:8 Yi-En	?	a	24 bw 8- and 5-letter	T:20–100 h,U l-r vf-r v-acc	En Yi b1 RVF* LVF* b2 RVF* RVF* b3 RVF* LVF*
Barton, Goodglass, & Shai 1965	b:20 En-He m:10 En	30M	a	15 bw 3-letter common disyll	T v,U l-bl vf-r v-acc	En He b RVF* RVF* m RVF* –
Orbach 1967	b:He-En b1:25 rhand b2:21 lhand	22M 24F	17–28	26bw 5-letter common	T:10–20 h,U l-r vf-r v-acc	En He b1 RVF* RVF* b2 RVF* LVF*
Tsunoda 1971	b: 3 Fr-Ja 1 En-Ja 1 Ge-Ja m1: 3 Fr 4 En m2:92 Ja	b:2M,3F m1:4M,3F m2:M = F	18–35	b,m1:En vowel /a/ m2:Ja vowel /a/ 1 kc pure tone	DAF Tapping rate: rhand	Interference %Ss /a/ Tone b 60 LE LE m1 86 LE LE m2 72 RE LE
Kershner & Jeng 1972	b:Ch-En b1:20 reye b2:20 leye	23M 17F	a	36 bw En:4-letter Ch:2-character	T:125 En-h,U,B Ch-v,U,B l-r vf-r w-acc	U & B En Ch b1 RVF* RVF* b2 RVF* RVF*

Tsunoda 1973	b:2nd gener. Ja 4 Po-Ja 3 Sp-Ja 2 En-Ja	4M 5F	25	En vowel /a/ 1 kc pure tone	DAF Tapping rate: rhand	Interference %Ss /a/ Tone b 90 LE LE
VanLancker & Fromkin 1973	b:23 Th-En m:14 En	?	20–30	Th w prs monosyll 5 tone 5 cons 5 hums	DL stim-bl w-acc	Tone Cons Hums b REA* REA* n.s. m n.s. REA* LEA
Bever 1974	b:(N)Sp-En	?	6–7	En prs	DL v-acc	n.s. ear effects
Maitre 1974	b1:18 En-Sp2D b2:18 En-Sp3D b3:18 En-Sp2P b4:18 En-Sp3P m:Sp	?	a	20 prs bw bs	DL 1-bl v-acc POE	En Sp w b REA* > REA* m – REA* s b REA* = REA* m REA* = REA* En b REA* = REA* Sp b REA* < REA* m REA* < REA* n.s. diff: D vs. P
Bellisle 1975	b:8 En,Fr m1:8 En m2:8 Fr	M = F	4½	20 prs bd monosyll	DL 1-bl v-acc order	Acc & order En Fr b REA* n.s. m1 REA* – m2 – n.s.
Kotik 1975	b1:21 Ru,Es b2:15 Ru-Es b3:17 Es-Ru high b4:13 Es-Ru med	35M 55F	21	bw	DL 1-bl v-acc POE	Ru Es w b1 n.s. n.s. b2 REA* = REA*

TABLE I (Continued)

Author(s)	Subjects	Sex	Age	Stimuli	Method	Results
	b5:24 Es-Ru low					b3 REA* > REA b4 REA* = REA* b5 REA* < REA*
Obler, Albert & Gordon 1975	b1:12 He,En b2:24 En-He b3:24 He-En	b2,b3: M = F b1:3M,9F	a	bw triads monosyll	DL 1-bl w-acc	En He b1 REA > REA b2 REA > REA b3 REA* < REA*
Hartnett 1976	b1:13 En-Sp Bull b2:16 En-Sp Barcia	?	a	En Sentences	CLEM	b1: REM* b2: LEM* REM: b1 > b2
Hamers & Lambert 1977	b:15 Fr,En	?	a	35 bw concrete	T:100 h,U l-r vf-bl m-RT	1 Overall RVF* 2 Same VF asym in both l's in 67%Ss Different pattern in 33%Ss
Rogers, TenHouten, Kaplan & Gardiner 1977	b:(N)Ho-En	?	Cr4–6	Ho & En taped stories	EEG alpha blocking	1 For both l's, LH alpha blocking greater than RH 2 RH blocking greater in Ho than En
Starck, Genesee, Lambert & Seitz 1977	t:24 En-He-Fr m:24 En	M = F	6–8	En d 5 single 5 double 5 triple monosyll	DL v-acc	1 Acc & order: greater REA in t than m 2 Acc: REA in t decreased with age Follow-up study 1 Acc & order: REA in t = REA in m
Albert & Obler 1978	b1:24 He,En b2:24 En-He	M = F	a	bw triads	DL l-r v-acc	1 Overall REA* 2 b1: He REA > En REA 3 b2: He REA = En REA

Gaziel, Obler & Albert 1978	b1:10 He,En b2:10 En-He b3:10 He-En	4M, 6F per gp.	17–30	bw 3-letter common nouns	T: 100(h) 150(v) U l-r vf-r m-RT	Horizontal En He b1 RVF RVF b2 RVF LVF b3 n.s. RVF* Vertical b1 n.s. n.s. b2 LVF* RVF* b3 n.s. RVF
Genesee, Hamers, Lambert, Mononen, Seitz & Starck 1978	b1:6 Fr,En b2:6 Fr-En 'child' b3:6 Fr-En 'adol.'	2M, 4F per gp.	a L2 acq. b1: birth b2: < 6 b3: > 12	16 bw common monosyll nouns	ML l-r ear-bl m-RT AER	1 RT: n.s. gp or ear effects 2 AER latency faster in b3 than b1, b2 3 AER latency faster in LH for b1, b2; RH for b3 4 AER amplitude: larger for Fr than En words
Hardyck Tzeng & Wang 1978	b: 2 En-Ch 6 Ch-En m:12 En	?	a	96 w same diff. in lang. and/or meaning	T:150 En-h Ch-v U,B vf-r m,v-RT	1 b: n.s. VF effects 2 m: RVF*–En; LVF*–Ch
Walters, & Zatorre 1978	b1:10 Sp-En b2:13 En-Sp	b1:4M, 6F b2:4M, 9F	a	10 bw 4-letter concrete nouns	T:40 h,B vf-r l-bl: L1 first CFD v-acc % VF diff	1 Overall RVF* in 70%Ss. 2 Sig. correl. in degree of VF diff for En and Sp

TABLE I (Continued)

Author(s)	Subjects	Sex	Age	Stimuli	Method	Results
Galloway 1979	b:30 Sp-En m1:32 En m2:38 Sp	100M	a	20 bw pairs 2–4 syll common	DL l-bl v-acc POE	b m1 m2 En REA* = REA* – Sp REA* – = REA*
Piazza & Zatorre 1979	(N)b:48 Sp-En	M = F	b1:9:6 b2:13:6	30 bw matched in frequency, grammatical category; phonetic composition	DL l-bl v-acc % ear diff	% Ear difference En Sp 1 b1REA* = REA* b2REA* = REA* 2 Sig. correl. in pattern of ear asym. for En and Sp
Scott, Hynd, Hunt & Weed 1979	b:20 Na-En m:20 En	M = F	18–27	30 En CV prs	DL v-acc POE	1 sex n.s. 2 b: LEA* m: REA*
Silverberg, Bentin, Gaziel, Obler & Albert 1979	b1:24 Gr7 b2:24 Gr9 b3:24 Gr11 (N) He-En	M = F	12–17	24 bw prs 3-letter concrete common nouns	T:120 h,U l-bl vf-r CFD m-RT	% Subjects En He LVF* RVF* b1 83 87 b2 67 100 b3 25 87
Soares & Grosjean 1979	b:10 Po-En 'late' m:10 En	20M	a L2 acquisition b: > 8	bw 20 abstract/ 20 concrete	T:150 vf-r b:l-r m-En v-RT	En Po b: RVF* = RVF* m: RVF* –

Vaid & Lambert 1979	b1:16 Fr,En 'early' b2:16 'late' (8 Fr-En; 8 En-Fr) m:16 En	M = F	21 L2 acquisition b1:5 b2:11	En: *high, low* Fr: *haute, basse* in high & low pitches	ML m-RT l-r	Interference from meaning b1 / b2 / m 1 En: M — RE*, LE* / LE* / RE* F — LE* / LE* / RE*, LE* 2 Fr: M — n.s. / LE* / – F — n.s. / LE* / –
Carroll 1980	1 b1:7 En-Na b2:14 Na-En b3:5 Na, En	10M, 16F	14–35 L2 acquisition <12 yrs:26	bw triads common	DL l-bl v-acc	In both languages: % Subjects REA / LEA / Diff'l 46 / 23 / 31
	2 b1:18 En-Sp1 b2:18 En-Sp2 b3:18 En-Sp3	7M, 11F per gp.	17–37 L2 acquisition <6 yrs:14 14–18 yrs:22 >18 yrs:15	bw	DL l-bl v-acc POE	En / Sp b REA* / <* (especially in late bils.) / REA*
Gordon 1980	b1:85 En-He b2:50 He-En b3:14 En, He	b1:26M, 49F b2:21M, 29F b3: ?	18–65	bw	DL 1-bl w-acc POE	% Subjects: REA En / He b1:64 / 66 b2:74 / 72 Trend: smaller ear diff's in b1 than b2 b2: sig. larger REA in En than He Males more lateralized than females
Hynd & Scott 1980	Gr2 b1:20 Na-En m1:20 En Gr5 b1:20 Na-En m1:20 En	M = F	Gr2:7 Gr5:11	30 En CV prs	DL v-acc POE	1 sex n.s. 2 b:LEA* m:REA* 3 b:LEA increased with age m:REA increased with age

TABLE I (Concluded)

Author(s)	Subjects	Sex	Age	Stimuli	Method	Results
Hynd, Teeter & Stewart 1980	b:14 Na-En m:14 En	10M 18F	23	(a) En CV 60 prs (b) 4 bw	(a) DL v-acc (b) finger tapping and concurrent vocalization	(a) REA* overall 1st block: b:REA – 52% m:LEA – 47% (b) En Na b:LH LH m:LH –
Wesche & Schneiderman 1980	b:61 En-Fr varied in L2 proficiency level; exposed to L2 after age of 11 yrs	22M 39F	18–40	8 bw monosyll concrete nouns	DL l-bl v-acc	1 n.s. sex effects 2 *REA in En, n.s. ear preference in Fr 3 Laterality coeff. for En was significantly larger than that for Fr 4 Sig. correlation bet. performance on Fr listening comprehension and Fr DL test 5 Sig. correlation bet. DL performance in En and that in Fr 6 Ss laterality score in En was the only sig. predictor of laterality scores in Fr

NOTES ON TABLE 1

Subjects

1 All subjects were right-handed, except where otherwise stated, e.g., Orbach (1967).

2 b: bilingual b1: b group 1, b2: b group 2, b3: b group 3
m: monolingual m1: m group 1, m2: m group 2
t: trilingual
N: nonproficient

3 A comma separating the two languages signifies that the bilinguals had learned both languages simultaneously.
A hyphen signifies that the languages were learned successively, in order indicated.

4 Abbreviations: Ch = Chinese; En = English; Es = Estonian; Fr = French; Ge = German; He = Hebrew; Ho = Hopi; Ja = Japanese; Na = Navajo; Ru = Russian; Po = Portuguese; Sp = Spanish; Th = Thai; Yi = Yiddish.

5 In Kotik's (1975) study, Es-Ru subjects were subdivided on the basis of their proficiency in their second language.

6 In Maitre's (1974) and Carroll's (1980) studies, En-Sp subjects were subdivided on the basis of their level of study in the second language.

Sex
1 ? indicates that the sex of subjects was not reported.
2 M = F: Number of males and females per group was equal.
3 Gr: school grade.
Age
1 a: Subjects were adults of unspecified age.
2 Where either the mean age, in years, or the age range was mentioned in the original study, it is reported as such.
Stimuli
w, d, s Stimuli used, whether words, digits, or sentences. Preceded by b indicates bilingual presentation.
Method
1 Tachistoscopic presentation: stimulus exposure duration given in milliseconds.
h or v: horizontal or vertical presentation.
U or B: Unilateral or Bilateral presentation.
2 l-bl; vf-bl: The stimuli were blocked on language, or on visual field.
l-r; vf-r: The stimuli were randomized on language or visual field.
3 v-acc; w-acc: Vocal or written accuracy of recall was the response measure.
v-RT; m-RT: Vocal or manual reaction time was the response measure.
4 POE: percentage of errors.
Results
*A star indicates that the laterality effect was statistically significant at (or beyond) $p < .05$.

script, characteristics of vowels, and tonality.

Appositional versus propositional modes of thought. One set of studies has proposed that languages differ in the degree to which they elicit appositional versus propositional 'modes of thought,' and that these modes, in turn, engage the cerebral hemispheres differentially. Rogers, TenHouten, Kaplan and Gardiner (1977) maintain that, whereas the Hopi language creates involvement with the perceptual field, English orients its users away from the immediate context, and, therefore, that one would expect greater right hemispheric participation in the processing of Hopi than English. To test this hypothesis, Rogers et al. monitored the EEG alpha wave activity of Hopi-English bilingual school children while they listened to taped folk tales in Hopi and English. The results indicated a greater left than right hemisphere alpha wave suppression in both languages; the extent of right hemisphere alpha suppression was greater for Hopi than for English, in apparent support of their hypothesis. However, since the stories Rogers et al. used had not been equated for content, factors such as concreteness or level of interest may have given rise to the apparent right hemisphere participation. Other EEG studies with monolinguals (Harman & Ray, 1977) and with bilinguals (TenHouten, Note 2) have provided evidence for different patterns of hemispheric involvement associated with these factors.

The Navajo language, like Hopi, is presumed to elicit a greater appositional mode of thought (cf. Critchley, 1974) and, accordingly, might be expected to require greater right hemispheric involement during processing. Indeed, two dichotic listening (DL) studies, one with an adult sample (Scott, Hynd, Hunt & Weed, 1979) and the other with a child sample (Hynd & Scott, 1980), have reported a significant left ear advantage (LEA) in Navajo-English bilinguals in contrast to a significant right ear advantage (REA) obtained in English monolingual controls. This finding may be interpreted as support for a language-specific effect related to the appositional character of Navajo but for the fact that the stimuli were English consonant-vowel syllables. An alternative explanation proposed by Scott et al. concerns the possibility that the group difference reflects a language-based difference in attentional bias, whereby the Navajo speakers were more attentive to, and thus more accurate in reporting, stimuli presented to the left side of space. Such an explanation, however, would seem to beg the question. Yet another explanation has placed the emphasis on an acculturation process (Hynd, Teeter, & Stewart, 1980) to account for the fact that the LEA noted for the Navajo-dominant subjects by Scott et al. (1979) and Hynd and Scott (1980) was not found in laterality studies with more proficient, acculturated Navajo speakers of English (Carroll, 1980, Exp. 1; Hynd et al., 1980).

In sum, while evidence from three studies is suggestive of greater right hemispheric involvement in the processing of languages presumed to be more appositional, it is by no means conclusive for, in the absence of adequate controls, alternative interpretations involving subject or stimulus parameters are equally plausible. Furthermore, the theoretical assumption underlying these studies, namely, that languages differ in the degree to which they serve as instruments for propositional versus appositional modes of thought, runs the risk of being circular unless a more specific characterization of the nature of the linguistic peculiarities presumed to involve the right hemisphere differentially can be formulated.

Direction of script. Visual field asymmetries in the processing of verbal material have been subject to several interpretations (cf. Kershner & Jeng, 1972; see White, 1973, for a review). Two are of relevance to the present discussion: a cerebral laterality effect and a scanning effect which accounts for visual field preferences in terms of a directional post-exposural scanning mechanism that develops from reading habits (Heron, 1957). To assess the relative contribution of the two effects, one can investigate the visual field preferences of bilinguals whose languages have opposing reading scan directions. In Hebrew and English bilinguals, for example, one would predict a strong RVF superiority for horizontally printed English words shown unilaterally, since the net effect of scanning and cerebral laterality would be facilitative. By contrast, Hebrew words should produce a weaker RVF superiority, or even a left visual field (LVF) preference, since the scanning effect would conflict with the direction of the cerebral laterality effect. When scanning biases are eliminated by presenting words vertically, both English and Hebrew stimuli should produce a RVF superiority.

Mishkin and Forgays (1952) presented native English speakers who had some knowledge of Yiddish with unilateral, horizontally printed English and Yiddish words. The Yiddish words were written in the left-going Hebrew alphabet. Consistent with the scanning hypothesis, a significant RVF preference for English and a non-significant LVF preference for Yiddish were found. In a subsequent study that controlled for the order in which the languages had been acquired, Orbach (1953) reported an overall RVF effect for English words, but a different pattern for Yiddish words across the two bilingual subgroups – while English-Yiddish bilinguals showed a significant RVF superiority, Yiddish-English bilinguals showed a significant LVF superiority for the Yiddish words – suggesting that the scanning effect of the first learned language overrides that of the second, if the two are in conflicting directions. In a subsequent study with Hebrew-English bilinguals, however, a RVF superiority was noted for words in both languages (Orbach, 1967).

Barton, Goodglass and Shai (1965) examined the cerebral laterality effect in English-Hebrew bilinguals by presenting them with vertically printed English and Hebrew words. Both languages produced a RVF superiority, which was comparable to that obtained for English in monolingual group. A control group of Hebrew-English bilinguals was not, however, tested (Barton et al., 1965). Finally, a study by Gaziel, Obler and Albert (1978) examined the strength of the visual field preference in a group of Hebrew-English and English-Hebrew bilinguals with different levels of proficiency in the second language. Significant results were obtained only for the non-proficient bilingual subgroups, and were generally consistent with the cerebral laterality effect.

Thus, the evidence indicates that bilinguals whose languages are read in opposite directions may demonstrate different patterns of visual field asymmetry for each language. However, these patterns do not reflect differences in cerebral laterality for each language, but rather an interaction between directional scanning tendencies and cerebral laterality. Moreover, proficiency and order of language learning may reinforce certain scanning effects.

Vowel characteristics. That vowels of different languages may be processed in different hemispheres was suggested in a study that compared Japanese monolinguals and speakers of various Indo-European languages (Tsunoda, 1971). Using a delayed auditory feedback method of measuring laterality differences (see O'Malley, 1978, for a critique), Tsunoda noted that monolingual speakers processed vowels in the left hemisphere and pure tones in the right hemisphere; 'Western' subjects, however, processed both vowels and pure tones in the right hemisphere. More recently, Tsunoda (Note 3) reported that monolingual speakers of various Polynesian languages also showed the pattern characteristic of Japanese monolinguals.

To account for the difference between the Japanese and Polynesian speakers, on the one hand, and the Indo-European speakers, on the other hand, Tsunoda (1971) has proposed that, since Japanese and Polynesian languages contain several vowels that form meaningful monosyllabic words, speakers of these languages may be predisposed to process even isolated vowels in an analytical, left hemisphere mode, in contrast to the non-differentiated cerebral processing of vowels by speakers of Indo-European languages (Shankweiler & Studdert-Kennedy, 1967). However, a left hemisphere superiority in processing isolated vowels has been reported in speakers of Indo-European languages when vowel length is reduced to correspond to that present in actual speech (Darwin, 1975) or when noise is presented along with the vowels (Weiss & House, 1970). Acoustic variables, in general, have been shown to influence the laterality pattern of dichotic speech stimuli (Berlin & Cullen, 1977). It is possible, therefore, that the vowels Tsunoda presented to his Japanese and Western subjects differed in critical acoustic parameters.

Whatever the mechanism giving rise to the observed language-specific effect (cf. Sanchez, 1979), one would expect bilingual speakers of Japanese and English or other Indo-European languages to show a different pattern of ear interference during delayed auditory feedback for vowels in the two languages. Tsunoda (1971, 1973) reports that the performance of bilinguals, all of whom were non-native speakers of Japanese, closely paralleled that of a 'Western' monolingual sample. Due to the small number of subjects tested, however, the fact that they were not systematically tested with stimuli from both languages, and that their proficiency in the second language was not objectively assessed, any conclusions about the performance of bilinguals on this task as distinct from that of monolinguals – Japanese or Western – cannot at present be drawn.

Tonality. Whether tones are processed differentially by the two hemispheres in speakers of tonal versus non-tonal languages was investigated in a DL study of Thai-English bilinguals by Van Lancker and Fromkin (1973). Their results revealed a significant REA among the Thai speakers for words varying in initial consonant and those varying only in tone, but no ear differences for the tone words when the latter were presented in a non-linguistic context. English monolinguals, however, showed a significant REA only for the words varying in initial consonant (Van Lancker & Fromkin, 1973; 1978). These findings clearly demonstrate a language-specific difference in the processing of tone by speakers of tonal and non-tonal languages (but see Benson, Smith & Arreaga, 1974). In addition, they indicate that the difference emerges only when the tones are presented in a linguistic context. Since Van Lancker and Fromkin only tested native Thai speakers, it remains to be determined whether the observed effect of tonality would also arise in speakers for whom Thai were a second language.

Language Acquisitional Factors

With few exceptions, studies of language-specific effects have failed to examine the possible influences of context-of-acquisition parameters, such as sequence of language acquisition, on the nature and size of a given language-specific effect. Nevertheless, it is of theoretical importance to establish the conditions under which a particular effect is or is not manifested. In the following sections, the neuropsychological implications of three such factors are reviewed – the age at which the second language is acquired, the stage of second language acquisition, and the manner of second language acquisition.

Relative age of second language acquisition. If the two languages of a bilingual are acquired successively rather than simultaneously, one might expect some difference in their underlying neural organization, insofar as the maturational state of the brain differs during the time of first versus second language acquisition (Lamendella, 1977; Whitaker, 1978). On a cognitive level, as well, it is reasonable to postulate a difference in processing strategies during first and second language acquisition, reflecting a developmental change in cognitive maturity (Hatch, 1977; Rosansky, 1975). The effect of these two factors – neurological age and cognitive maturity – would give rise to the following prediction: the pattern of hemispheric involvement of balanced bilinguals will more closely resemble that of monolinguals of the same age the earlier second language acquisition takes place, and will differ from that of monolinguals the later the second language is acquired.

Seven studies in the experimental literature are of particular relevance to this hypothesis. Genesee, Hamers, Lambert, Mononen, Seitz and Starck (1978) examined salient indices of the average evoked responses recorded from the left and right hemispheres of subgroups of French-English balanced bilingual adults during a language recognition task. They found that latencies to the N1 and N2 components, which provide a measure of speed of neural response, were shorter in the left hemisphere of bilinguals who had acquired their second language in infancy or in early childhood, but shorter in the right hemisphere of bilinguals who had acquired the second language after the age of 12. The generalizability of the Genesee et al. findings may be limited, however, in light of the small sample size, lack of monolingual controls, and unequal sex composition. A study by Vaid and Lambert (1979), in which these factors were taken into account, replicated the findings of Genesee et al. using an auditory interference paradigm and, in addition, found a sex difference whereby females appeared to be less lateralized than males. A dichotic study with French and English monolingual and bilingual children found no group differences in accuracy of recall per ear of words in the two languages (Bellisle, Note 4). Another DL study, comparing monolingual Anglophone school children with native English-speaking children receiving extensive instruction in French and Hebrew, reported a comparable performance by both groups for English words (Starck, Genesee, Lambert & Seitz, 1977). The DL performance of the bilinguals on their other languages was unfortunately not studied. In a dichotic study of bilingual adults in Israel varying widely in language acquisition histories, a subgroup of proficient English-Hebrew late bilinguals tended to show a LEA, as compared to the REA of the group at large (Gordon, 1980).

In contrast to the findings of the studies discussed so far, those of two other studies are discrepant with the age hypothesis. In a tachistoscopic study of Portuguese-English late bilinguals, an equivalent RVF superiority for word recognition was noted in both bilinguals and in English monolingual controls (Soares & Grosjean, Note 6). In a DL study of early and late bilingual adults proficient in Estonian and Russian, Kotik (Note 5) reported a greater REA in the second language of the late bilinguals as compared to the performance of the early bilinguals in the same language.

In sum, the evidence pertaining to the issue of age of second language acquisition generally supports the hypothesis that hemispheric processing of language in early bilinguals resembles the pattern characteristically noted in monolinguals, but that late second language acquisition engages the two hemispheres differently.

Stage of second language acquisition. While the studies reviewed in the previous section focused on the balanced bilingual state, several other studies have examined the pattern of hemispheric involvement during second language acquisition (Galloway & Krashen, 1980). Current psycholinguistic research suggests that the strategies used by learners in their early stages of second language acquisition, as reflected in their language performance, are compatible with the demonstrated linguistic capabilities of the right hemisphere (Galloway, Note 1). In particular, it has been shown that the speech production of beginning second language learners, adults as well as children, consists of highly contextualized formulaic utterances (Scarcella, 1979; Wong-Fillmore, 1979) and that their speech comprehension relies more on content than function words, prosodic rather than phonetic features, and pragmatic rather than syntactic information (McLaughlin, 1978). These components of language are believed to be within the competence of the right hemisphere (Blumstein & Cooper, 1974; Searleman, 1977; Zaidel, 1978a, b; Zurif, 1974).

The apparent compatibility between right hemispheric processing of language and strategies adopted by beginning second language learners has led to the following hypothesis: right hemispheric processing is more evident in the initial than final stages of second language acquisition (Krashen & Galloway, 1978; Silverberg, Bentin, Gaziel, Obler & Albert, 1979). An ideal test of this hypothesis would require tracing the relative participation of the two hemispheres of the same learners at various levels of proficiency in the second language. This has seldom been undertaken in the literature to date (but see Wesche & Schneiderman, Note 7). The stage hypothesis has typically been tested by comparing hemispheric involvement during first and second language processing of subgroups of bilinguals who differ in their second language proficiency; the hypothesis would lead one to predict greater right hemispheric involvement in the less proficient language.

In a preliminary report of a DL study, Bever (1974) noted that bilingual Hispanic-English children showed no significant ear differences for English, their less proficient language. Kotik (Note 5) reported that a subgroup of Estonian-Russian bilinguals tended to show a smaller ear difference on a DL task in their second, less proficient language, as compared to that in their first; this effect did not reach statistical significance. In a pilot DL study of Hebrew and English bilinguals, Obler, Albert and Gordon (Note 8) reported that non-proficient English-Hebrew (but not Hebrew-English) bilinguals showed a greater REA in their first than in their second language. However, this effect was not replicated in a later extension of the pilot work (Albert & Obler, 1978), nor was the significance level reported in either study.

Maitre (Note 9) compared the DL performance of groups of native English-speaking college students enrolled in intermediate and advanced level Spanish courses. Both groups showed a significantly larger REA for English than Spanish words, but demonstrated an equivalent REA for dichotically-presented sentences in the two languages. The size of the ear asymmetry for Spanish words and sentences was equivalent to that observed for native Spanish-speaking controls (Maitre, Note 9). That the bilingual subjects had a greater REA for words in their first relative to the second language is consistent with the stage hypothesis. It is possible, however, that the results may reflect a language-specific effect; that is, the English items may simply have been more conducive to left hemispheric processing for some unknown reason. Since Maitre did not test monolingual English controls, one cannot rule out this hypothesis. It seems an unlikely explanation in view of a DL study by Galloway (Note 1), who used stimuli similar to those of Maitre and found an equivalent REA for English words presented to English monolinguals and to Spanish-English non-proficient bilinguals. Unlike Maitre's study, however, that of Galloway found no evidence in support of the stage hypothesis, since she obtained an equivalent REA for words in both first and second languages in the bilingual group, which was, in turn, equivalent to the size of the ear asymmetry found in both English and Spanish monolingual controls (Galloway, Note 1).

Gordon (1980), as well, did not find a significant difference in the size of the REA between highly proficient and less proficient groups of Hebrew and English bilingual adults. He also investigated the variable of length of use of the second language, an indirect index of stage of language acquisition, but, again, found no evidence for a differential laterality effect – the size of the REA was the same regardless of whether the subjects had used their second language for two years or for twenty years. Gordon's findings may be misleading, however, in view of the fact that responses of the Hebrew-English and English-Hebrew groups were not considered separately even though, as he noted, these groups differed appreciably both in their criteria for self-ratings of proficiency and in the manner in which their second language had been acquired.

Piazza and Zatorre (Note 10) examined the performance of native Spanish-speaking children from two age groups who were attending a Spanish-English bilingual education program. The results of a DL experiment indicated an equivalent REA for Spanish and English words for both groups. The size of the ear asymmetry was independent of the children's proficiency, as measured by their overall accuracy on the English words used in the DL test.

Using a tachistoscopic procedure, Kershner and Jeng (1972) compared the visual field asymmetries of nonproficient Chinese-English bilinguals in the recognition of words in their two languages. A significant RVF superiority was found for both Chinese and English words under unilateral and bilateral viewing conditions. In another study of Chinese-English bilinguals, Hardyck, Tzeng and Wang (1978) measured reaction times for same-different meaning judgments to within- and cross-language word pairs, none of which were repeated. No significant visual field differences were found. A group of English monolinguals were presented with a smaller set of Chinese and English word pairs that were repeated in order to test out the possibility that laterality differences may reflect differences involving the storage of information. The results of a same-different language judgment task revealed a RVF preference for English words and a LVF preference for Chinese words. Whether Chinese-English bilinguals show similar hemispheric differences in storage is unknown since the bilinguals were not tested on the repeated stimulus list.

Also using a tachistoscopic paradigm, Silverberg et al. (1979) undertook a cross-sectional study of the stage hypothesis. Subjects were Hebrew-speaking school children in grades 7, 9, and 11, who had been studying English as a second language since grade 5. All subjects showed a significant RVF preference for unilaterally presented Hebrew words. English words, however, produced a LVF preference that was most evident among the grade 7 subjects, and diminished in the higher grade levels. The finding of a significant LVF superiority for English words obtained in the group with the least experience in English would tend to support the stage hypothesis. However, since the Hebrew children were exposed to English primarily in a school setting, which, in turn, mainly emphasized reading, it is possible that the presumed right hemisphere effect that Silverberg et al. (1979) report is limited to the initial stages of reading; the right hemisphere has been implicated in the acquisition of reading skills in the first language (Silverberg, Gordon, Pollack, and Bentin, Note 11). The generalizability of the findings of Silverberg et al. is further restricted since the age of the subjects was confounded with their length of exposure to the second language. It is questionable, moreover, to propose a shift in hemispheric processing on the basis of cross-sectional evidence since one cannot rule out the possibility that the older, more proficient subjects would not have shown a RVF preference even when younger and less proficient. Finally, the existence of the presumed shift is itself questionable; while 83% of the grade 7 subjects showed a LVF preference for English words, only 54% of the grade 11 subjects showed a RVF superiority, clearly not much greater than what would be expected by chance alone.

To conclude, five studies have provided evidence supporting the stage hypothesis (Bever, 1974; Kotik, Note 5; Maitre, Note 9; Obler et al., Note 8; Silverberg et al., 1979), although two of these (Maitre, Note 9; Obler et al., Note 8) failed to be replicated. A far greater number of studies provide evidence against the hypothesis. Six studies have reported an equivalent pattern of hemispheric involvement in both the first and second language of non-proficient bilinguals (Albert & Obler, 1978; Galloway, Note 1; Gordon, 1980; Hardyck et al., 1978; Kershner & Jeng, 1972; Piazza & Zatorre, Note 10). If the right hemisphere is indeed involved to a greater extent in the initial stages of second language acquisition, the DL method, as employed in most of these studies, would not seem to be a sensitive indicator of its involvement (cf. Galloway, Note 1). Four additional studies have implicated right hemispheric involvement in the second language of proficient bilinguals (Genesee et al., 1978; Gordon, 1980; Kotik, Note 5; Vaid & Lambert, 1979), suggesting that right hemispheric involvement may persist even in the final stages. In its present form, the stage hypothesis cannot accommodate such a possibility.

Manner of second language acquisition. A number of studies have suggested that the manner in which a second language is acquired may have implications for differential hemispheric involvement in second language processing. Krashen (1977) has proposed a useful distinction in this regard between formal and informal modes of language acquisition. Formal language acquisition, or what Krashen terms language learning, is characterized by contexts in which there is an emphasis on the structure of language through, for example, rule isolation and error correction. Such an approach is thought to engender in the learner an awareness of language as an abstract, rule-governed system. Informal language acquisition, on the other hand, appears to require participation in naturalistic communicational settings (Krashen, 1977), and is thought to be characterized by a relatively unconscious internalization of linguistic skills through a process of 'creative construction' (Dulay & Burt, 1974), where the user's attention is directed more to the content than the form of linguistic utterences. It has been suggested that there is bilateral hemispheric processing of language prior to the age of 5 (Witelson, 1977), a period during which language is typically acquired informally. Stable left hemispheric superiority for certain linguistic skills emerges around the age of 5 or later, and appears to correspond to an increasingly formal mode of language processing (Rosansky, 1975). In the case of second language acquisition, one might accordingly hypothesize less left hemispheric participation if acquisition is informal and greater left hemispheric involvement if acquisition is formal (Carroll, 1980).

In a test of this hypothesis, Hartnett (1976) used a conjugate lateral eye movement paradigm (see Ehrlichman & Weinberger, 1978, for a review) to compare the performance of two groups of native English speakers who were receiving different methods of instruction in Spanish. The results indicated that students exposed to a relatively deductive method showed significantly more rightward eye movements, implicating left hemispheric activity, than those exposed to an inductive method, but this was true only of the successful learners in each group (Hartnett, 1976). To this extent, the findings support the manner of acquisition hypothesis. Another study examining the variable of method of instruction failed to support the manner hypothesis in that both students from a direct method and those from a programmed method of Spanish instruction showed a smaller REA for Spanish than English words (Maitre, Note 9). However, the fact that nearly a third of the students had been taught in both methods precludes any generalization with respect to the manner variable.

Kotik (Note 5) reported that whereas Russian-Estonian bilinguals showed an equivalent REA in their first and second languages, a group of Estonian-Russian bilinguals showed a greater REA for words in their second language. This effect reached significance in a subgroup that was most proficient in Russian; the subgroup that was least proficient in Russian showed a non-significant trend for a larger REA in the first than in the second language. Kotik attributed the differences between the Estonian-Russian and Russian-Estonian groups to the fact that the majority of the native Estonian bilinguals reported using Russian primarily in an educational setting, whereas the majority of the native Russian group reported using Estonian for communication. That the two groups also differed in their relative age of second language acquisition may also have contributed to the pattern of results. Carroll (1980, Exp. 2) similarly reported a significantly greater REA in the second language for a group of English-Spanish bilinguals who had had formal instruction in it; a subgroup who had learned Spanish informally tended to show a weaker REA, the size of which increased with the subjects' age.

Gordon (1980) reported that non-proficient Hebrew-English bilinguals showed a significantly greater REA in their second than in their first language. A more proficient English-Hebrew group, on the other hand, did not show such a difference, and tended, instead, to show less left hemispheric lateralization in both languages. Gordon suggests that in Israel native Hebrew speakers typically learn English in school and have little occasion to use it in non-academic settings, whereas native English speakers have far greater opportunities for acquiring and using Hebrew in naturalistic settings. Interestingly, a group of proficient Hebrew-English bilinguals from the United States tended to show less left hemispheric lateralization in both their languages, comparable to the performance of English-Hebrew speakers in Israel (Gordon, 1980).

To conclude, the available neuropsychological evidence pertaining to manner of second language acquisition supports the hypothesis that, to the extent that method of instruction may influence manner of acquisition, involvement of the left hemisphere will be greater for formally than informally acquired languages. The evidence suggests, in addition, that manner of second language acquisition may interact with age and proficiency. The nature of these and other interacting effects will be addressed in the following section.

Hemispheric Involvement in the Language Processing of Bilinguals: A Model

In light of the evidence currently available, an empirical model of hemispheric involvement in second language processing of bilinguals can be proposed. According to the model, right hemispheric involvement will be more likely the later the second language is learned relative to the first, the more informal the exposure to the second language, and, possibly, the earlier the stage of language acquisition. Left hemispheric involvement is more likely the earlier the second language is learned relative to the first, the more formal the exposure to the second language, and the more advanced the stage of acquisition. A tenet of the model is that the more similar the conditions of first and second language acquisition, all other things, e.g., language-specific and constitutional factors, being equal, the greater the likelihood that bilinguals will show comparable patterns of hemispheric involvement in processing their two languages. Conversely, the less similar the conditions of language acquisition, the greater the likelihood of dissimilar patterns of hemispheric involvement. The dissimilarity will reflect a complex interaction of the effects of age, stage and manner of second language acquisition, in addition to the main effects that have been outlined already for these factors.

Thus, right hemispheric involvement would be more likely in the initial stages of second language acquisition the younger the learner (cf. Silverberg et al., 1979) and less likely the older the learner (cf. Galloway, Note 1) insofar as adults, relative to children, are more likely to use a formal mode of processing language, reflecting their more advanced stage of cognitive development. In the final stages of second language acquisition, the relative pattern of hemispheric involvement in both children and adults would correspond mainly to differences in how proficiency in the second language was achieved. Thus, as in the case of Carroll (1980, Exp. 2) and Kotik (Note 5), the more formally the second language is learned, the greater the likelihood of left hemispheric involvement. Conversely, as in the case of Genesee et al. (1978), Vaid and Lambert (1979) and the English-Hebrew bilinguals studied by Gordon (1980), the more informally the second language is acquired, the greater the likelihood of right hemispheric involvement.

The account presented above by no means exhausts the set of possible combinations of age, stage and manner of acquisition. It would be difficult to predict the direction that other combinations may take (for example, early formal instruction in the language) since one cannot know, a priori, how the particular factors (e.g., age and manner) are weighted. Thus, the nature of other possible interaction effects may only be assessed through further empirical investigation.

DISCUSSION

The most striking feature of the findings to emerge from studies of bilingual/polyglot aphasia is their extreme variety and complexity, which, as Paradis (1977) has noted, at times verge on the 'imponderable.' This complexity is most impressive when one examines individual cases of bilingual/polyglot aphasia and is much less evident when viewed in the context of unselected cases. While investigations of the differential cases will probably always be of research interest for their own sake, their relative importance for our understanding of neuro- and psycholinguistic aspects of bilingualism could change considerably when more accurate estimates of their prevalence are available.

A pervasive and fundamental problem that has traditionally characterized investigations of polyglot aphasia, and continues to do so, has been the lack of adequate information concerning the patients' neurological and psycholinguistic condition. While historically it can be said that sophisticated procedures have not been available to carry out adequate neurological examinations, this is no longer true. Moreover, the perennial problem with the lack of diagnostic tests in many languages should receive some relief from the multilingual aphasic test battery which has been prepared by Paradis (Paradis & Lecours, 1979).

Continued cataloguing of exemplary individual cases of previously established possibilities seems of limited value at this time. If single case studies must continue to be reported, then there must be much more systematic, careful, linguistic and neurological assessments made of the patients, and much more rigorous hypothesis testing of the resulting information. It seems of questionable utility to re-examine existing case studies to test out new, or old, hypotheses. As has already been mentioned repeatedly, most extant case studies do not meet basic criteria of neurological and linguistic adequacy and, therefore, are not likely to serve sophisticated hypothesis testing well.

If studies of polyglot aphasia are going to advance our knowledge of brain-language relations in bilinguals, fundamental changes in approach will be required. It would seem important that studies of aphasia in polyglots move away from the traditional case study approach to incorporate experimental or quasi-experimental methods (see, for example, work by Goodglass, as reviewed by Caramazza & Berndt, 1978, and B. Milner, 1975, and their colleagues for research models of this sort). Studies by Ojemann and Whitaker (1978) and Pettit and Noll (1980) who have used electrical stimulation techniques and dichotic listening procedures, respectively, also represent promising approaches.

Finally, it would seem desirable to begin to examine issues of language organization in bilinguals suffering from aphasia irrespective of issues concerning brain-language relationships, which have been the preoccupation to date. Paradis (1980), for example, has made steps in this direction, although, owing to the poverty of existing data, the conclusions that can be made now are of a fairly rudimentary nature.

The laterality literature on neurologically-intact bilinguals, albeit fairly recent in comparison to the bilingual aphasia literature, has, nevertheless, grown at an astonishing rate, and promises to expand even further. Like its clinical counterpart, the experimental bilingual literature is striking in its diversity, both methodological and theoretical. Of the variety of language-specific and language-acquisitional factors that have been proposed, not all have received the same attention, nor have all recieved the same support. Thus, it may be premature to draw more than tentative conclusions from the available evidence. Future studies should investigate possible factors under more carefully controlled conditions than have characterized the studies in the literature to date.

The focus of this paper has been on factors that are unique to the bilingual situation. However, a comprehensive theory of hemispheric processing of language in bilinguals will also have to incorporate those factors that are common to bilinguals and monolinguals, such as handedness (Andrews, 1977; Albert & Obler, 1978; Obrach, 1967) and sex differences (Gordon, 1980; Vaid & Lambert, 1979; Waber, 1977), which have been shown to influence the pattern of laterality in both monolinguals and bilinguals.

To the extent that studies of cerebral lateralization in bilinguals have adopted the paradigms used in the laterality literature on monolinguals, they are subject to the same methodological criticisms that have been directed at studies using monolinguals (cf. Bryden, 1978). An issue that is particularly relevant to bilingual studies is whether it is justifiable to infer group differences in degree of underlying cerebral lateralization on the basis of differences in the size of ear or visual field asymmetries (Colbourn, 1978). Another problem concerns inferences made about language processing on the basis of fairly crude verbal stimuli. That the dichotic listening and tachistoscopic viewing procedures commonly used in both monolingual and bilingual laterality research are amenable to more sophisticated linguistic examination is suggested by the work of Berlin on acoustic and phonetic parameters (Berlin & McNeill, 1976), that of Zurif (1974) on prosodic and syntactic factors and that of Zaidel (1978b) and others (Vaid, Note 12) on lexical characteristics.

In addition to exploring the upper limits of the standard techniques, further research in this area might benefit from examining alternative methods of measuring hemispheric involvement that impose fewer constraints on the types of stimuli and tasks that may be employed. Two approaches that appear particularly promising include prolonged visual hemifield exposure afforded by a special contact lens procedure (Zaidel, 1978a) and electrophysiological monitoring of hemispheric activity during ongoing language processing (Neville, 1974).

Advances in research methodology are of value only to the extent that they are accompanied by corresponding theoretical advances in our conceptualization of the nature of hemispheric differences. To this end, further research on hemispheric processing of language in bilinguals may contribute some useful insights.

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