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Ecology, language, and performance on spatial cognitive tasks

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The study of the orientation systems that people use in different cultures to describe the location of objects in space has drawn some interest of researchers in the fields of anthropology, psycholinguistics, and cognitive psychology There has been a rethinking of the "linguistic relativity hypothesis," and some empirical studies tend to support the notion that language is the major determinant of encoding and cognitive performance on spatial tasks This paper reports a cross-cultural study carried out with 545 children aged 4 to 14 years, both schooled and unschooled in India and Nepal The field sites were selected taking into consideration how reference to spatial locations is organized in the language as well as in the local cultural practices In a village near Varanansi in India, people organize spatial locations mainly with reference to cardinal directions, but in the city of Varanasi, relative references are also used, although people in both the locations speak the same language (i e , Hindi) In a village in Nepal, on the other hand, the "uphill–downhill" geocentric frame of reference is the most compelling We test the relationship between ecology, culture, and language, encoding of spatial information, and performance on some Piagetian spatial tasks, taking age and schooling into account Berry's eco-cultural model is used to discuss the findings that support linguistic relativism at the group but not at the individual level

Les systèmes d'orientation spatiale utilisés dans différentes sociétés pour décrire la localisation d'objets ont attiré l'attention de chercheurs en anthropologie, en psycholinguistique et en psychologie cognitive L'hypothèse du relativisme linguistique a été remise à l'ordre du jour et des études empiriques ont montré que la langue était un déterminant majeur de l'encodage spatial et de la performance à des épreuves de cognition spatiale Cet article porte sur une étude interculturelle comparative effectuée avec 545 enfants de 4 à 14 ans, scolarisés ou non, en Inde et au Népal Les trois terrains ont été sélectionnés en tenant compte de la façon dont les références spatiales sont organisées aussi bien dans la langue que dans les pratiques culturelles locales Dans un village près de Bénares, en Inde, les objets sont localisés selon les points cardinaux, alors que dans la ville de Bénares, des références relatives (droite, gauche, devant, derrière) sont également utilisées, alors que la langue parlée est la même (le Hindi) Dans un village au Népal, le système spatial le plus utilisé est un cadre de référence géocentrique formé par l'opposition « en haut vers la montagne / en bas vers la vallée » Nous étudions les relations entre l'écologie, la culture et la langue, l'encodage d'informations spatiales et la performance à des épreuves spatiales dérivées de la théorie de Piaget, en tenant compte de l'âge et de la scolarisation Le modèle éco-culturel de Berry est utilisé comme cadre théorique pour mettre en perspective les résultats, qui confirment le relativisme linguistique au niveau du groupe mais pas au niveau individuel

El estudio de los sistemas de orientación espacial utilizados en diversas culturas para describir la localización de los objetos ha atraído la atención de los investigadores en antropología, psicolingüística y psicología cognitiva A partir de una renovación de la hipótesis del relativismo lingüístico, algunos estudios empíricos parecen apoyar la noción de que el lenguaje es el determinante más importante de la codificación y el desempeño cognitivo en tareas espaciales El presente artículo informa sobre un estudio transcultural comparativo, efectuado con 545 niños de 4 a 14 años, escolarizados o no,

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urbanos y rurales, en India y en Nepal. Los sitios en donde se llevó a cabo el trabajo de campo se seleccionaron tomando en cuenta la forma en que se hace referencia a localizaciones espaciales en la lengua y en las prácticas culturales. En un pueblo de las planicies del Ganges, los habitantes organizan el espacio de manera geocéntrica, según los puntos cardinales, mientras que en la ciudad de Benares, también se utilizan referencias relativas (izquierda/derecha), aún cuando la lengua es la misma (el hindú). En un pueblo de Nepal, el cuadro de referencia geocéntrica "arriba/abajo" es predominante. El presente estudio examinó las relaciones entre la ecología, la cultura, la lengua, la codificación de la información espacial y el desempeño en algunas tareas espaciales de Piaget, teniendo en cuenta la edad y la escolarización. Este estudio está basado en el marco teórico eco-cultural de Berry. Los resultados confirman una forma moderada de relativismo lingüístico a nivel grupal, más no así a nivel individual.

THEORETICAL BACKGROUND

The point of departure for our study is the assumption made by Piaget and Inhelder (1948, 1956) and other Western developmental psychologists that children first build up spatial concepts in relation to their own body, both at the sensorimotor level of action and at the later representational level. This is linked to the assumption that development occurs through decentration, i.e., infants and children are first egocentric, taking into account only their own point of view, before "perspective taking" (i.e., the ability to take other points of view into account) develops with age. Piaget and Inhelder's theory posits the developmental sequence of topological, projective, and Euclidean spatial concepts. While it is well established that topological space comes first and is universal, the sequence between projective and Euclidean concepts is less clear, and seems to be more of a logical than an empirical implication.

> Euclidean space also derives from topological space and is constructed parallel with projective space, from which it is distinct but to which it is closely related. While projective space is limited to co-ordinating different perspectives of an object (...), Euclidean space co-ordinates the objects among themselves with reference to a total framework or to a stable reference system (...). It is quite clear that this conservation of Euclidean relations would not be possible without the concomitant structuring of projective relations (...). It is for this reason that the development of Euclidean space is parallel to that of projective space (Laurendeau & Pinard, 1968/1970, p. 17).

The distinction between these three types of spatial concepts is akin to the distinction at the linguistic level between intrinsic, relative, and absolute spatial terms. "Theorists of spatial language have distinguished three kinds of reference frames depending on their origins: deictic or viewer-centered, intrinsic or object-centered, and extrinsic or environment-centered" (Taylor & Tversky, 1996, p. 372). Although there is some controversy about the best terminology, these three frames correspond to Levinson's (2003) distinction between relative, intrinsic, and absolute (or extrinsic) frames, which seems to have gained a wide acceptance. In the relative frame, the locations of objects are described in relation to an individual's left, right, front, and back (LRFB); they are viewer-centred and require knowledge of the viewer's orientation. Within an intrinsic frame, locations are described in relation to an object's front, back, or sides, and depend on the agreement on the intrinsic orientation of the reference object. In the absolute or extrinsic frame, objects are located according to a coordinate system that is external to the scene. The study of spatial reference systems has become an important paradigm and since different language communities preferentially use different reference frames (Levinson, 2003; Taylor & Tversky, 1996), this paradigm also has to be examined in a cross-cultural perspective, which is what we do in this paper, also adding a developmental dimension.

There are many studies exploring infants' abilities to locate objects according to body-oriented or geocentric landmarks in the sensorimotor period (e.g., Acredolo, 1990; Bremner, 1989; Lepecq & Lafaite, 1989). Some nativists aside, there is agreement that the baby first uses his or her own body as a reference before establishing outside, independent landmarks. Most of the research concentrates on the exact age at which this shift occurs, and the main findings are that this is earlier than Piaget had thought, but depends almost entirely on the precise way the task is set up.

Much the same could be said about the results of research at the later representational stage, with which we are more concerned: Whether or not the child can be described as egocentric seems to depend a lot on the task situation, rather than on some inherent property of stage-wise development. Although the ability to use geocentric landmarks varies with age depending on the experimental conditions, it seemingly never occurs before the child has built up body-related spatial representations. As we have seen with Laurendeu and Pinard (1968/1970), there is a suggestion that the two kinds of abilities might develop together, but there never seems to be any complete reversal from the sequence originally described by Piaget. The theory that spatial representation is basically built up from the point of view of the human body is still current:

> One of the first aspects of space that we confront is our own bodies. Our bodies have three axes that formed by our heads and feet, that formed by our fronts and backs, and that formed by our left and right (...) Space as we perceive and experience it is anchored, asymmetric, and biased. These facts about the space of our bodies and the world they interact form the basis for our conceptions of the spatial world (Tversky, 1996, p. 3).

One problem with the area of spatial concept development is that it has relied almost completely on research with Western samples. Would the sequence of stages hold up in other cultures? Could it be that the very centration on the individuals' construction of space on the basis of their own body is a bias due to Western individualism (Kagitçibasi, 1997)?

While there is some cross-cultural research on spatial cognition, most of it is not directly relevant to our issue. The situation can perhaps best be described as a contrast between the emic and etic approaches (Segall, Dasen, Berry, & Poortinga, 1999). On the emic side, there are a large number of anthropological descriptions of how space is organized in different cultures, but they say little about developmental aspects. For example, the very interesting studies on traditional navigational systems (Gladwin, 1970; Hutchins, 1983; Lewis, 1980) that demonstrate culturally specific, extremely complex, and abstract thinking, fail to describe the precise cognitive processes that are involved and, again, are not developmental. On the etic side is the cross-cultural replication of Piaget's theory, using classical "Piagetian" tasks (Dasen & Heron, 1981; Dasen, 1998b). While systematic cultural differences were found in the rates of cognitive development, which could be related to eco-cultural factors, there is no indication from this body of research that there could be any reversals in the sequence of stages, nor indeed any culturally specific cognitive processes (Dasen, 1993; Mishra, 1997, 2001).

Basic cognitive processes have been found to be universal (Dasen, 1993; Mishra, 1997; Segall et al., 1999), and languages themselves have been shown to conform to many universal principles (Holenstein, 1993), although recent research in language acquisition has tended to emphasize differences as well as similarities across languages (Mohanty & Perregaux, 1997). It is clear that every language allows us to conceptualize the surrounding space and to communicate about it. It is widely assumed that the coding of spatial arrays for memory will be determined by general properties of visual perception, and that it is natural and, thus, universal to conceptualize space from an egocentric and anthropomorphic point of view.

Speakers of European languages are quite used to egocentric encoding. Other forms of encoding will appear peculiar or even impossible to them; in developmental psychology, in cognitive sciences, and even in philosophical traditions, the conception of space has been considered to necessarily emanate from one's own body, standing in an upright position and looking straight ahead, which is in its so-called "canonical position" (Clark, 1973, p. 34). It is also considered that the egocentric conception of space is universal, because it is "more natural and primitive" (Miller & Johnson-Laird, 1976, p. 34). However, there are growing doubts about these basic assumptions, because they may well be ethnocentric (Wassmann, 1994).

Linguistic relativism

Does language constrain the way one thinks? The issue of linguistic relativity has been revived by Lucy (1992) and by Levinson and his colleagues of the Cognitive Anthropology Research Group (CARG) at the Max Planck Institute for Psycholinguistics, Nijmegen (Brown & Levinson, 1993, 2000; Gumperz & Levinson, 1996; Levinson, 1996, 2003). In the middle of the last century, Whorf's theory of linguistic relativism enjoyed prominence, but in more recent times, the answer to our initial question had become an emphatic "no." Berry, Poortinga, Segall, and Dasen (1992, p. 105) summarized the empirical data in the following fashion: "In general, we can conclude that there is at best limited support for the linguistic relativity hypothesis at the lexical level, but the last word has probably not been spoken on this issue ..."

If one has to describe the position of an object or person with respect to another, in English this is achieved by utilizing the projective notions of right and left in reference to the speaker's body. For example: "two men are standing before me side by side, the man on the right is holding a stick." A viewer taking up a position on the other side of the two men would say "the man on the left is holding the stick." At first sight this seems obvious and natural, also because the linguistic encoding is congruent with the kind of information provided by the visual, auditory, and haptic senses. But it is not so. Some languages do not use the apparently fundamental, body-centred spatial notions of "left"/"right," "front"/"back." Instead, they rely on fixed, environment-centred (also called geocentric) frames of reference, such as cardinal directions or related terms. For example, "the man on the west side is holding a stick." In this case, the description does not change with the viewer's changes of position.

This has a surprising consequence: Such a nonegocentric linguistic coding of a spatial array seems to be *incongruent* with the perceptual information, and the question arises whether these linguistic differences correspond to conceptual differences. We may assume that spatial representations are influenced either by sensory information (which is egocentric) or by language (which may or may not be egocentric). In European languages, which are egocentric, the two are confounded. Carrying out a study in languages that do not use the egocentric frame of reference (e.g., Balinese or several languages in India and Nepal) will allow us to dissociate the two.

Pederson, Danziger, Levinson, Kita, Senft, and Wilkins (1998) have provided a typology of languages along these lines, distinguishing languages that use exclusively the intrinsic (e.g., Mayan), relative (e.g., Dutch, Japanese), and absolute (e.g., Australian Aboriginal languages; Tzeltal, a Maya language from Chiapas in Mexico) frames of reference, as well as several mixed cases, such as Dravidian and Tibeto-Burman languages (Bickel, 1997; Pederson, 1993), but in several cases, including Balinese and several languages in India, the absolute frame is dominant.

CARG members have carried out coordinated research in several locations, working on language acquisition in longitudinal studies with children (de León, 1994, 1995), carefully documenting language use in everyday situations and through standardized situations called "space games" (e.g., de Ruiter & Wilkins, 1997; Levinson, 2003; Wassmann, 1994, 1997), and studying the impact of language on spatial encoding through a series of memory tasks (Levinson, 2003). Some of this work will be described below in more detail. We cannot do justice, in this brief review, to all of the work carried out by this group, and will, therefore, concentrate on just a few publications.

Among the many papers emanating from the Nijmegen group, one that is directly relevant to the present study is Pederson's (1993) research in South India. First of all, the author provides an interesting classification of subtypes of the geocentric systems:

A: North/South/East/West (NSEW); monsoonwards; towards sunset/sunrise; etc.

B: Uphill/downhill

C: Inland/seaward

D: Conventional landmark, e.g., "towards the headman's house", used to designate distant direction (usually beyond the horizon)

E: Situationally based local landmark (LLM), e.g., "towards the door", used to designate direction in a limited universe of discourse.

Tamil speakers have both a geocentric system (NSEW) and a relative one (LRFB). While both exist in the language, in rural areas people tend to use the NSEW system, while in urban areas, the LRFB system is dominant, with an occasional reference to an LLM system. Further, both groups of speakers have the ability to shift between absolute and relative terminology.

Drawing evidence from the study with Tamil speakers in India and from those carried out in the Mayan cultures in Mexico, Levinson (2003, pp. 190–191) concludes that "... ecological factors, or factors to do with material culture, or indeed religion or other cultural variables, do not seem to have a decisive role to play in non-verbal coding. No doubt better controlled cases can be found, but on present evidence there is no reason to doubt the significant influence of language on non-verbal coding strategy."

In a study in Mexico, de León (1994) found that Tzotzil-speaking children begin to master the geocentric system between the ages of 4 and 9 years, in a succession of stages. After an initial stage where locative terms are used randomly, a first contrast appears between "here" (the village) and "downland." The contrast "downland/upland" starts to be used at age 4; at age 5, "the opposition represents a socially conceptualized space with more emergent locations on the local map (...). At a final stage, around age 9, the upland/downland contrast is associated with the path of the sun and becomes a terrain-independent system of geocentric location" (p. 878). These stages represent a shift from an egocentric frame of reference, through locally anchored references, to abstract coordinates. While this sequence is congruent with Piaget and Inhelder's (1956) predictions, and with Slobin's (1985) data on linguistic spatial development, it still represents two departures from the Western developmental data: (1) "the acquisition of geocentric location appears earlier with Tzotzil children relative to the age of acquisition of left/right concepts in European children" (de León, 1994, p. 880), and (2) the relative, projective LRFB system is absent in this language.

Since this study concentrated on language development, the consequences for cognition could only be speculative. The author concluded:

> Tzotzil children seem to acquire an orientation skill at an earlier age than is predicted by Piagetian studies of the development of spatial cognition. The data reported here thus suggest that a geocentric system in grammar may have an influence on the acquisition of a spatial skill. More comparative research between languages with and without geocentric location remains to be done to assess this preliminary finding (de Léon, 1994, p. 880–881).

The same author also carried out a developmental study on language acquisition among Guugu Yimithirr (GY) Aboriginal children in Australia, between the ages of 6 and 14 years (de Léon, 1995). The GY use an absolute orientation system, and there is no left and right in the language (Levinson, 1997). But, according to Haviland (1993), among the GY, geocentric directional terms are used mainly by old people; middle-aged and young Aborigines do not use directional terms, but rather a simplified form of the traditional language, and standard and Aboriginal English

Very young GY children (4 years) use intrinsic words (in, on, off, out) and up/down. Left and right do not exist in the GY language, and front/back are used only in relation to motion, not position By age 7, the children use a locally anchored frame of reference, and by 9–10 years, contrasts of terms are built up. However, only 3 out of 26 children had acquired the fully fledged system of four GY cardinal terms, and these three children (aged 10–12) had learned it from their grandparents, who insisted on the importance of learning the traditional form of the language. The use of the term for "East" was found to be acquired through four stages: First, it is used as a general demonstrative form ("look there") with no relationship to a precise direction; then, at around age 8, children associate it to a specific beach located east of the settlement, and then with the general eastern region Then follows the contrast with "west" (or sometimes with "south" at 90°), and finally the system with four directions, but only for the three children mentioned above.

These two studies are important for the present research for two reasons: (1) they show how important it is to document the complexity of the sociolinguistic situation as well as the developmental patterns of language use; (2) the overall developmental trend seems to go from the egocentric and intrinsic terms to locally geocentric, and in some cases to abstract geocentric terms. This seems to confirm the classical developmental trend despite the fact that adults use an absolute geocentric system only. These studies only deal with the development of language; it cannot be directly concluded, unless one advocates a strong form of linguistic relativity, that cognitive development has to follow the same sequence.

Further information on early language development comes from a study by Brown and Levinson (2000) among the Tenejapan Tzeltal of Southern Mexico, where the language comprises an intrinsic and an absolute (uphill/downhill), and no relative LRFB system is said to exist. The productive use of absolute vocabulary is documented in children as young as 2; 6 to 3 years, while intrinsic vocabulary appears only by age 4. We have, in this case, an example of reversal (in terms of Piaget's theory) between topological and Euclidean spatial languages. Even though they support a Vygotskian rather than Piagetian perspective, the authors hasten to say that "the acquisition of a Euclidean absolute linguistic system before a topological intrinsic system does not necessarily show anything about the ordering of conceptual development" (p. 194) However, their results do point to multiple pathways of development They conclude that "such an ecological view of the Tenejapan child suggests that there are multiple motivations, and multiple scaffoldings, for acquiring these precocious spatial understandings" (p 195).

Spatial orientation in Bali

The Balinese orientation system, studied by Wassmann and Dasen (1998), is an important aspect of Balinese culture. Orientation is geared to the island's central volcano, the dwelling place of the Hindu gods of Bali; *kaja,* "towards the mountain," is the sacred and pure direction, opposed to *kelod,* "towards the sea." The axis *kaja–kelod* is in effect a variable direction as one turns around the island In principle, the axis *kangin–kauh* is orthogonal to it This type of topography-dependent orientation system can also be found in other languages of South-East Asia and Oceania (Barnes, 1993; Ozanne-Rivierre, 1987; Senft, 1997).

The entire Balinese cosmology is related to this orientation system: from the human body to the whole of the universe, from the architecture of temples and villages to the social structure. Children learn the use of the orientation system very early in life, although they also learn the ritually important distinction between the left and the right hand. However, left and right are only applied to the body and to objects in contact with the body, while all other objects are located with the geocentric orientation system In other words, while cardinal directions in European languages are applied only to the macro-space, in Bali they are also applied to the micro-space, in fact any time and everywhere an object has to be located or a direction has to be indicated.

In order to document the use of spatial terms in Balinese, Wassmann and Dasen (1998) carried out a linguistic survey, examining in detail how the inhabitants of various sites on the Eastern peninsula of Bali use the system, and they discovered quite some complexity in the local adaptations of the system In previous research, Wassmann and Dasen (1994a, 1994b) had shown how the linguistic and ethnographic parts of the research are absolutely essential before turning to the use of "induced situations" such as psychological tasks

Wassmann and Dasen (1998) used two spatial encoding tasks based on a simple paradigm developed by CARG (Levinson, 2003): Let us suppose, for example, that three toy animals, aligned and all looking to the left, are presented on a table in front of you. You are asked to remember this display, then turn around by 180°, and you have to place the animals in the same way as they were on the first table. If you orient them to the left, you have used an egocentric (relative) encoding, related to your own body. But, if you are encoding space in the geocentric way, you will orient the animals to the right, keeping the same absolute direction.

This simple task, called "Animals in a Row," and another similar task (Steve's Mazes), were used with 26 Balinese children aged 4 to 15 years and 12 adults. In the Animals task, most subjects showed systematically absolute (geocentric) reactions, similar to those obtained with the Tzeltal of Tenejapa in Mexico, and completely opposite to those of a sample of Dutch adults (Brown & Levinson, 1993, 2000). In Steve's Mazes, coding was also mainly absolute, but more subjects also made relative choices, especially older children and adults.

This research showed that the Balinese can use two coding systems, but the preference for the absolute system is clear. In the Balinese language, the system of geocentric spatial reference is so strong that it determines not only the manner of speaking, but also a mode of spatial representation and its commitment to memory. The results show a kind of moderate linguistic relativity: While the very young children (4–5 years) use exclusively the absolute system in their language and in their way of memorizing a spatial device, there seems to be a developmental change towards relative solutions. Note that this age trend is in contradiction with the developmental theories of Piaget and Inhelder, and others, as discussed above. It was therefore essential to continue the research in similar cultural and linguistic contexts, using other spatial development tasks, in order to determine if we would really find a reversal of the developmental sequence described for Western children.

The research in Bali can be considered as a pilot study that has to be replicated. What is needed is a study with larger samples, and using other tasks assessing not only spatial encoding but also spatial concept development. Having been unable to include a sample of unschooled children, Wassmann and Dasen (1998) were not in a position to separate the confounded factors of schooling and age. Schooling in Bali takes place in Indonesian, which is akin to European languages in its use of relative terms. Hence, we do not know whether the trend from absolute to relative encoding is linked to age or to schooling or, more generally, to acculturation.

Previous research in Nepal

The spatial cognition of Nepalese children has been considered in a study with 6- to 12-year-old rural and urban Newar children of the Kathmandu valley (Niraula, 1998; Niraula & Mishra, 2001). Children were given a pictorial display in which they had to describe the location of objects encountered along a pathway. They were also asked questions regarding the spatial location of objects with reference to each other in such a way that words relating to all cardinal and relative directions were likely to appear with equal probability. The findings demonstrated that relatively older children not only used more geocentric language in describing the display, but also provided evidence for greater memory for spatial location of objects than younger children did. Absolute language was found to be positively correlated with the memory of objects shown in the spatial layout and their spatial position along the path, as well as with performance on Sinha's (1984) Story-Pictorial Embedded Figures Test, which measures perceptual differentiation. It may be mentioned here that children in Nepal generally acquire geocentric language (NSEW) through schooling. Later analysis showed that the relationship of language with performance on cognitive tasks did not change even when the effects of age and schooling were partialled out.

OBJECTIVES

The present study was carried out with the following broad objectives:

1. To examine in a developmental perspective the use of spatial language in three different ecological settings, namely a village in the flat Gangetic plain, the city of Varanasi, and the mountains in Nepal.
2. To examine the spatial encoding systems used by children of different age levels in village, city, and mountain ecologies.
3. To analyse the relationship between spatial language use and spatial encoding.
4. To examine the relationships of spatial language and spatial encoding with performance on some Piagetian and other cognitive tasks.

We place this study within the eco-cultural framework developed by Berry et al. (1992) that has guided our research over the years (Dasen, 1998a; Mishra, Sinha, & Berry, 1996; Niraula, 1998; Niraula & Mishra, 2001). According to this framework, individual psychological characteristics are functionally linked to culture, which is itself an adaptation to ecological and sociohistorical contexts. In other words, people develop preferentially those skills that are needed in a particular eco-cultural setting.

With the assumption that, like other human behaviour, spatial behaviour (language, encoding, and conceptual development) would be adaptive to the demands of the ecology, and in view of some of the previous research findings, it was hypothesized that:

1. In describing space, village children (due to inhabiting a flat terrain with hardly any landmarks, or a mountainous up–down terrain) would use more geocentric language than city children, who would use more egocentric language (due to compelling left–right turns on streets).

2. In the developmental course, the village children would be more likely to use geocentric language from an early age than city children, who are likely to use this language at a later age, particularly with its learning in schools.

3. Spatial encoding would be linked with the language use of children such that children using geocentric and egocentric languages would encode the displays respectively in absolute and relative terms.

4. Geocentric language and absolute encoding is likely to be positively correlated with performance on various cognitive tasks.

METHOD

Sample description

In the present study in India and Nepal, three locations were chosen because they represent three clearly different eco-cultural settings, each with a spatial orientation system (and its appropriate language) that is adapted to the ecological context. The three samples correspond to the features summarized in Table 1.

Roopchandpur and Bhimeshwor were selected because they were known, from pilot work, to represent geocentric spatial orientation systems of two different sorts; in Roopchandpur cardinal directions (NSEW), and in Bhimeshwor an up/down (U) system in which "up" represents the north and east quadrants, and "down" the south and west. While partly similar to the system in Bali, which is also based on a main up/down direction (towards the mountain/towards the sea), it is quite different in other respects; for example, in Bali this direction changes as one turns around a central mountain (cf. Wassmann & Dasen, 1998), while in Nepal it is independent of local topographic features. In Bali, the transverse axis is bipolar with named directions (although actually referring to quadrants rather than to precise directions), while in Nepal, additional information is provided through the use of landmarks (L). In both Bali and Nepal, the NSEW system is taught in schools. Beyond these differences, Roopchandpur and Bhimeshwor also have similarities; they are both small rural villages surrounded by dispersed hamlets, and people practise agriculture and animal husbandry, with occasional wage employment in cottage industry, business, and government jobs. In both areas, Hindus are predominant, with a Buddhist minority in Bhimeshwor, and an even smaller Muslim minority in Roopchandpur. Adult literacy rates are about 50%. In our Bhimeshwor sample, most of the children speak Nepali (77%), a language similar to Hindi, 54% being bilingual with Newari, a Tibeto-Burman language, 5% are Newari monolinguals, and the remaining children (18%) speak various Tibeto-Burman languages such as Thami, Tamang, and Sherpa.

The city (Varanasi) and village (Roopchandpur) samples in India were chosen because the same language, Hindi, is spoken. Hindi contains a rich vocabulary of directional terms, but the use of these terms indicates a clear preference on the part of village people: They use NSEW in referring to objects and places in their environment, and also the proximal features. LRFB are used very rarely, and only to refer to objects that are either part of one's body (e.g., the glass is in the right hand), or placed close to one's body. Children are socialized from early childhood to make a distinction between the right and left hand, because the use of the right (socially accepted) hand for purposes like eating, drinking, and writing is greatly emphasized. The NSEW terms have a functional value for the society, because many activities are oriented to different directions. For example, south is believed to be an inauspicious direction (abode of *Yama,* the god of death). Hence, facing south is avoided while eating, engaging in religious activities, during excretory behaviours, and when sleeping. Verbal interactions in the community involve the use of conventional landmarks (e.g., headman's orchard, pond, road, Kali or Durga temple, mosque) that are known to all people of the village. Interactions with young children in restricted settings (e.g., in a room) may also involve reference to local

TABLE 1
Characteristics of the samples

Location	*Ecological features*	*Language*	*Spatial orientation system used by adults*
India, village: Roopchandpur	Flat Ganges plain	Hindi	NSEW
India, city: Varanasi	Old city	Hindi	Mixed (LRFB and NSEW)
Nepal, village: Bhimeshwor	Himalayan slope	Nepali + Newari + various Tibeto-Burman languages	Up/down

environmental features (e.g., door, wall, window, chair), but people refer to various rooms by using cardinal directions (e.g., eastern room, northern room).

In the city of Varanasi, the same language, Hindi, is spoken (with minor dialectical variations), and the same NSEW system may be used. However, it is frequent, both for route descriptions and object localization, to use the LRFB system. The city is very old, with a complex pattern of small alleys and roads, almost none of which are aligned in a grid pattern. Although the Ganges River and two of its tributaries on each side of the town provide some overall guidance, finding one's way in the city requires a close familiarity with it. Further work is needed to ascertain how children become familiar with these surroundings, and how they are induced to use either the NSEW or the LRFB systems.

In each of the three locations, we sampled children from age 6 to 14, boys and girls, schooled or completely unschooled, in about equal numbers, leading to a total number of 449. We later added some groups of 4- to 5-year-old children, who were tested with a reduced range of tasks (Steve's Maze, Perspectives, and Route memory tasks were not used). The details of the samples are presented in Table 2.

In this paper, we will mention schooling as a variable only occasionally, when it is most appropriate; a detailed analysis of this topic has been published elsewhere (Dasen, Mishra, & Niraula, 2003).

Tasks

The tasks used in this study were divided into three main categories.

Language tasks

Three different tasks were used for eliciting spatial terms used by children. They provide a variety of situations that are likely to elicit different types of descriptors; the first task involves movement in a relatively large space, while the two others concern table-top space.

Route description task. In this task, the child is asked to guide one of the experimenters (E), who is blindfolded, to move along a pathway laid out on the ground. All verbalizations of the child are tape-recorded for later transcription. This task was inspired by a similar situation designed by Cottereau-Reiss (1999).

Perspectives task. This is modelled on Piaget's perspectives task. Three familiar non-fronted objects are displayed. The child is asked to describe the objects from three different positions. These descriptions are recorded.

Spatial encoding tasks. These include the "Animals in a Row," "Chips," and "Steve's Maze," described below. On the last two items of each task, the child is asked to give the reason for his or her answer. The language used is recorded.

On each task, the proportions of each language category were computed, using the classification scheme presented in Table 3.

The terms are roughly ordered along the dimension from relative to geocentric (G). While N and U are clearly G, CL implies a direction away from the display and from the viewer, and hence also has some projective properties. The same applies to SL, for which the reference is outside the display but inside the room. "Terso" (T) is a term used mainly by Nepali speakers to designate a direction along an uneven path; it seems to indicate a direction and is therefore placed between CL and U, and could be considered as a part of geocentric language.

The proportions of each language category produced on the three tasks were averaged over the three situations. The category with the highest proportion was called the modal language for each child.

TABLE 2
Design, and number of children in each sample

	India, village				*India city*				*Nepal*			
	No school		*School*		*No school*		*School*		*No school*		*School*	
Age groups	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*
4–5	4	5	12	11			16	16			15	17
6–8	16	14	10	13	12	13	13	12	12	12	12	12
9–11	12	13	13	16	12	12	12	12	13	12	12	12
12–14	12	11	14	15	12	12	12	12	11	12	11	13
Total	44	43	49	55	36	37	53	52	36	36	50	54
				191				178				176
												545

TABLE 3
Language classification scheme, adapted from Pederson (1993)

E	*Egocentric*	
R	Relative	Right, left, in front in back in relation to speaker
P	*Projective*	
SL	Situationally specific landmarks	Towards the window the door (landmarks within the room)
CL	Conventional landmarks	Towards the temple the hospital a locality (landmarks outside the room)
G	*Geocentric*	
T	"Terso	Nepali word. meaning along a path that is uneven or zigzag
U	Up/down	In Nepal up represents north and east quadrants down south and west
N	NSEW	Cardinal directions north, south, east west
Other		
I	Intrinsic	One object related to another. e g next to, near before. etc
D	Deictic	"This way that way (usually accompanied with the gesture of a finger or the whole hand)

Spatial encoding tasks

These are tasks initially devised by CARG (Levinson, 2003) Hence they are sometimes called the Nijmegen tasks

Animals in a row This task presents the child with three animals (chosen in this study from locally available models of duck, elephant, horse, tiger, and tortoise) aligned on a table, all facing in one direction. The child is asked to remember this display, and move on to another table after a 180° rotation to align another set of the same animals the way they were shown before. Five trials, with animals oriented to right (downhill) or left (uphill), are given in the RLLRL sequence. The way animals are aligned by the child is noted, and the configuration is coded as indicating an absolute or relative encoding of the display.

This task is also repeated at the end of the testing (for children aged 6 to 14 years) in order to see if the child can shift from one encoding to the other. Depending on whether the child had previously encoded the display in an absolute or relative manner, instructions are imparted to encourage an encoding opposite to the previous one To induce relative encoding, the table on which the animals are displayed is placed within 30° of the main direction, so that absolute encoding is less obvious.

The Chips task For this task, two-dimensional shapes (small or large, red or blue and yellow or green, circles and squares) are drawn on cards, two at a time. The child is shown five cards of a series, all with the same orientation, and is asked to notice that all of them are similar. Then one of the cards is rotated by 90°, and the child is asked to explain how it is now different from the other cards Following this exercise, the child is presented with a card oriented in a particular direction by the configuration of shapes, and is asked to remember this orientation. Then the child moves on to another table (after a 180° rotation) to choose the one displaying the same spatial orientation as seen before from a set of four cards set out as a cross A series of practice trials are given before moving on to actual testing of five items.

Steve's Maze task. This task consists of six pictures of landscapes that depict a house, rice fields, trees, and an incomplete pathway The child is presented with a picture and is told a story, showing the route that one can take from the end of the drawn path back to the house The child is asked to remember this route while moving on to another table (with 180° rotation) where three cards are displayed showing three different path segments. One of these represents a relative encoding, another an absolute solution, and the third one an irrelevant choice (called distractor) One item is used for demonstration; another five items constitute the test series

Spatial cognitive development tasks

Route memory The route description task, described earlier, was also used for the study of route memory. This task was inspired by the previous work of Gauvain and Rogoff (1989) A number of objects are placed at different points of a route The child moves along the route, and names each object as it is encountered. On reaching the end point, in another room, the child is turned 180°, and is asked to explain how to go back to the starting point Then the child is asked to recall the objects that were placed along the route, and arrange, on the basis of memory, the models of those objects at appropriate locations along a miniature display of the route Correctly recalled and correctly placed objects are counted

The younger subjects (9 years and below) were presented with a simple path with six objects, and the older ones with a more complex path with nine objects (however, 128 children were given both forms of this tasks) In the analysis, these two forms of the task are therefore treated separately. The scores used for these tasks are the proportion of objects placed correctly These tasks were not used with the very young children (4 to 5 years)

Rotation of landscapes Rotation of landscapes is done in three phases In the first phase (training), two similar landscapes are displayed side by side in front of the child on a table. Attention is drawn towards different parts of the landscape (e g., house, river, bridge, hill, etc), and their location. The experimenter puts a doll on one of the landscapes, and the child is asked to set another doll in the same place and position on the other landscape In the second phase, one of the landscapes is rotated by 180° in full view of the child, who does the same exercise as in the first phase (placing and positioning the doll). In the third phase, a screen is placed between the landscapes The child looks at the experimenter's landscape, and on the basis of memory puts the doll in the other landscape at exactly the same place and position as seen before Five such trials are given The task is scored into five substages, the early stages reflecting the use of topological space only, the middle stages projective space, and the last stage Eucliden space

Horizontality A bottle half-filled with coloured water is presented on a table The child's attention is drawn to the level of water in the bottle. Then, the bottle is hidden in a cloth bag and the child is asked to draw the level of water in the outline of the bottle presented on the record sheet The hidden bottle is presented in five different positions: (1) right side up; (2) upside-down; (3) on its side; (4) tilted at 45° to the right; (5) tilted upside-down at 45°. For each position the child draws the level of water in the outline of the bottle The task is scored in five stages: (1) all positions wrong except position 1; (2) all positions wrong except positions 1 and 2; (3) positions 2 and/or 3 correct and/or some movement of the water drawn for one position among 4 and 5; (4) movement of water in positions 4 and 5, but not horizontal; (5) correct for positions 4 and/or 5

Perspectives task This uses the same display as described for the language task The child, having first described the display from different positions, is then asked to stay at position 1 and describe the display from the point of view of the experimenter (E) (i e , how E will see the display) as she or he moves to different positions The child is also trained to choose, from a set of four pictures, the one that matches E's view of the display (i e , as E will see them), E being either opposite to the child, to the right of the child, or at a diagonally opposite corner. In the last phase, the child is presented with a picture (the display seen from the left of the child) and is asked to tell where E should go to see the display as depicted in the picture For young children (4–5 years) the task was used only for language elicitation The task is scored as the number of correct descriptions on the four items, and the number of correct choices of pictures.

All the tasks are presented as games The child is allowed enough practice to ensure complete understanding of the tasks. If needed, the child is allowed to come back to the display on all the tasks that place reliance on memory (e.g., Animals, Chips, Steve's Maze,

TABLE 4
Mean proportions (and standard deviations) of language use on combined tasks, by age group in the three locations

		Language categories							
		Ego-centric	*Projective*		*Geocentric*[a]			*Other*	
	No of children	*R*	*SL*	*CL*	*T*	*U*	*N*	*I*	*D*
India village									
4–5	32	00 (0)	28 (38)	00 (0)	–	–	00 (0)	.00 (0)	72 (41)
6–8	52	03 (12)	.39 (32)	.00 (0)	–	–	36 (.42)	.11 (11)	11 .20)
9–11	54	01 (06)	12 (23)	00 (0)	–	–	.75 (32)	09 (11)	03 (07)
12–14	52	08 (14)	06 (15)	00 (0)	–	–	76 (29)	08 (10)	.02 (06)
India city									
4–5	32	01 (16)	14 (02)	00 (0)	–	–	00 (0)	03 (16)	82 (30)
6–8	50	18 (26)	.29 (26)	00 (0)	–	–	25 (35)	.14 (10)	14 (13)
9–11	48	28 (33)	16 (24)	00 (0)	–	–	.40 (41)	10 (.10)	06 (08)
12–14	47	.55 (35)	04 (.09)	00 (0)	–	–	.30 (35)	06 (08)	05 (05)
Nepal. village									
4–5	32	01 (04)	14 (24)	00 (0)	00 (0)	00 (0)	00 (0)	.03 (09)	82 (26)
6–8	48	04 (.12)	18 (19)	14 (16)	08 (15)	32 (14)	08 (21)	05 (08)	11 (19)
9–11	49	02 (11)	.09 (15)	.09 (14)	11 (17)	39 (.26)	22 (33)	02 (06)	06 (09)
12–14	47	04 (10)	04 (18)	.09 (13)	.12 (15)	.39 (23)	27 (29)	01 (.03)	04 (06)

[a] I and U are specific to Nepal See Table 3 for language categories

Rotation of landscapes). The child is allowed enough time on each task.

RESULTS

Language use

Table 4 presents the change with age of the language used on the three language elicitation tasks—Route description, Perspectives, and items 4 and 5 of the Nijmegen tasks (two tasks for 4- to 5-year-olds, three tasks for 6- to 14-year-olds)—using the categories presented in Table 3.

Note that T and U are specific to Nepal, and have never been recorded in our observations in India. CL is a different case: It actually occurs as a modal speech category only in Nepal, but it does occur as a secondary spatial marker in India; when we carried out a retest outside (actually on the roof of a building), some of the children who had predominantly used SL inside a room systematically switched to CL.

In all three samples, it is noticeable that the young children (4–5 years) use predominantly what we called D, namely "this way" and "that way," usually accompanied by a gesture of a finger or the whole hand. The status of this category is inherently ambiguous in terms of absolute/relative encoding: It could be body related since a body movement is involved, and could mean "to the right/left," but the movement also points to a direction that is outside of the display. The latter interpretation is reinforced by the fact that, in both samples in India, very young children also use SL references (i.e., outside of the display, but within the room), a category that is still quite strong at age 6–8 years, but which then disappears with age. In Nepal, some very young children already use up/down (U), and this use then increases with age.

The main difference in language use between the three samples occurs in the type of geocentric references used: In India, the children use N almost exclusively in the village, and to a large extent in the city. In Nepal, N is also used increasingly with age (mainly by schooled children), but less than the dominant U (for nonschooled children the almost exclusive reference), and the Nepali word *Terso* (T). The city sample is the only one where a significant number of children use the egocentric references of right and left, and this use increases with age.

This distinctive pattern of language use makes sense in terms of the different ecologies. In the Ganges plain (India, village), the terrain is completely flat, there are no major features such as mountains or hills, and there are in fact hardly any landmarks at all, except different fields or the occasional house or tree. In such ecological conditions, the use of N based on the daily path of the sun (and reinforced by cultural and religious practices) is quite obviously adaptive. In the village in Nepal, on the other hand, the overwhelming reference is the slope: One constantly goes up or down! Because of the terrain, CL (such as prominent buildings like the temple or the hospital) are also more noticeable.

In the city of Varanasi we get a mixed pattern, but it is the only location where R use is current (as well as some intrinsic references). It is difficult to say with certainty whether the use of egocentric terms is linked to the topological features of the city (it certainly makes more sense to use left and right turns in a city, whether driving or walking, than in open countryside or on mountain paths) or whether it is an influence of English on Hindi at the group level (none of the children in our sample were themselves bilingual with English).

Spatial encoding ("Nijmegen") tasks

To summarize the spatial encoding on the three Nijmegen tasks used in this study, we use a measure called the R–A gradient, following the scheme worked out by Levinson (2003). It represents the proportion of items coded A out of 5 items in each task, with Ds (choice of distractors) counting as .5. Table 5 shows the R–A gradients over age in the three samples.

It is immediately obvious that the three tasks differ consistently, with a similar pattern in the three samples. On the Animals tasks, most of the encoding is absolute (A), even among the youngest children, and this proportion further increases over age. On the Chips task, a similar increase of A encoding with age is noticeable, but at a slightly lower level. If we had

TABLE 5
R–A gradients (and standard deviations) on spatial encoding tasks by age group in three locations

	Animals	*Chips*	*Steve's Maze*
India village			
4–5 years	.73 (.25)	.50 (.23)	–
6–8 years	.80 (.19)	.65 (.21)	.41 (.19)
9–11 years	.90 (.14)	.70 (.25)	.51 (.22)
12–14 years	.94 (.13)	.76 (.25)	.47 (.22)
India city			
4–5 years	.59 (.25)	.42 (.26)	–
6–8 years	.68 (.25)	.46 (.23)	.39 (.20)
9–11 years	.79 (.26)	.51 (.30)	.42 (.23)
12–14 years	.75 (.24)	.53 (.53)	.40 (.23)
Nepal village			
4–5 years	.55 (.25)	.40 (.29)	–
6–8 years	.75 (.25)	.57 (.22)	.47 (.17)
9–11 years	.83 (.18)	.64 (.24)	.45 (.17)
12–14 years	.88 (.20)	.71 (.27)	.43 (.20)

TABLE 6
R–A gradients on spatial encoding tasks by age group in Bali (Wassmann & Dasen, 1998)[a]

Age group	*Animals*	*Steve's Maze*	*N*
4–5	96	–	9
6–8	80	58	8
9–11	.73	58	7
12–14 + adults	86	49	14

[a]Results were computed using the R–A gradient and comparable age groups; in Bali, only two children were in the 12–14 age group so they were combined with adults. Steve's Maze was not administered to young (4- to 5-year-old) children, for whom the Animals task was used with two animals only.

TABLE 7
Proportions of language categories used with absolute (A) and relative (R) encoding on items 4 and 5 of three Nijmegen tasks combined

	Language			
Encoding	*Egocentric*	*Projective*	*Geocentric*	*Other*
A	08	.22	54	16
R	14	17	34	35

used only these two tasks, we might have concluded that there is an overall preference for absolute encoding, with an age-trend from more relative to more absolute. On Steve's Maze, however, there is almost no age trend, and there is in fact a slight predominance of relative (R) encoding.

Comparison with previous results in Bali

In Bali, Wassmann and Dasen (1998) had found a marked difference between the two Nijmegen tasks that had been used, with almost systematic A encoding on Animals, and somewhat more R encoding on Steve's Maze. The trend was towards a decline of the R-A gradient with age (Table 6).

Language and encoding

We used one-way Anova with Tukey's post hoc tests to explore the relationships between the main language used and encoding on Nijmegen tasks. In the Nepalese sample, there is no significant relationship between language and encoding on Animals task, where encoding is predominantly A, nor on Steve's Maze, where it is mainly R. This could, of course, be due to the lack of variation in encoding (ceiling effect). A significant relationship, $F = 3.184, p < .006$, occurs on the Chips task: There is more A encoding in children who use N, U, T, or CL than those who use D, SL, or R (Tukey's test). In the village sample in India, N users have a higher R–A gradient and are significantly different from D users on the Animals and Steve's Maze, but not on Chips. No statistically significant differences occur in the city sample, although there is a trend for D users to have a low R–A gradient (i.e., to encode more R).

These results suggest that, generally speaking, children who use predominantly geocentric language also tend to use predominantly an absolute encoding on the Nijmegen tasks, and those who use predominantly egocentric language use predominantly relative encoding. From here we could conclude that the results are in favour of linguistic relativism, namely that there is a correspondence between the language used and the encoding process. But things are not that simple. If we look at the data in more detail, we find several discrepancies.

For example, on the Nijmegen tasks, we asked the children to explain, on items 4 and 5 of each task, how they had remembered the display, and recorded the language they had used. Table 7 displays the correspondence between encoding and language used (all items and all subjects in the three locations combined).

Obviously, geocentric language tends to go with absolute encoding, but it is also used in a number of cases (34%) to justify a relative encoding. In fact, a relative encoding is justified more often using absolute than relative language. Conversely, egocentric and intrinsic terms are used to justify mainly relative encoding, but also occur with absolute encoding.

Another discrepancy with the literature occurs on the Perspectives task. According to Senft and Wilkins (1995), people who use absolute spatial language should describe a display in the same way independently of their position. In our study, we asked the children to move around the display of three objects of the Perspectives task, and to describe it from three different positions.

When comparing the second and third descriptions to the first one (Table 8), only 7% (of 449 children tested) give the same description on all three positions, and

TABLE 8
Description on Perspectives task when moving around display by predominant spatial language used (6- to 14-year-old children combined)

Descriptions	*Egocentric*	*Projective*	*Geocentric*	*Other*	*Total*
3 different	53	81	232	7	373
2 same	7	17	20	3	47
3 same		6	22	1	29
Total	60	104	274	11	449

TABLE 9
Partial correlations between language use and performance on cognitive development tasks controlling for age and schooling

	N	*Egocentric*	*Projective*	*Geocentric*	*Other*
India village	125	.13	−.31**	.22**	−.21**
India, city	128	.05	−.24**	.21**	−.38**
Nepal	129	−.004	−.15	.17*	−.09

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

another 10% for two of the positions. The majority of the children (83%) give three different descriptions for the three positions. Since the initial hypothesis is disconfirmed strongly by this, it may be interesting to look at what the children say in more detail. For example, is there a link between giving the same description and using absolute spatial language?

As we can see in Table 8, those few children who do give three identical descriptions are using predominantly geocentric (N, U) and projective (SL) language, but using such language does not imply giving the same descriptions. A more detailed analysis of this issue will be presented in a separate publication.

Cognitive tasks

We focus here on the question of whether using a particular spatial language, or a particular frame of encoding, has wider consequences in terms of spatial cognitive development concerning topological, projective, and Euclidean spatial concepts in Piaget's theory. As a measure of the latter, we have combined the scores on the various tasks through a principal component factor analysis into a factor score (the first factor explains 48% of the variance). We will therefore not detail the results for each separate task; these will be reported elsewhere. Generally speaking, the cognitive developmental tasks show significant correlations with age (between .12 and .39, which is highly significant with an *N* of 449), and schooling (.14 to .39), but not with gender. This is why, in subsequent analyses, partial correlations are used, controlling for age and schooling. Inter-task partial correlations were statistically significant (.15 to .53), except with the Perspectives task, which did not produce valid results and has been removed from the analyses. While this task provided an excellent setting for language production, the cognitive testing part involved the selection of pictures, which was possibly inappropriate for most of our subjects, even though this was not obvious during testing.

Is there a relationship between modal language use and cognitive performance? The results of correlations with language are presented in Table 9.

The spatial cognitive development factor score correlates significantly with the use of geocentric language in all three samples, confirming the previous results of Niraula's studies in Nepal. The correlations are negative with projective language (landmarks) and with the "other" category combining intrinsic and deictic language use. The latter are, of course, typical of younger children, but in this case, since age was controlled, this finding suggests a developmental pattern where children who are less advanced in spatial cognitive development (at any given age) also tend to use language typical of children younger than their age.

The partial correlations between encoding on the Nijmegen tasks and the spatial cognitive development factor score are presented in Table 10.

The expectation was to find positive correlations: Children using an absolute encoding were hypothesized to have a greater facility with the cognitive developmental tasks. This is only very partially born out with the Chips task and only in the two village samples. The encoding is rather systematically absolute on Animals, suggesting that there may not be sufficient individual variation on this task. On Steve's Maze, there is even a statistically significant negative correlation in the city sample, indicating that children who use more relative encoding are showing a higher task performance. Generally speaking, we can conclude that the link between encoding and spatial cognitive development is both weak and inconsistent.

TABLE 10
Partial correlations between spatial encoding (R–A gradients) and performance on cognitive development tasks, controlling for age and schooling

Maze	*N*	*Animals*	*Chips*	*Steve's*
India, village	125	.12	.29**	.13
India, city	128	.04	.08	−.28**
Nepal	129	.16	.17*	−.12

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

DISCUSSION

As stated in the objectives, the study attempted to address four main questions: the role of ecological setting in the use of spatial language, change, if any, in spatial language and encoding in the course of child's development, the relationship between spatial language use and spatial encoding, and the role of spatial language and encoding in cognitive task performance. All these questions are theoretically interesting, since they reflect considerable controversy in research reported in this particular field. We will address these specific issues first before moving on to a discussion of more general issues

Spatial language

Using the eco-cultural theoretical framework, we had hypothesized that the spatial orientation system, and the language that goes with it, would be adapted to the respective ecological conditions that prevail in the flat and mountainous villages and in the city of Varanasi. The findings tend to support our predictions to some extent. As we have seen earlier, the obvious feature of reference in the mountains of Nepal is the slope, and the main adult usage is to refer to "up" and "down," and occasionally to local landmarks. In the flat plains of the Ganges, where there is barely a hill and few obvious landmarks, using cardinal directions is the norm. The ecology of the city is more varied, and the processes involved undoubtedly warrant a more detailed study; city-dwellers use a variety of spatial references, and are the only ones (among the three locations of this study) to use egocentric ("left/right") spatial references. We do not deny complexity by claiming that the physical environment is the single determinant of these orientation systems and the language that goes with them; anthropology is quick to demonstrate cultural and linguistic diversity within the same ecological conditions.

We may also note here that it is not possible to distinguish language as a causal factor in relation to cognition, since it does not occur out of a more general cultural context that is itself adaptive to the ecological context. An orientation system based on cardinal directions, such as occurs in rural India, is completely congruent with the Hindu religion and the symbolism attached to it, as well as with daily routines and practices. The same, of course, was true of the previous research in Bali (Wassmann & Dasen, 1998). In other words, language comes as a package with other cultural features. Determining which of language, culture, and cognition comes first is a chicken and egg problem that does not make much sense.

Our findings also indicate that children learn the normative adult system and language progressively, and become competent in it by about the age of 9 years. At an earlier age (the 6–8-year age group) they may attempt to use the adult system without being able to do so correctly (particularly where cardinal directions have to be learned; in Nepal this learning is restricted to schooled children), or to use what we have called SL (references outside of the display, but inside the room) or CL in Nepal (or for children in India, when testing is done outside). Even younger children (4–5 years) tend to say "this way/that way" (D), a fairly restricted linguistic code accompanied by gestures, and that needs more detailed research, because it could hide markedly different processes (egocentric and geocentric).

The overall age trend in spatial language development is not incongruent with Piaget's theory: Whatever the interpretation of D may be, the references are first centred on the display and the child's own body, then projective references become important, either in the immediate surroundings (SL) or further away (CL), until the geocentric systems are fully mastered. This occurs, however, without the use of egocentric language (R), except for the city sample in India

Spatial encoding

When a simple spatial array has to be encoded (as in the spatial encoding tasks we have used), most of the children in India and Nepal do so in an "absolute" rather than a "relative" frame, which is congruent with the geocentric orientation systems that are prevalent in all three locations. While this finding seems to fit a hypothesis of linguistic relativism at the group level, there are severe limitations that argue against any strong form of such a hypothesis

For example, the results show that encoding is task specific, with more absolute encoding if the task can be easily encoded in linguistic terms (e.g., Animals), and more relative encoding if the task is more difficult to encode linguistically and easier to encode iconically (e.g., Steve's Maze). This clearly shows that there is no overall linguistic determinant of a frame, but that the two frames coexist in every individual, with situational determinants as to which frame is used preferentially

Task specificity in encoding and performance

The issue of task specificity seems to be quite compelling in research on language and cognitive development. The fact that spatial tasks are very sensitive to small changes in the display or the instructions has been found repeatedly both in infancy (Acredolo, 1990) and at later ages. Cottereau-Reiss (1999) cites Hatwell (1990, p. 56, our translation) in this respect: "Seemingly minor variations in the content or procedures that do not change the formal structure of the problem sometimes have important effects on behavior and change significantly the proportion of responses classified as egocentric or exocentric at a given age." More specifically, the fact that the Animals task produces more A encoding and Steve's Maze more R encoding has been found repeatedly, in Bali (Wassmann & Dasen, 1998), in New Caledonia (Cottereau-Reiss, 1999, 2001), and now in India and Nepal[1]

One feature to explain this systematic difference could be the ease of linguistic encoding—simply how many words or sentences are needed to describe the display, and hence to remember it verbally—as against the ease of iconic encoding. On the Animals task, the display consists of three discrete objects, each of which is oriented, and the overall pattern is easy to encode in linguistic terms (e.g., "they all look north/to the right") On the Chips, although the objects are also discrete, they are not oriented; it is the spatial relationship between the square and the circle that defines the orientation, and although a linguistic encoding is quite likely (e.g., "the blue square is north, the red one is south") when confronted with a selection of four such cards set out in a pattern (cross), the visual image is likely to predominate. This may explain why relative encoding is more frequent. This visual pattern is, of course, even more striking on Steve's Maze, where encoding the path linguistically would entail a rather complex route description, while remembering a shape (or a pattern of movement, as shown by some children who actually move their finger or hand) is more likely (and hence more likely to be related to the body)

Furthermore, it has been shown repeatedly that the same task can produce quite different results depending on the details of the procedure. Cottereau-Reiss (1999), for example, had the Kanak children in New Caledonia carry the animals themselves from the first to the second table; this form of the task produced much more R encoding than the standard format. A recent controversy between Li and Gleitman (2002) and Levinson, Kita, Haun, and Rasch (2002) also illustrates this point. Li and Gleitman found markedly different results on the Animals task with American students depending on the availability of landmarks in the experimental setting, i.e., when the task was set inside a room with shutters closed, shutters open, or outside on the campus, or when a reference object was placed on the table. Levinson et al. remark that an A encoding is inherently ambiguous as to the frame of reference actually used, which can be either intrinsic or geocentric[2]. A small change in the procedure, such as giving the subject only the three animals on the second table, or four animals out of which to choose the three relevant ones, can change the results considerably, presumably by increasing the memory load of the task, and/or attracting attention to the order of the animals rather than on the direction only. Levinson et al. therefore advocate the use of several more complex encoding tasks, such as the Motion Maze task and the Transitivity task.

The very fact that the instructions can influence the type of encoding has been used by Wassmann and Dasen (1998) in Bali to assess the flexibility with which the subjects could change from their spontaneous preferred mode to the other. They repeated the Animals and Steve's Maze tasks by changing the instructions, in particular by explicitly using relative language for those who had first used A encoding, and placing the table at 30° off the main orientation axis. They found that young children (7–9 years) would not change their mode despite prompting, while about half of the older children and adults would do so more easily. In the present study, only 6% of the children in the Indian village, 11% in Nepal, and 21% in Varanasi changed their encoding; there was no significant age trend, except that in both samples in India, among those children who did change, the younger ones (6–8 years) changed from R to A, and the older ones from A to R

Using either the Animals or the Chips tasks in Tahiti and France, Troadec, Martinot, and Cottereau-Reiss (2002) and Troadec and Martinot (2001) also used different types of verbal induction with different groups, and found various effects of eco-cultural setting, age, gender, and task content. In Papeete, Tahiti, older children (10–11 years) were more prone to follow either a relative or an absolute induction from the instructions than were younger children (5–6 years).

In conclusion, task specificity can be used for a finer analysis of the processes that are involved. Varying the tasks and the task instructions should be done systematically instead of relying on single measures

Group vs. individual level data

Looking at the data at the individual rather than at the group level, the relationship between language use and frame of encoding is certainly less than perfect; we have found not only that children may encode a situation with a relative frame but use absolute language when

[1]But in the Trobriand islands, Senft (2001) found predominantly A encoding on four tasks, including Animals Chips, and Steve's Maze. while he found more R encoding on the Motion Maze task

[2]Additional situations would have to be used to distinguish between the two for example a 90° rotation or using a two-dimensional array by placing a fourth animal between the row of three animals and the subject

asked to explain how they did it (which can easily be understood in terms of the dominant geocentric adult norm), but also the reverse, i e , use an absolute mode of encoding explained with relative language, a more puzzling (but also less frequent) combination That individuals say something but do something else is, of course, a common problem in psychology when one deals with attitudes and values, but is also true in the cognitive domain

Previous research (e g , Wassmann & Dasen, 1998, and by the CARG group) had examined the relationship between language and spatial encoding only at the group level A linguistic analysis shows that in many of the societies that have been studied, an absolute orientation system exists in the culture, is accompanied by a predominance of absolute language, and goes with a strong trend towards absolute encoding. Hence, seemingly, a strong confirmation of linguistic relativism. In this study, we have been able to record the language used by each individual, and to relate: (1) the dominant language use for each individual to his or her encoding measured task by task, and (2) the particular language used on particular items in relation to the encoding on the same items With such an analysis at the individual level, the correspondence between language and encoding is much less impressive

Another important question was whether the use of geocentric orientation systems and absolute language would have an impact only on spatial encoding in situations (tasks) specifically geared to be sensitive to this feature, such as the tasks developed by the CARG group, or whether it would have an impact on spatial cognitive development at a more general level Using a series of Piagetian tasks in the area of spatial concept development, we have found no systematic relationship between absolute or relative spatial encoding (on the Nijmegen tasks) and broader aspects of cognitive development. On the other hand, the data show some correlations between modal geocentric language use and some of the cognitive development tasks, even when age and schooling are partialled out; this is in line with previous research in Nepal (Niraula, 1998; Niraula & Mishra, 2001).

Reversal in developmental trend

Wassmann and Dasen (1998) had found, in their research in Bali, a trend from completely absolute encoding towards more relative encoding with increasing age and/or schooling, a trend that seemed to contradict mainstream (Western) theories of cognitive development. In this study, this trend was not confirmed in any of the three samples, each showing a trend opposite to that found in Bali, i e., slightly more relative encoding in young children and then increasing absolute encoding This trend, however, is not reflected in the modal language use, where relative language almost never occurs, except in the city of Varanasi (where it increases with age, while relative encoding decreases with age, another contradiction to the hypothesis of linguistic relativism)

We are thus left with the question of whether the results in Bali could be replicated in Bali itself using a larger sample and more tasks, or in other island locations using a similar orientation system Further developmental research of this kind is also needed in populations where LRFB are not used at all, as well as in those where it is the main reference system Curiously, except for some small studies with French children (Cottereau-Reiss, personal communication; Troadec & Martinot, 2001), there has been little published research carried out with children who speak a European language. We expect to continue our own research by taking advantage of ecological, cultural, and linguistic diversity in India and Nepal in order to add more samples selected on theoretical grounds, and by pursuing research on language acquisition and comprehension at earlier ages, as well as searching for possible cognitive style and neuropsychological bases to the choice of different frames of spatial reference

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