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Culture, Language, Spatial Frames of Reference and Hemispheric Dominance

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Abstract

A study was conducted in Varanasi with 376 boys and girls, aged 10 to 15 years, attending Hindi-medium or Sanskrit schools. In addition to language elicitation and spatial encoding tasks, Block Design and SPEFT were used as measures of psychological differentiation (field-dependence/independence). A structural link is found between these three areas of psychological functioning even when controlling for age, gender and schooling. A further study of a sub-sample of 80 children using neuro-psychological indicators of brain lateralization revealed Geocentric encoding to be linked to indictors of central brain lateralization but not to peripheral measures (hand, foot, eye and ear dominance).

Introduction

This paper reports a part of a larger research study carried out in Varanasi City. The purpose is to examine the linkage between language, spatial frames of reference (FoR), and hemispheric dominance. It also explores the relationship of these measures with psychological differentiation (field independence/field dependence). The theoretical background and the general intent of the project have been described in Mishra and Dasen (this symposium). The focus of this paper is on structural dimensions of these measures and their linkages with hemispheric lateralization.

Literature on language socialization indicates that language is largely a product of parent-child interaction particularly in early years (Bates, Dale & Thal, 1995; Harris, 1992; Snow, 1995). In later years other influences (e.g., peers, teachers) may also shape language development. This indicates that there may be different routes into language (and cognition, if it is linked to language) for different individuals, with different patterns of causation along the way (Bates et al, 1995). Studies distinguish between "expressive" and "referential" uses of language. While almost all individuals seem to function adequately in both, the use of referential language seems to be highly correlated with cultural features on the one hand and cognitive functioning on the other (Gumperz & Levinson, 1996; Levinson, 2003; Werner & Hubel, 1999).

A striking feature of the work on spatial cognition is the diversity of tasks and mental processes subsumed under this term (Linn & Peterson, 1985). Involvement of different brain structures makes it even more complex. As a result, many researchers define spatial cognition in terms of the tasks that are processed predominantly by the right hemisphere. Neuropsychological studies of spatial cognition generally hold on to the hemispheric lateralization hypothesis. Witelson and Swallow (1988) have presented an overview of the tasks that clearly involve a strong spatial component and are processed by the right hemisphere of the brain. They have also made reference to some tasks that are characterized by seemingly a strong spatial component, but are found to be more dependent on the left than right hemisphere. This makes prediction of spatial cognition difficult in terms of hemispheric lateralization theory.

Recent advances in neuroimaging have made it clear that both hemispheres of the brain are active in almost all tasks (e.g., Grimshaw, 1998; Sergent, Ohta, & Mac Donald, 1992), but there is some sort of division of labor between these coordinated hemispheres. This is accomplished by dividing stimulus inputs: the right hemisphere deals with information in the left visual field, and the left hemisphere deals with information in the right visual field. It is also indicated that the same type of processing may occur in each hemisphere with distinctive qualitative differences, and that the corpus callosum aids parallel processing by shielding each hemisphere from the other until some late integration stage (Chiarello & Maxfield, 1996). Task characteristics may play an important role in determining the process of integration and the efficiency of one hemisphere over another in dealing with information. Thus, tasks that require processing in terms of global features (e.g., recognition of male or female faces) may not reveal distinctive superiority of one hemisphere over another. On the other hand, tasks that require processing in terms of analytic features (e.g., words related to different semantic categories) may reveal distictive superiority of the right over left hemisphere in terms of efficiency (quicker processing) in dealing with stimuli.

Research on spatial cognition in Nepal (Niraula, 1998; Niraula & Mishra, 2001) suggests that children, who are psychologically more differentiated, use predominantly an absolute frame (NSEW) to describe spatial information, whereas those who are less differentiated describe spatial information predominantly by using a relative frame (LRFB). Witkin & Goodenough (1981) cite studies that tend to support the hemispheric lateralization hypothesis of psychological differentiation. Children, who perform cognitive tasks in a more differentiated manner, demonstrate a right hemispheric dominance, whereas those who perform cognitive tasks in a less differentiated (global) manner demonstrate a left hemispheric dominance. Taylor and Tversky (1996) suggest a probable linkage between the predominant spatial reference system (encoding) and hemispheric lateralization, but convincing data in this respect are lacking.

In the present paper we have attempted to examine the relationship between language, spatial frames of reference (FoR), psychological differentiation (field independence -field dependence) and hemispheric lateralization. It was hypothesized that there will be a structural link between geocentric language, absolute spatial FoR, psychological differentiation and hemispheric lateralization. It was also expected that this relationship would stand even when controlling for age, gender and schooling. It was further posited that superiority of right over left hemisphere would be evident particularly in processing categorical information on a verbal task more efficiently than in processing distinctive features of male or female faces.

Sample

The study was carried out with 376 boys and girls, aged 10-15 years, attending Hindi-medium and Sanskrit schools. Sample characteristics are given in Table 1 along with the total number of children tested in each type of school. The schools are described in Vajpayee et al (this symposium).

Table 1: Sample characteristics

		Gender			Total
	Age	Boys	Girls	Total	
Hindi-medium schools	11	9	30	39	
	12	26	59	85	
	13	9	46	55	
	14	5	31	36	
	15	0	6	6	
	Total	49	172	221	
Sanskrit schools	10	2	0	2	
	11	6	3	9	
	12	35	5	40	
	13	49	6	55	
	14	30	7	37	
	15	3	9	12	
	Total	125	30	155	376

Tasks and Tests

In addition to language elicitation and spatial encoding tasks described in Mishra and Dasen (this symposium), the following tests were also used.

Psychological differentiation

Psychological differentiation (field-dependence/ independence) was measured with the help of Block Designs Test and Story-Pictorial Embedded Figures Test (SPEFT). *Block Desings Test* (Koh's Blocks) involved construction of pictorially presented designs of increasing difficulty with the help of 4, 9 and 16 blocks within specified periods of time. Both time and accuracy of performance were recorded. A short (10 designs) version of the test (Mishra, Sinha & Berry, 1996) was used.

The *SPEFT* (Sinha, 1984) comprised seven sets of pictures. Each set consisted of a simple and a complex card. In the simple card some objects and animals were depicted, which were embedded in a larger situation depicted in the complex card (e.g., squirrels on a tree). The child had to locate within maximum 90 seconds the objects and animals of the simple card in the complex card in the background of a story that was narrated with each card to encourage the child to locate the embedded items. Time taken and the number of objects correctly located by the child were recorded.

Hemispheric lateralization

This included a peripheral and a central measure. The *peripheral measure,* called handedness, was adapted from Mandal, Pandey, Singh and Asthana (1992). It consisted of a number of tasks that the child could do with hand, foot, eye or ear. Children were first asked about their preference to do the task with the left or right limb/organ, and whether they would choose right or left "always" or "sometimes". Then they were asked to perform the tasks (there were separate tasks for hand, foot, eye and ear). The use of the right or left limb/organ was recorded.

The *central measure* consisted of a brain lateralization task administered with the help of a laptop using a programme developed by Mandal (personal communi-cation). It used the "split-field" technique in which the child was asked to concentrate on a black spot that appeared in the centre of the computer screen. Then an arrow appeared that pointed either to the left or right in a random order. The child was asked to look at the object or the word that appeared in the direction the arrow pointed to. The child's hand was placed on a key that was to be pressed as soon as the stimuli pointed by the arrow was correctly recognized. The presentation time of each stimuli was 180 milliseconds. The child's reaction time to stimuli presented to left and right was assessed with the help of the computer programme. Accuracy of response was recorded manually on a sheet developed for that purpose. In one sequence of trials, the child responded to words of objects or animals. In another sequence, responses for male or female faces were obtained. Before conducting the test, the child was given practice trials to make sure that responses were not made just randomly; the eligibility criteria was eight correct responses out of twelve presentations during practice trials.

Procedure

The study was carried out in two phases. In the first phase, all tests, except the brain lateralization measure, were administered to children, generally in two or more sessions. Based on their performance on language elicitation and language encoding tasks, we attempted to classify them as using either a "geocentric" (G) or an "egocentric" (E) frame of reference. In this classification, consistency in correct language use and encoding were considered separately. Of the 376 children tested in the first phase of the study only 86 were found to fulfil these criteria. For the G language group, there had to be at least 5 out of 6 G items on Encoding tasks, at least 6 out of 7 on Road, and 6 out of 9 on Perspectives. For E language group, there had to be more than 2/6 E items on Encoding, 3/7 on Road and 3/9 on Perspectives. There were 28 subjects who demonstrated consistent use of G language and 16 who used E language consistently.

In terms of encoding, 13 subjects showed completely G encoding on Animals (on the 7 items), completely on Chips (also 7 items), and 3 or more G on Steve's Maze. There were 14, called "mainly G" the criteria for whom were less stringent (5 G items out of 7 on Animals, 6 out of 7 on Chips, and 2 or more on Steve's Maze). Another 25, called "mainly E", had more than 3 completely E encodings on Animals and on Chips, and 2 or more E on the Steve's Maze.

Using the above stated language and encoding criteria 86 children were selected for administration of the brain lateralization measure. Unfortunately 6 of them were no longer available for testing; this reduced the sample size to 80 in the second phase of the study. In addition to the brain lateralization measure, a child questionnaire and a home questionniare were administered to children and parents to assess a number of socio-environmental variables that might be linked to G or E FoR, but this part is not reported in this paper.

Results

The language and encoding scores were derived from several measures that were reduced to factor scores by principal component factor analyses, and coefficients of correlation were computed across different factors (Table 2). The analysis revealed that not only G encoding and G language were positively and significantly related, but they were also correlated positively and significantly with FDI scores. These relationships were found to stand even after controlling for age, gender, preschooling, grade, years of schooling and school type (Table 3)

Hemispheric lateralization

Separate ANOVA were performed on preference and performance measures of peripheral lateralization (hand, foot, eye, ear); they revealed no significant differences either between encoding or language groups.

Analysis of brain laterality measures revealed no significant differences on accuracy scores indicating the pattern of performance for words and faces presented either to the left or right visual field to be almost similar across groups. ANOVA on Total Reaction Time computed for words and faces presented to right and left also revealed no significant difference for the language groups.

Table 2: Pearson Correlations between language, encoding and FDI

		Regression factor scores		
		G+ language	E+ language	FDI
G encoding	R	.455	-.334	.324
	Sig. (2-tailed)	.000	.000	.000
	N	375	375	375
G+ language	R		-.625	.191
	Sig. (2-tailed)	.	.000	.000
	N		376	376
E+ language	R			-.034
	Sig. (2-tailed)			.510
	N			376

Table 3: Partial correlations controlling for age, gender, preschooling, grade, years of schooling and school type

	G+ language	E+ language	FDI
G encoding	.27**	-.21**	.23**
G+ language		-.55**	.05
E+ language			.07

For encoding, ANOVA (Table 4) revealed one significant difference for Word left ($F_{2,49} = 3.86$, $p < .05$) in favour of G encoders. Other differences were not significant.

Table 4: ANOVA outcomes on brain lateralization measures, G and E encoding groups

		df	Mean Square	F	Sig.
Words right reaction time	Between Groups	2	85919772.315	2.131	.130
	Within Groups	49	40319844.657		
	Total	51			
Word left reaction time	Between Groups	2	159207329.359	3.855	.028
	Within Groups	49	41301112.122		
	Total	51			
Face right reaction time	Between Groups	2	397177.324	.051	.951
	Within Groups	49	7817764.327		
	Total	51			
Faces left reaction time	Between Groups	2	3950106.181	.917	.407
	Within Groups	49	4309852.387		
	Total	51			

Discussion

The findings of the study suggest that although the relationship between language and encoding is not perfect, G and E languages often go with G and E encodings of spatial arrays respectively. The relationship between G and E language is negative, and so is the relationship between G and E encoding. This finding may be taken to offer support to a moderate form of the linguistic relativity hypothesis (Niraula, Mishra, & Dasen, in press).

Analyses further suggest a structural link between G language, G encoding and FDI. This means that those who use G language and encoding also tend to be psychologically more differentiated. This supports the previous findings of Niraula and Mishra (2001) that suggested a significantly positive correlation of G language and encoding with SPEFT scores. While Niraula and Mishra (2001) also reported a significantly negative correlation of E language with SPEFT scores, the present findings suggested a very marginal negative correlation. It indicates that field independence (higher level of differentiation) is seemingly governed by the right hemisphere with which G encoding and G language use are also supposedly linked.

With respect to hemispheric dominance, the findings consistently show that in Varanasi, peripheral measures of lateralization are related neither to G language nor to G encoding. The pattern of results is the same for preference and performance measures. This suggests that users of G language and encoding do not differ signficantly in terms of peripheral aspects of brain functioning.

On the other hand, the central measures of brain lateralization do provide us with some evidence of difference between G and E in terms of the functioning of their right hemisphere. The difference in RT of G and E groups for words presented to the Left was significant, indicating a more efficient (quicker) processing by the G than the E group in the right hemisphere. This finding is understandable in view of the nature of the functioning of left and right brain hemispheres. Processing of faces takes place in a holistic manner (at a global level). This function is localized in the left hemisphere, which, according to the present findings, does not seem to differ between G and E groups in terms of its development. On the other hand, reading words, and processing them as “objects” or “animals” by hooking them with these conceptual categories requires a high level of analysis and abstraction. These functions take place in the right hemisphere, which, according to our findings, is more lateralized among G than E encoders. Consequently G encoders perform significantly more efficiently than E encoders when the words are presented to the left than to the right.

It may be mentioned here that the present study has attempted the analysis of brain lateralization only at the functional level. Hence, we cannot claim that the G and E encoders really differ with respect to structural or neural organization of the brain. As Witelson and Swallow (1988) inidcate, brain lateralization studies with normal subjects demand that before attempting to determine brain lateralization in a new group with a new task, certain conditions must be fulfilled. For example, it is necessary to ensure that the new task has been validated with individuals who can be claimed to have structural brain lateralization. If this condition is not fulfilled, it would not be possible to specify the mechanisms undelying differences in performance of subjects. Efficiency of performance on a cognitive task can be explained in terms of physiological mechanisms (e.g., differential neural organizations) as well as psychological mechanisms (e.g., use of differential cognitive strategies). The laterality task used in this study still requires validation with individuals who may be claimed to have well established lateralization of the brain at the structural level. We expect to discover some of these linkages in a study in which brain damaged patients have been examined not only for the size, site and severity of the damage with the help of CT and MRI scans, but also for the use of language and encoding on the same tasks that were used in the present study. Until these results are worked out, our claim regarding right brain dominance in the G group is confined to the functional aspects of the brain on the particular tasks we have worked with in this study. In fact, there is also need to focus more on other behavioural characteristics of right brain dominant people in order to cross-validate the findings with respect to differences in the functional organization of the brain in G and E encoders .

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