Cerebral Lateralization, Preferred Cognitive Mode and Reading Achievement in American Indian Bilingual Children

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Although it is generally accepted that the left cerebral hemisphere is dominant for language in most people, the nature of the relations among cerebral dominance for language, academic performance, and preferred cognitive mode remains controversial. As early as 1937, Orton suggested that a strong left hemisphere dominance would be reflected in excellence of verbal functions such as reading.[1] However, cerebral dominance studies conducted with bilinguals seem to indicate that language for them may be more diffusely organized. Albert and Obler proposed a stage hypothesis in which there was participation of the right brain hemisphere in the initial stages of learning a second language with increasing left hemisphere participation as proficiency developed.[2] Unfortunately, further research evidence and a comprehensive review of over one hundred studies of the bilingual brain by Galloway in 1982 have failed to support the stage hypothesis.[3] Nevertheless, it seems evident that bilinguals do show greater right hemisphere participation in language, but how this is related to cognitive style preference and academic performance remains a question.

American Indian bilingual groups have consistently shown a greater right hemisphere involvement in language.[4] Rogers et al. propose that the structure of some Amerindian languages corresponds to an appositional mode of thinking associated with the right brain hemisphere. For example, there is a greater concern with concrete notions rather than with abstractions; there is a projection of subjective experience to outside influences (i.e., I am drowning → water is drowning me); and modified verbs and participles rather than nouns and adjectives assume importance. Navajo handling verbs require a selection process whereby the verb stem differs if the object referred to is long, small, rounded, clustered, bundled up, alive, or inanimate. The Navajo speaker must be fully aware of the perceptual field and concentrate on the physical characteristics of the object rather than its name. In English we say, "Give me the rock, stick, paper, etc." In Navajo a speaker must decide on the object's characteristics before selecting a verb form:[5]

shaa nî'aah · single, hard, bulky object
shaa nîtiih · single, slender, stiff
shaa nîɁtsoos · single, flat, flexible
shaa nîlé · single, slender, flexible
shaa nîjááh · plural, profusion
shaa nîɁjooɁ · non-compact matter
shaa nîtleeh · mushy matter
shaa nîyeeh · load, pack, burden
shaa nînîîɁ · plural, slender, flexible
shaa nîɁteeh · single, animate

Because of the appositional characteristics of Navajo, it is hypothesized that Navajo-English bilingual children will show a greater right hemisphere participation in language than is generally found in monolingual children.

A second notion that bears upon bilingual cognitive strategies is offered by Galloway who sees language as consisting of two factors: linguistic competence (grammar) and communicative competence (nonverbal, interactional, context-dependent abilities).[6] The communicative competence is highly dependent upon neural substrates lateralized in the right brain hemisphere such as perception of facial affect, tone of voice, and linguistic gesture. Galloway proposes that there is a relationship between minority group membership and patterns of cerebral asymmetry. She states that members of bilingual minorities who are unacculturated and socially less powerful in the surrounding Anglo majority world but who are under pressure to assimilate will show greater right hemisphere involvement in language processing. The suggestion is made that the person who must function in two or more languages may have to develop a greater pragmatic flexibility and sensitivity to interactional cues in order to support and maintain communication. No claim is made that the actual left lateralization of the linguistic grammar is altered or that the brain has such plasticity that

the linguistic grammar is suddenly shifted toward the right. Right hemisphere language would be a reflection of a cognitive strategy adopted to increase available communicative cues.

This study examines the relations among sex, school grade, verbal dichotic listening asymmetry, cognitive strategic preference, and reading ability in Navajo-English bilingual children and attempts to compare the findings with those of Caplan and Kinsbourne in their research with monolingual children.[7] Therefore, the following hypotheses are also investigated:

1. Bilingual children who are more highly left hemisphere lateralized for language on the dichotic listening test will show a stronger preference for verbal strategies on cognitive style measures.
2. Bilingual children who prefer the verbal mode on cognitive style measures will demonstrate reading achievement superior to that of the children whose preference is for a nonverbal mode of information processing.
3. Children in the lower grades will display a greater preference for nonverbal stragegies than older children.
4. Females will show a greater preference than males for verbal strategies and will display reading achievement superior to that of males.

The subjects were 78 Navajo-English students in an isolated Bureau of Indian Affairs boarding school on the Navajo Indian Reservation. All instruction at the school is in the second language (English); however, all social interaction is in Navajo. The students are from the most traditional area of the reservation where pressure for assimilation is felt, but where there has been relatively little acculturation. The group included 35 boys and 41 girls in grades 3 to 8 (23 in grades 7-8, 27 in grades 5-6, 28 in grades 3-4). The mean age was 10.6. An eight-item handedness measure was administered in both languages to eliminate subjects with a left hand preference.

Test Instruments

Dichotic Listening (Navajo Word Test and English Word Test)

An 80-item Navajo word test and a 74-item English word test was administered to each student. Word pairs were matched for syllable length. Six practice items familiarized the children with the procedure. Headphones were reversed to control for variation in channel intensity. Half the children heard the Navajo test first and half the English test first. The children were told to report both words if possible.

Cognitive Mode (Auditory and Visual)

Word-Shape Sorting: This test was used in the research of Caplan and Kinsbourne in 1981. The child selects the one item of three that does not fit with the other two. The two equally correct responses indicate a preference for visual-spatial processing (on the basis of shape) or visual-verbal processing (on the basis of words). The test was administered in English only as the students were not literate in Navajo.

Auditory Style Test: This test was based upon one used by Gross, Franko, and Lewin (1978).[8] The child selects two verbal items that "go together" from three words heard. The two equally correct responses indicate a semantic preference (synonyms or category relationship) or a nonsemantic preference (rhyme). This test was administered in both Navajo and English since it is entirely verbal.

Reading Achievement (California Test of Basic Skills, CTBS)

A reading achievement score was obtained from students' performance on the California Test of Basic Skills that was administered to all of the boarding school students immediately prior to this project. The test is entirely in English and the bilingual students who are from a minority language and culture consistently perform below grade norms. For example:

Grades	Grade Mean	CTBS Reading	CTBS Math	CTBS Combined
3-4 (n=28)	3.35	2.38	3.02	2.55
5-6 (n=27)	5.44	3.57	4.51	4.04
7-8 (n=23)	7.30	4.48	6.19	4.67

Results

The data for the total sample were analyzed by correlational methods, ear-differences on dichotic listening were determined by *t* tests, and sex and group (3-4th grade, 5-6th grade, 7-8th grade) comparisons were made by analysis of variance.

A strong right-ear advantage, indicating left hemisphere lateralization for language, was obtained on the English dichotic listening task for the entire sample ($t = 3.56$, $p < .001$). However, for the Navajo dichotic listening task, there was no significant difference in right and left ear scores indicating a greater right hemisphere participation in Navajo. Comparisons of the Navajo and English ear difference scores indicate that although there is relationship between the two measures ($r = .329$, $p < .002$), students are significantly less left hemisphere lateralized for Navajo than for English ($t = -2.32$, $p < .02$). When the three age groups are considered, there was no significant developmental increase in the size of the right ear advantage for either language (Navajo, $F = .679$, N.S.; English, F, $= .058$, N.S.).

Table 1

Correlation Matrix, Total (N = 78)

	Age	Navajo Lateral-ization	English Lateral-ization	Visual-Verbal Preference	Auditory-Verbal Preference/English	Auditory-Verbal Preference/Navajo	CTBS Reading
Age		-.0946	-.1025	.1924*	.2901**	.3732**	.6616**
Navajo Lateralization			.3297*	-.2340*	-.0380	.1113	-.0501
English Lateralization				.0308	-.0203	.0407	-.0528
Visual-Verbal Preference					.1761	.0803	.4430**
Auditory-Verbal Preference/English						.6396**	.2508*
Auditory-Verbal Preference/Navajo							.3585**
CTBS Reading							

*p .05.

**p .01.

Correlational data for the total sample is presented in Table 1. There is a highly significant correlation between strength of verbal performance on all visual and auditory cognitive style measures and performance on the CTBS reading measure. However, there is no indication of a relationship between the visual and auditory cognitive style measures indicating that they may be measuring separate aspects of cognitive style preference. Dichotic listening measures are unrelated to reading performance, but the Navajo dichotic listening measure is negatively correlated with performance on the visual-verbal preference measure.

No sex differences for verbal preference were found; however, a significant developmental increase in verbal preference on the auditory cognitive style measures was obtained for the sample as a whole (Navajo-Auditory, $F = 4.506$, $p < .01$; English-Auditory, $F = 7.131$, $p < .01$). No developmental increase occurred for the visual-verbal preference measure. Significant developmental increases were evident for the CTBS reading scores as was anticipated.

Given that verbal strategic preference correlates significantly both with age and reading ability, and the age-related improvement in reading, the association between cognitive style and reading could be a consequence of a common association with age. Therefore, as in Caplan and Kinsbourne's analysis, partial correlations were calculated to eliminate reading age (grade equivalent) and chronological age.[9] Results for the English language cognitive style measures are consistent with previous findings that greater preference for verbal strategies accompanies better reading, regardless of age. However, this does not hold for the Navajo cognitive style measure where greater preference for verbal strategies does not accompany better reading but is based upon age and reading proficiency.

Discussion

Caplan and Kinsbourne suggest that the nature of the problem-solving strategy adopted may affect the size of the observed lateral bias. If a strategy is selected which has a predominantly lateralized neural substrate, then one hemisphere will be preferentially activated. However, some tasks may be adequately accomplished by more than one strategy and a strategic choice may be relatively stable across situations regardless of cognitive demands of the task.[10] Therefore, it is possible to speculate that Navajo-English bilinguals, although anticipating verbal input in Navajo, may preferentially engage the right hemisphere and adopt a holistic, pragmatic, interactional strategy biasing attention to the left side of space. The degree of dichotic listening asymmetry becomes an index of differential hemispheric use without structural implications for the degree of lateralization of function. Initial preference for a particular mode may become habitualized, and there is some evidence that stylistic preferences may be learned.[11] If such is the case, the greater left lateralization for English may be a product of the classroom situation that is heavily biased toward a verbal mode with sequential, analytic processing.

The present finding of right hemisphere representation of language may be a reflection of the habitualized use of an interactional, nonverbal strategy to obtain additional cues from language input. Since the dichotic listening task is unfamiliar, the students may shift to a right hemisphere strategy to try to pick up additional cues. They may indeed not recognize the situation as a language task in Navajo while they assume all situations involving English are language tasks because of habitualized classroom experience.

Since the preference for verbal strategies was unrelated to the size of the left hemisphere lateralization, and there is no positive correlation between results on dichotic listening and verbal cognitive style preference, the current findings would support the notion that dichotic asymmetry is an index of differential hemisphere use without structural implications of function. Additionally, since asymmetry did not increase significantly with increasing age, results support earlier studies that argue for the existence in infancy of hemispheric specialization and stability of lateralization across ages.[12]

No sex differences on lateralization, cognitive style, or reading achievement were evident for the bilingual students although previous studies have generally reported greater verbal preference and advanced reading scores for girls and frequently stronger right ear advantages for boys. It is speculated that the English language barrier, Navajo cultural expectations, and the factor of minority group membership tend to override sex differences.

The pivotal variable, preferred cognitive strategy, was found to relate to reading performance. Preference for a verbal approach on both the visual and auditory cognitive mode tests is associated with better reading and the association is maintained when effects of ability and age are eliminated. Caplan and Kinsbourne suggest that performance is improved when task demands and cognitive bias are concordant. Therefore, a child who typically chooses verbal strategies will more easily grasp the nature of the "reading code."[13]