In L. Nucci, G. Saxe & E. Turiel (eds.)
Culture, thought and development. Erlbaum.

Chapter 8

Frames of Spatial Reference and Their Acquisition in Tenejapan Tzeltal

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GOALS OF THIS CHAPTER

In this chapter, we describe a line of research, essentially independent of the Piagetian tradition, which, nevertheless, bears on some of the central tenets of Piagetian thinking. We describe some specific results concerning language learning in a Mayan Indian community in southern Mexico, where the essential spatial discriminations in language and cognition employ Euclidean rather than topological or projective concepts and where these linguistic terms—despite their apparent complexity—seem to be learned very early by children.

It may be helpful to summarize our argument in advance, but we return to elaborate each of the points. Many languages utilize one or more of three basic frames of reference in reckoning spatial relationships: *Relative* (using the speaker's viewpoint to calculate spatial relations, like the familiar 'left'/'right'/'front'/'back' systems of European languages); *absolute* (using fixed angles extrinsic to the objects whose spatial relation is being described, like the cardinal direction systems of many Australian Aboriginal languages); and *intrinsic* (relying on intrinsic properties of objects being spatially related, e.g., parts and shapes of the Ground or landmark object) to reckon spatial relations, as in the body part systems of many languages. In the Mayan language Tzeltal, as spoken in the southern Mexico community of Tenejapa, the predominant

emphasis is on the intrinsic and absolute frames of reference. Longitudinal speech data from Tzeltal children ages 1;6 to 4;0 suggest that the acquisition of spatial systems may run counter to the Piagetian ordering of cognitive stages—topological prior to projective. The children use and understand the rudiments of the absolute 'uphill/downhill' system, which requires them to project coordinates based on the prevailing slope of the landscape to spatially related objects, before the grammatically analogous intrinsic systems (body parts, relational nouns), which encode topological relations such as containment, surface support, and immediate proximity. Older Tzeltal children can extend the absolute system productively to the novel context of a referential matching task by age 6 to 7;8, well before many Western children can use their relative 'left/right' in similar tasks. This evidence for both unexpectedly early acquisition of language-specific spatial categories and the early ability to use these in novel tasks motivates a reassessment of theories that attribute developmental priority to universal cognitive categories over cultural categories and insist on a universal sequence of cognitive development uninfluenced by culture and language input.

This study is part of a much larger cross-cultural survey of the relationship between language and spatial thinking conducted at the Max Planck Institute for Psycholinguistics.[1] That larger study suggests the following four theses:

1. Languages differ, sometimes fundamentally, in the spatial concepts they encode.
2. Spatial concepts in a specific language correlate with the kinds of spatial coding used in nonlinguistic thinking in the community that speaks that language.
3. Language appears to play a causal role in that correlation.
4. Consequently, language- and culture-specific concepts play a role in the conceptual development of the child, and, specifically, they may affect the order or rate of development of particular concepts in "representational thought."

The implication for the Piagetian tradition is that the child's development must be relativized to the local adult norms toward which development is directed. The course of development likewise has no ineluctable directionality, but may be influenced by the nature of the requirements that learning the local language places on children.

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[1]See Pederson et al., 1998, for some results of this research program; see also the Max Planck Institute for Psycholinguistics Annual Reports 1992–1996.

BACKGROUND

Cross-Cultural Studies of Adult Spatial Language and Cognition

Our research team has been preoccupied with a large cross-cultural investigation, over more than 20 cultures, into the relationship between spatial language and spatial cognition. One of our findings is that the language for describing spatial locations and directions on the horizontal dimension[2] differs systematically across cultures. In fact, as mentioned earlier, there appear to be just three major types of frame of reference or coordinate system usable in small-scale local space: absolute, in which locations are specified by reference to fixed bearings (as in 'The boy is west of the tree'); relative, in which locations are specified by reference to the body-planes of the viewer (as in 'The boy is to the left of/behind the tree'); and intrinsic, in which locations of one object are specified by reference to a landmark or 'Ground' object's parts (as in 'The boy is to the rear of the truck').

The background concepts here are actually quite complex, and the details within each category can differ significantly across languages,[3] but what is shared among the three systems is a way to express an angular relation between a landmark object or place L, and the object to be located, O. One can do so by saying, for example, that O is 'west' of L (absolute), O is 'left' of L (relative), or O is at the 'front' of L (intrinsic; where L is, for example, a car or other object with an inherent front).

Not all languages employ all of these systems, at least in colloquial parlance. Some languages use only absolute coordinates, some use absolute plus intrinsic, some use all three, and so on. In a language that uses only absolute, or only absolute and intrinsic coordinates, one cannot, for example, say 'The ball is to the left of the tree'; one must instead say something like 'The ball is south of the tree.' The same holds even for small-scale space, including the description of things immediately in front of one. We may illustrate the uneven distribution of frames of reference across languages with a selection from our cross-linguistic sample (see Pederson et al., 1998):

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[2]By "language for describing spatial locations on the horizontal dimension," we intend the language dedicated to specifying precise angles (directions) on the horizontal (words glossing as 'left/right,' 'front/back,' 'north/south/east/west,' 'uphill/downhill/across,' 'upwind/downwind,' 'seawards/landwards', etc.). Deictic expressions that simply indicate relative distance from the speaker ('here/there', 'this/that') without indicating a particular direction are not considered here.

[3]See Levinson, 1996 for discussion.

<1> Distribution of Frames of Reference.

INTRINSIC	INTRINSIC RELATIVE	INTRINSIC RELATIVE ABSOLUTE	ABSOLUTE	ABSOLUTE INTRINSIC
Mopan	Japanese Dutch	Kalagadi Yucatec Maya	Guugu-Yimithirr	Tzeltal Hai//om

The generalization is clear: any frame of reference (coordinate system) can appear alone or in combination with any other, except that the use of a relative system implies the presence of an intrinsic one. Note that Tzeltal, the language focused on here, has intrinsic and absolute but no relative frames of reference.

Our large-scale project has been interested in correlations between linguistic frames of reference and nonlinguistic thinking, for example, coding of spatial arrays for memory or inference. We therefore have carried out independent but parallel investigations in many cultures, testing language use under many conditions, on the one hand, and testing memory and inference under many conditions, on the other. To test nonlinguistic cognition one must devise tasks of a kind that have no essential reliance on linguistic instructions. We trained subjects to do tasks such as memorize arrays of objects, and then rotated the subjects 180 degrees and got them to reconstruct the arrays. An egocentric or relative coding (in terms of notions such as left/right/front/back) should result in subjects reconstructing the array rotated 180 degrees from the stimulus, whereas an absolute coding should result in no such rotation. The general finding over a range of cultures whose members use absolute or relative coordinates but not both when describing small-scale spatial arrays is that in nonlinguistic tasks the type of coding for memory matches the linguistic coding. More specifically, the following prediction seems to hold:[4]

<2> Isomorphism in Adult Cognition.

> If an adult speaks an absolute language, then he or she will almost certainly code in fixed bearings on a nonlinguistic task.
>
> If an adult speaks a relative language, then he or she will almost certainly code in 'left/right/front/back' concepts on a nonlinguistic task.

This correlation is strong and reliable across cultures where the language is highly restrictive in this manner (one may expect weaker results where a language *prefers*, say, relative over absolute, but where both are colloquially current). We believe that this correlation comes about at least in part

[4]See Brown & Levinson, 1993a; Levinson, 1997; and Pederson et al., 1998, for further details of these studies.

because coding for language requires an isomorphic coding in memory and cognition; in general, you cannot speak in terms of 'A is to the north of B' if your coding for memory is in a different coordinate system, for example, 'A is to the left of B.' In order to speak using concepts appropriate to one coordinate system, it seems essential to remember scenes in the same terms (see Levinson, 1996 for detailed arguments). We therefore propose that there is a causal relationship in these cases, as indicated in <3>:

<3> Causal Hypothesis.

> If language L specifies a restricted set of frames of reference for spatial description, then this will induce a standardization of nonlinguistic coding in the community that speaks L, using the same frames of reference employed in the language.

Perhaps we should emphasize that this is a neo-Whorfian prediction but for non-Whorfian reasons. The prediction is based not, as Whorf proposed, on the grounds of linguistic habit, but on apparently necessary facts about cognitive architecture: certain linguistic expressions presuppose certain conceptual distinctions, and in many cases those distinctions must be coded in memory at *experience time*, otherwise they will not be available at *speaking time*.

But these findings do not necessarily entail a tabula rasa view of conceptual development. There may be some highly structured innate dispositions on which languages build in divergent ways. Some aspects of these linguistic systems may thus be, in some way to be explicated, "unnatural." For example, little Korean children will need to rapidly learn honorific distinctions that are irrelevant in other societies; they will do so independently of some hypothesized natural course of conceptual development. So is the learning of absolute specifications unnatural in the same sort of way, requiring some overriding of more natural inclinations toward a relative system? Relative concepts of front, back, left, or right, for example, seem independently motivated by the analysis of humans' visual field or by the needs of motor behavior. Consider the "symptoms of natural categories" specified by Landau and Gleitman (1985):

<4> Four Symptoms of Natural Categories in Language Acquisition.

1. Early learning (e.g., in the third year).
2. No alternative construals considered.
3. Universal lexicalization in core vocabulary.
4. Learnable under poor input conditions.

However, in terms of these criteria, it seems clear that both absolute distinctions and relative ones are in some respects "unnatural"; neither, for example, are universally lexicalized in core vocabulary, nor are they fully

learned in the third year. Interesting questions then arise about children's acquisition of the vocabulary for such spatial systems:

<5> Is the Vocabulary for Absolute Spatial Systems Delayed?

Question 1: Do children in "absolute speech communities" learn absolute terms later than children in "relative speech communities" learn relative terms?

Question 2: Do children in "absolute speech communities" learn absolute terminology later than alternative intrinsic descriptions of spatial relations?

It is to these questions we now turn.

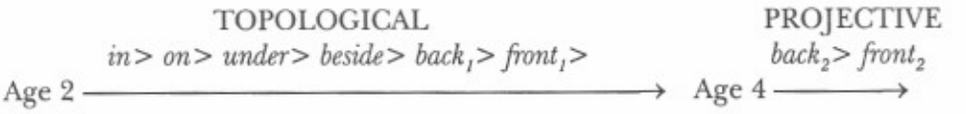
Consequences for Theories of Conceptual Development

Piaget proposed a sequence of development in spatial reasoning. He believed that children's early spatial reasoning is "topological." Topology is often characterized as "rubber-sheet geometry" (i.e., concerning relations invariant under elastic deformation), but Piaget meant something more specific. For him topological concepts involve only proximity, separation, inclusion, and order (see Piaget & Inhelder, 1967). Children are held to build more complex spatial concepts only slowly from about the age of 4 on, first utilizing their own perspectives (as in sighting along objects to construct a straight line), then understanding other persons' perspectives (as in the famous three mountains task), and finally building (around the age of 11) a more abstract conception of spatial relations independent of perspective. He characterized this progression as from a "topological" to a "projective," and finally to a "Euclidean" model of the spatial world. The projective understanding makes available a fairly rapid transition to the Euclidean level of understanding, but the full transition only takes place in late childhood.

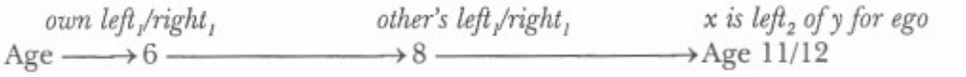
Developmental psychologists and psycholinguists have assumed that there is some resemblance between Piaget's projective and topological schemes and the relative (or "deictic") and intrinsic (or "inherent") systems in language. Take, for example, the linguistic distinction between topological and projective/deictic adpositions, as illustrated by the English prepositions. (In the following description, O is reference object and E is ego or other person.) The English topological prepositions expressing nonoriented two-place spatial relations are *in*, *at*, *on*, and also arguably O's *front*$_1$/*back*$_1$ (i.e., front/back as inherent body parts of a featured O, as in 'at the car's front'), and E's own inherent *left*$_1$/*right*$_1$ (as in 'turn left'). The projective ones (involving at least a three-place relation, projected from E's viewpoint) are *in front*$_2$ *of*, *in back*$_2$ *of*, *to the left*$_2$ *of*, *to the right*$_2$ *of*. In this second sense of

these same word forms, something is, for example, 'in front of the tree,' if it lies between the viewer and the tree. Despite the fact that there are various different usages of the same words, there is reasonable overlap between the developmental psycholinguistic scheme and the Piagetian categories. The observable order of acquisition in the familiar languages is indeed in the predicted Piagetian order, as shown in and <6> and <7>:

<6> Acquisition Order of Adpositions in Several European Languages (Johnston & Slobin, 1979).



<7> Piaget's 1928 Data.



Because of this correspondence between acquisition order and the predicted Piagetian order, it is generally held that *the order of language acquisition is driven by conceptual development*. In other words, the presumption is that language does not facilitate or influence the course of conceptual development but depends on it.

However, some recent developments challenge this story. One is the discovery of absolute languages, where primary or sole emphasis is put on fixed-bearing systems for spatial reference. How are these to be placed in the Piagetian scheme? In fact, the inclusion is simple enough. These systems employ fixed angles ('north,' 'downhill,' etc.) and, as Piaget and Inhelder (1967; p. 30) declared: "It is the analysis of the angle which marks the transition from topological relationships to Euclidean ones."[5] The interesting thing about the angles employed is that they are (in the adult language) entirely abstract concepts: 'north' or 'downhill' defines a conceptual slope across the environment, or, if one likes, a conceptually infinite series of north-pointing parallel arrows across the landscape, as illustrated in Fig. 8.1. These are thus indubitably Euclidean notions, which do not rely on a physical slope; they are used to establish spatial relationships even on completely flat terrain, even in the dark and at night.

To fit the Piagetian conceptual development sequence, the acquisition of these absolute concepts would need to come after the development of topological ones, and should be enabled by prior projective relations. But as we shall see, the Tzeltal language acquisition data do not fit this prediction.

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[5]See also Piaget, Inhelder, B., & Szeminska, A. (1981) for Piaget's later views on Euclidean thinking.

'He's downhill (north) of the house.'

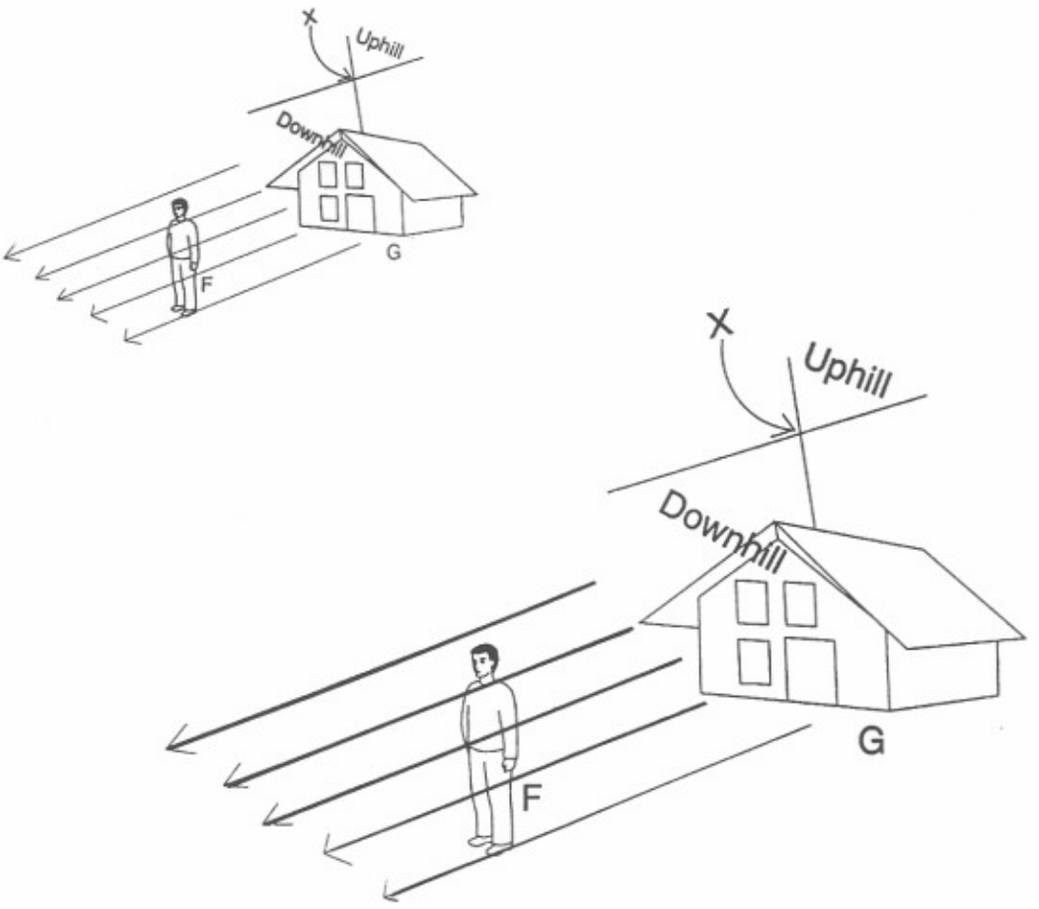


FIG. 8.1. The geometry of absolute coordinates.

A second basis for doubting the presumption that conceptual development is always prior to and independent of linguistic development comes from the work of Bowerman. This work shows that, in some respects, conceptual development is led by the linguistic nose, rather than vice versa (Bowerman 1996, chap. 9, this volume; Bowerman & Choi, 2000; Choi & Bowerman, 1991). For example, even at 18 months of age, infants can be shown to have internalized language-specific spatial categories. In addition, there are also reasons to think that some spatial concepts are intrinsically linguistic: for example, *south* is not given by any individual's independent act of cognition, and even if it were, it would have no necessary collective (communicative) utility. In this respect *north 180 degrees* is just as culturally arbitrary as feet and inches or other systems of metric distinc-

tion. These kinds of spatial notions, then, are the sort of concepts that may be learned first through language and only later come to play a language-independent role in mental life. They are thus good candidates for where language might promote conceptual development of a sort and at an age unlikely in cultures where the language provides no such concepts in everyday child-relevant contexts.

These developments re-invigorate the old debate between the two titans of developmental psychology, Piaget and Vygotsky. Whereas Piaget held that it is action and nonlinguistic experience that spurs conceptual development (Ginsburg & Opper, 1969, p. 171), Vygotsky held that the internalization of linguistic categories can play a central role in conceptual development (Vygotsky, 1986; Wertsch, 1985). This distinction is shown schematically in <8>:

<8> The Two Hypotheses.

A. Conceptual development drives linguistic development (PIAGET).
Evidence: for example, order of acquisition of Indo-European prepositions matches Piagetian order: topological prior to projective

B. Language can also drive conceptual development (VYGOTSKY).
Evidence: (a) language-specific concepts are encoded very early (Bowerman, 1996; Choi & Bowerman, 1991; Bowerman & Choi, 2000)
(b) Euclidean spatial descriptions emerge at the same time as, or even prior to, topological ones, in absolute communities (possible development described in this chapter)

It is obvious that any investigation of the relation between language and thinking ought to tap linguistic and nonlinguistic data independently. This is precisely what we have tried to do in our large-scale cross-cultural project. But if one is interested in the early stages of language acquisition this is often impractical: trying to get pre- or almost prelinguistic infants to perform on a conceptual (as opposed to a perceptual) task is difficult, especially in cultures where childrearing practices inhibit exploration and manipulation of the environment. Nevertheless, by studying the first two years of language acquisition, much can be learned about the child's cognitive development, providing one subscribes to the following assumption, which we believe needs no justification:

<9> Semantic Distinctions Presuppose Cognitive Distinctions.

If the semantics of linguistic expression L presupposes a conceptual distinction D, then evidence that a child/adult *uses L correctly* is prima facie evidence that the child/adult is employing D.

When a large set of related terms in different grammatical categories is correctly used by a child, we can be reasonably certain that the relevant conceptual distinctions are being employed. Note, however, that a few cautions must be observed:

1. The rote-learning problem: Because correct usage could be based on memorized collocations, the child should be observed using novel combinations.
2. The subdomain problem: Because the correct usage in one context alone might be based on rote learning or some partially correct understanding, the child should be observed using L across a wide range of applications, in different contexts, and with syntactic variations.
3. The absence problem: Absence of the use of L does not allow us to infer absence of the distinction D. For that, one needs direct evidence that the child cannot reason using D.
4. The problem of usage versus meaning: It is in principle possible to exhibit apparently correct usage based on incorrect analysis of meaning. However, to the extent that adults themselves converge on identical meanings, they do so through extended use in all domains and contexts. Therefore, child language should ideally be monitored across all relevant contexts.

We return to these caveats when discussing the significance of our results.

We now turn to a study of the first years of spatial language acquisition in the Mayan community of Tenejapa, in southern Mexico. (See Fig. 8.2). In this community, the absolute frame of spatial reference is the single, major adult coordinate system for spatial description except where objects are touching or in close proximity, in which case an intrinsic system is used.

TENEJAPAN TZELTAL: ADULT SPATIAL LANGUAGE AND COGNITION

Let us first describe the relevant properties of the linguistic systems used in each of the two available coordinate systems. We use the term *Ground* to refer to the landmark object with respect to which the location of the *Figure* (the object to be located) is described (Talmy, 1983).

The Intrinsic System: Topological, Object-Centered

Where two objects are contiguous, the exact relation of one of them (the Figure) to the other (the Ground) can be specified by using the name of a part of the Ground, so that one says, in effect, things like 'The axe is at

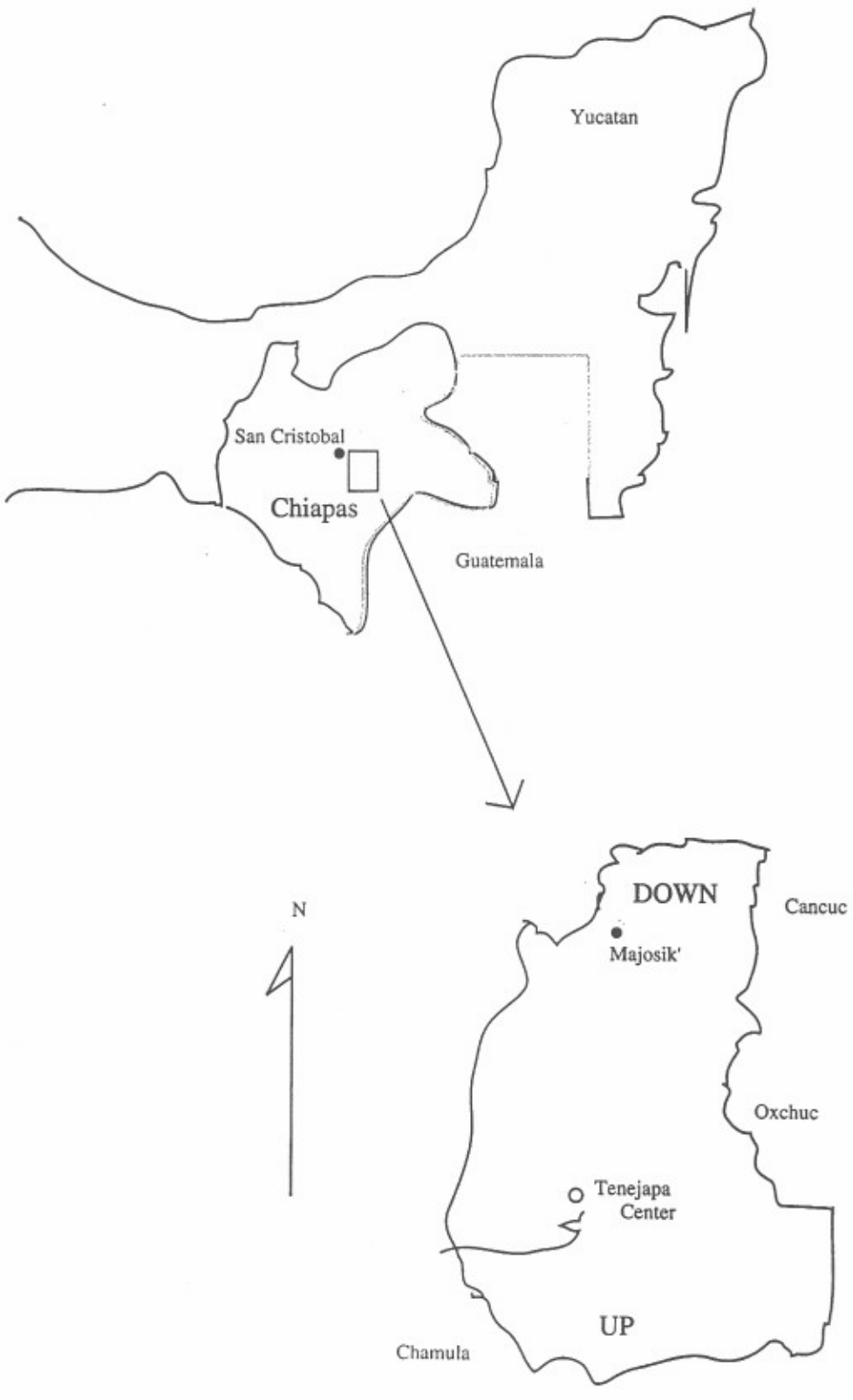


FIG. 8.2. The geographical setting of Tenejapan Tzeltal.

the mouth of the house.' Tzeltal provides a rich set of part names, based on human and animal prototypes, which can partition any physical object (see Levinson, 1994; Brown, 1994). These part names are used in the possessive (as in 'the mouth of the house'), and are thus grammatically similar to the relational nouns involved in the absolute system described later. Some examples are given in <10>:

<10> *kotol ta sjol karo te tz'i'e.*
'The dog is standing at the "head" of the car' (i.e., directly in front of it, at its front end).

waxal ta xchikin mexa te limete.
'The bottle is standing at the "ear" (i.e., corner) of the table.'

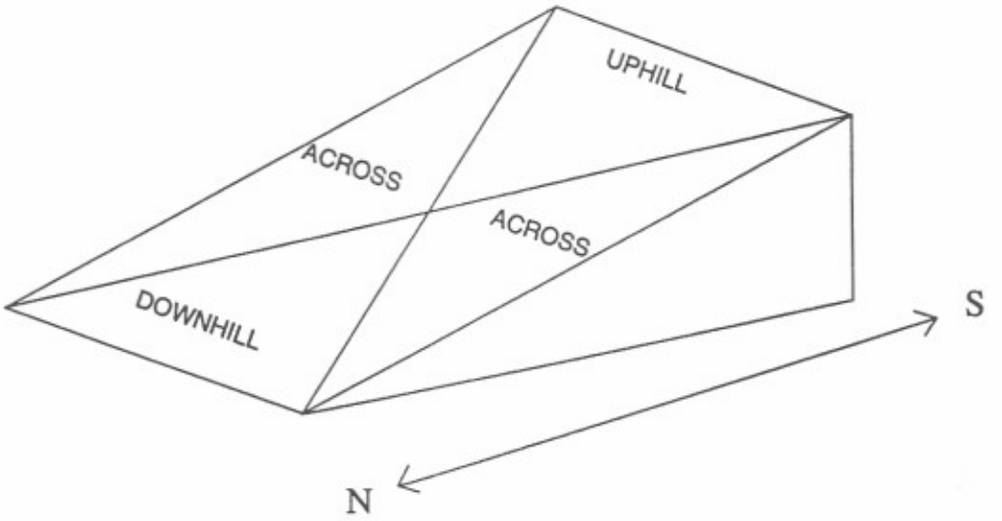
ta yakan xalten ay, te use.
'The fly is at the "leg" (i.e., handle) of the frying pan.'

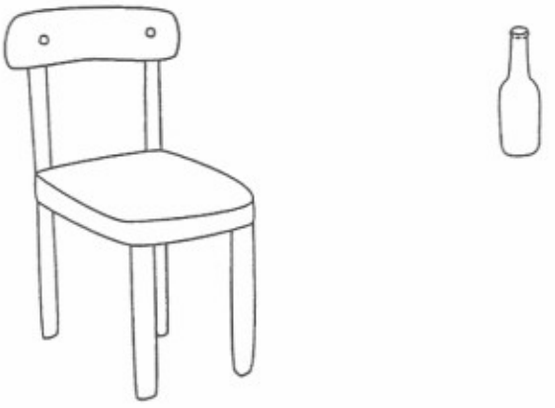
ta yutil bojch, te mantzanae
'The apple is at the "inside" of the gourd.'

The vocabulary of the intrinsic system is in some respects quite similar to English spatial prepositions like *in*, *on*, and *under*, which, as we have seen, are among the first spatial words to be learned by English-speaking children. The Tzeltal terms are restricted to situations where objects are directly adjacent; for objects that are further apart, the absolute system comes into play.

The Absolute System: Euclidean/Projective, Geographically Centered

There is no relative 'left'/'right'/'front'/'back' system in Tenejapan Tzeltal. Instead, there is an absolute 'uphill'/'downhill' system based ultimately on the overall general slope of the territory of Tenejapa (downward from high south to low north). This has been abstracted, however, to yield an abstract cardinal direction axis analogous to 'south/north' although systematically skewed from our cartographic axis, as indicated in Fig. 8.3. Together with an orthogonal axis, labeled 'across' at both ends, this provides a system of cardinal directions (see Fig. 8.3). These directions are used to specify locations of both the small scale (e.g., things on a tabletop) and the large scale, and are not restricted to outside space. The cardinal direction system is independent of the actual slope of the terrain, being usable on the flat, and even outside the territory altogether. The system is expressed both in nouns and in verbs of motion (e.g., 'ascend' can mean in effect 'go south'). Because there is no relative system (with notions like 'in front of,' 'to the left of,' etc.), and because the intrinsic body-part system can only be used when objects are contiguous, the absolute system





'The bottle is uphill of the chair.'

FIG. 8.3. The Tzeltal absolute system.

plays a crucial role in linguistic descriptions of location. Thus in Tzeltal one describes spatial relationships as in the following examples:

<11> *waxal ta yajk'ol bojch te limete.*
'The bottle is standing "uphillwards" (i.e., southwards) of the bowl.'

chotol ta yanil amak' te tz'amalte'e.
'The bench is "beneath" the patio.' (downhillwards/north of)

ya xmo ta jobel te winike.
'The man is "ascending" to San Cristobal.'

ya xwil koel mut.
'The bird is flying in a "descending" direction.' (either downhillwards, or straight down)

jelaw ta colonia.
'He "crossed" to Colonia.' (i.e., went across (orthogonal to) the south-north slope of the land)

tzakben tal machit tey xik'il ta yajk'ol ti'nel.
'Bring me the machete standing "above" (uphillwards of) the door.'

ta alan otzesa.
'Put it (a puzzle piece) in downhillwards (in the downhillwards hole).'

There is a dedicated spatial vocabulary for this purpose, consisting of (a) intransitive verb roots ('ascend'/'descend'), (b) their transitivized counterparts ('cause it to 'ascend'/'descend'), (c) directional adverbs ('ascending'/'descending') and (d) nouns, which may be unpossessed and hence only implicitly relational ('uphill'/'downhill') or explicitly relational possessed nouns ('its above-or-uphill-side'/'its underneath-or-downhill-side'). This vocabulary is given in Table 8.1.

There are systematic ambiguities in the usage of the whole set of these words. First, the vertical axis ('up/down' vertically) is conflated with the absolute system of spatial reference for calculating angles on the horizontal ('up/down' in relation to the south/north slope of the land). So when people say the Tzeltal equivalent of 'ascend' or 'descend', they can mean

TABLE 8.1
Dedicated Spatial Vocabulary for the Tzeltal Absolute System

	MOTION		*STASIS*	
	Verb	*Directional*	*Relational Noun: unpossessed*	*Relational Noun: possessed*
UP	*mo* 'ascend'	*moel* 'ascending	*ajk'ol* or *kajal* 'uphill'	*y-ajk'ol* 'its-above-side' *s-ba* 'its top or uphill side'
DOWN	*ko* 'descend'	*koel* 'descending'	*alan* 'downhill'	*y-anil* 'its underneath or downhill side' y-e'tal 'its downhill side'
ACROSS	*jelaw* 'cross'	*jelawel* 'acrossways'	*jejch* 'side'	*s-tz'e'el* 'its side'

either vertically or along a coordinate abstracted from the lay of the land. Secondly, there is yet another ambiguity between the *local* actual gradient as opposed to the global absolute (south-north) slope, because, if the local slope deviates from the absolute slope, it may be used as an additional coordinate for describing local spatial relationships. Thus an utterance glossing 'It is uphill from the house' might mean either 'It is south of the house' (cardinal direction sense) or 'It is up the local slope from the house' (local geographic sense). This is a vocabulary that is therefore not only semantically complex, but also has a range of alternate complex interpretations, which are disambiguated by pragmatic principles (see Brown & Levinson, 1993b, for details). In short, nothing makes this easy for children to learn.

In Piagetian terms, spatial relations describable with the Tzeltal intrinsic system (where an object is spatially related to the named body parts or regions of a reference object), are essentially topological. A two-place relation is at issue: a Figure is said to be '*AT*' some named part or region of a Ground object. The absolute system, in contrast, is Euclidean: the location of objects is described in a coordinate system independent of the scene described, and indeed independent of the perspective of the observer. Because precise directions and angles are involved in using the coordinate system and the system is independent of the objects related, it constitutes an abstract spatial framework at least Euclidean in character, if not Newtonian! At least a ternary relation is involved: 'A is uphill from B' involves A, B, and the direction C, 'uphill.' On first principles, and judging by studies of Western children, we would expect the Tzeltal intrinsic system to be conceptually easier, and therefore earlier learned, than the absolute 'uphill/downhill' system. We might also expect this on the grounds that intrinsic systems seem to be found in nearly all languages and might thus be held to be based on universally available concepts. The very general hypothesis that language encoding cognitively simpler concepts (such as topological spatial concepts) is learned earlier by children than that encoding more complex concepts (such as projective spatial concepts) is generally well-grounded. Moreover, in the domain of spatial language, it is very robustly supported by evidence from the acquisition of European spatial adpositions. As shown in <8> and <9>, children learn topological prepositions ('in', 'on') before intrinsic 'in front'/'behind', and they learn those before projective 'in front'/'behind', and well before 'left'/'right'. As mentioned, this has long been taken as support of the position that conceptual development drives language development.

Yet these studies did not consider languages with absolute systems. These would be expected to develop late, because they have cognitive properties that are considered to be difficult. They are (at least potentially) decentered, making no reference to ego's point of view, and (at least in

full-blown adult form) they require an oriented mental map. The first acquisition study of an absolute system (to our knowledge) was conducted by de León (1994), working in another Mayan language, Tzotzil, spoken in a neighboring community, and very similar linguistically to Tzeltal. She found evidence of remarkably early competence of children in the absolute system. In a cross-sectional study, she found competent child use by about age 4 in production and comprehension placement tasks on a tabletop (although full adult-like performance is much later) and concluded that absolute and intrinsic come in together, at about the same age, around age 4.

In this Tzeltal study we build on her work, but we are interested in the very earliest appearance of the absolute system, the form it takes, how it develops, and how it relates to the acquisition of the intrinsic system.

THE CHILD DATA

The Data

The data reported on here are drawn from a longitudinal study of five children in monolingual Tzeltal families, covering the ages of 1;6 to about 4;6 with four to six weekly samples, plus any older siblings or cousins that happen to be present. (The data cover a total of more than 20 children less than 10 years old). The database consists of more than 600 hours of tape-recorded and/or videotaped natural interaction of children, mostly in their own homes, interacting with caregivers, siblings, and/or cousins. This is supplemented by elicited production and "space game" tasks with older children. The data have been transcribed by native speakers in the field and are still in the process of being checked, computerized, and coded by P. Brown.

Questions: Children's Production, Ages 2 to 4

The questions to be addressed here by looking at Tzeltal children's language development are the following:

Q1. Does the intrinsic system appear earlier than the absolute one in children's language production? (Recollect that Tzeltal has both.)

Q2. Within the absolute system, is the vertical sense (being more "natural") learned earlier than the horizontal sense?

Q3. In the horizontal absolute uses, is the local-slope sense (because it is more concrete and visible) learned earlier than the abstract cardinal-direction sense?

Q4. Are absolute systems so complex and "unnatural" that children learn them later than the corresponding relative (left/right/front/back) systems are learned in communities that use relative coordinates?

We take these questions in turn.

Question 1: Is Intrinsic Learned Before Absolute?

Insofar as we can infer from production data alone, the answer is no. Children's production of intrinsic vocabulary in locative expressions is either simultaneous with or actually later than absolute vocabulary. The evidence from longitudinal data of three children[6] is summarized in Table 8.2, which presents the absolute vocabulary, with columns for each major grammatical category in which it is encoded. As Table 8.2 shows, absolute vocabulary first appears in children's speech around the age of 2;0, in some cases when the child is still in the one- or two-word stage. It is fully productive (in contrast sets, in different contexts, in different grammatical constructions, in both possessed and unpossessed forms, etc.) by at least age 3;7.

Intrinsic vocabulary, in locative uses (i.e., not just as names of animate body parts), appears somewhat later in this natural production data, as shown in Table 8.3. The nouns meaning things like 'top,' 'back,' 'middle,' 'inside' in either unpossessed or (explicitly relational) possessed form are extremely rare until age 3;6, and possessed body parts used as locatives are virtually nonexistent in the data even by age 4. On the basis of this production data, then, absolute vocabulary appears to come into use prior to the intrinsic terms.

We consider the Tzeltal dedicated intrinsic system to consist of possessed body parts and in addition certain relational nouns (e.g., indicating 'underneath', 'on top') used as locatives. As can be seen from Table 8.3, this whole vocabulary comes in relatively late. However, topological place relations can also be expressed using the single Tzeltal preposition with little inherent meaning: such expressions of the form 'AT trail,' or 'AT town' for example, without any further spatial discriminations, do appear much earlier, at the two-word stage (around the age of 2;0). But the intrinsic system of body parts and topological relational nouns ('inside,' 'outside,' 'topside,' 'middle,' etc.) is used productively very late. There are no

[6]The two other focal children are omitted here as their data are not yet processed sufficiently to analyze. Their performance in terms of absolute and intrinsic vocabulary, however, is consistent with that of these three focal children, as is that of several other children present in the data collected. See Brown, 2000, for details.

TABLE 8.2
Summary of Production, Ages 2 to 4, for Absolute Vocabulary

Age	*Verbs ('ascend' 'descend')*	*Directionals ('ascending' 'descending')*	*Unpossessed Nouns ('uphill' 'downhill')*	*Possessed Nouns ('its-uphill', 'its-downhill', 'above it', 'below it')*
2;0–2;5	x[a]	x	x	
2;6–3;0	yy[b]	yy	yy	
3;0–3;6				x
3;7–4;0				yy

Note. Sample size is 3.
[a]x = first appearance of terms; [b]yy = Productive use, in contrast sets, with no errors.
From "Learning to Talk about Motion UP and DOWN in Tzeltal: Is there a Language-Specific Bias for Verb Learning?, 2000 by P. Brown, in M. Bowerman and S. C. Levinson (Eds.), *Language Acquisition and Conceptual Development*, Copyright 2000 by Cambridge University Press. Reprinted with permission.

TABLE 8.3
Summary of Production, Ages 2 to 4, for Intrinsic Vocabulary

Age	*Unpossessed nouns ('middle', 'top', 'back', etc.)*	*Possessed Relational Nouns ('its-middle', 'its-inside', 'its-top', 'its-underneath')*	*Unpossessed Body Parts ('its-head'/'its-foot'/'its-belly'/'its-nose'/'its-ear', etc.)*
2;0–2;5			
2;6–3;0			
3;0–3;6			
3;7–4;0	x[a]	x	
4;1–4;6	yy[b]	yy	x ??

Note. Sample size is 3.
[a]x = first appearance of terms; [b]yy = Productive use, in contrast sets, with no errors.

examples of possessed body parts used as locatives—the Tzeltal dedicated intrinsic system—in the three children's speech in the data examined to date (sampling ages 1;6 to 4;0).[7] Children less than 4 years of age do not seem to use these productively as locatives, although they probably understand adult locative uses of them.

[7]This is with the exception of a few frozen unpossessed forms that are compound nouns and not productive combinations; for example, *ti'nel* 'door [lit: mouth-house],' *patna* 'back (of) house.' In such cases, saying that something is 'at the *ti'nel*' is equivalent to saying it is 'at the door,' not that it is 'at the mouth/edge of the door.'

Although these nouns constitute the main intrinsic vocabulary, there are other, more indirect ways of expressing topological concepts, for example, through verbs of 'putting in' or 'taking out'. These do appear in children's speech earlier than the intrinsic nouns, some even earlier than the corresponding absolute verbs of 'ascending,' 'descending,' and 'crossing.' The motion verbs 'enter' and 'exit' might also be held to encode topological notions of containment, and they also appear at about the same time as 'ascend'/'descend' (around age 2;0), at around the two-word stage. (These verbal notions also appear in gerundive directional adverbs at about the same age.) There is therefore evidence from language production of early understanding of some topological notions, especially those of containment.

On the basis of this linguistic evidence, we can see that Tzeltal children of 2 years of age do indeed talk about some topological relationships using the single preposition to express location at a place, and verbs to indicate motion in and out of containers. We can therefore infer that they have the corresponding topological concepts, as would be expected on Piagetian grounds. But the children do not seem to use these concepts as the basis for an early acquisition of the more detailed Tzeltal intrinsic body part system, which requires both an analysis of the shape of objects (e.g., an 'arm' is a rigid protrusion) and the use of the parts isolated on the basis of shape to speak about the location of other objects close to those parts. There is evidence that children have mastered many of the basic body part words for humans and animals between the ages of 2;0 and 2;6, suggesting that there is nothing inherently complex in the phonology or constructions. Nevertheless, they do not use the same lexemes as intrinsic spatial relators until much later.

Let us return to the early use of the absolute vocabulary, as shown in Table 8.2. Of course we need to know just how children of ages 2 to 3;6 are *using* their absolute vocabulary. Is it really being used in the abstract, cardinal direction sense that would entail a Euclidean level of conceptual development? To assess this, we must place their usage within the physical and geographical context in which it occurs, which is initially the children's own house compound (consisting minimally of two small houses). Even when the layout of a household compound is relatively flat, children from about age 2;0 use absolute vocabulary to talk about spatial relations within this local household space. They use absolute motion verbs ('ascend'/'descend') to describe movement between the houses, absolute directionals ('ascending'/'descending') to convey the direction of motions and the orientation of positions vis-à-vis the absolute axis, and relational nouns ('uphill'/'downhill') to talk about the spatial relations of objects within this local arena. Thus when playing with toys, they might say 'push the truck uphill here; it's ascending' and so forth, either in the cardinal

direction sense, or in the sense of up the local slope. They also use absolute vocabulary for more distant spatial relations: for example, someone who has gone south to the school may be said to have gone 'uphill,' or when coming back may be said to be 'descending.'

Now, there is of course a progression in understanding the system. From production data one can see that, although the terms appear to be used with correct reference from the beginning, children may have some simplified understanding of the meaning. On the basis of limited productivity, one may guess that children's first usage of the 'uphill/downhill' nouns is perhaps much like the use of place names; it is nonprojective and nonrelational, in the kind of examples illustrated in <12>.[8] Verbs of motion encoding correct cardinal directions also occur, as in <13>, but early uses may be constructed by emulated collocation with named places rather than by active construal of the direction:

<12> From Age 2;0 to 2;6: Possibly Nonprojective, Nonrelational Uses of 'Uphill/Downhill' nouns.

'Mrs. (at) uphill.' (the uphill-living Mrs. is the one I mean)
'I come (to) across, that is, I traverse.' (orthogonal to the uphill/downhill axis)
'He's gone (to) downhill.' (down to place where their cornfields are)
'Antun (at) downhill.' (response to 'Who hit Father's foot?')
'He's gone (to) house (of) father downhill.' (response to 'Where's your namesake?')

<13> Age 2 to 2;5: Early Use of Absolute 'Ascend/Descend' Verbs.

'I'm ascending/descending.' (For example, to the other house, either actually up/down the slope of the land, or on the flat but in the direction of the south/north overall slope of land)
'It descended toward here.' (toy car down hillside)
'I'll ascend too.' (to other house, steeply 'uphill')
'Nik is ascending away.' (to his house)

We can only be sure that children have the abstract ternary conceptual relation in mind (e.g., A is in the uphill relation to B) when the ground object (B) is explicitly mentioned. Certainly by age 3;6, some examples of explicitly relational absolute uses are found in the children's data, showing that they are now able to use absolute coordinates to project angles in order to calcu-

[8]The examples here are from naturally occurring language production of the children. For reasons of space only the English glosses are given; see Brown, 2000, for many full Tzeltal examples.

late novel spatial relationships of moveable objects in relation to fixed landmarks or reference objects, as illustrated in <14> in English gloss:

<14> By Age 3;6 : Explicitly Relational Uses of Absolute Nominals.

'There it (the ball) is downhill of the mandarin tree.'
'To "its uphill" (uphill side of house) here we come again.'
'We went for injections to uphill-of Alvina's house.'
'It was found below (downhill of) the water tap.'
'He lives downhillwards of the school.'

The complexity of the Tzeltal constructions can be best seen from examples <15> and <16>:

<15> (3;6) *ya ka'y xan tza'nel jo'tik lum a ine ta yanil retrina.*
'We're going again for a shit over below ("downhillwards of") the latrine.'

<16> (3;11) *lum ay ta yanil mantarinae.*
'It's below (lit: at-its-downhill) the mandarin tree.'

To return to our initial question, the answer is clear: on the basis of children's linguistic production, the absolute system appears to be produced in its entirety and to be productive (at least in a limited way) well prior to the full appearance of the body part intrinsic system.

We turn now to our second question.

Question 2: Within the Absolute Usages, Are Vertical Uses Earlier Than Horizontal Uses?

The essential answer is no, except for one child. In general, the vertical senses of these up/down words do not seem to necessarily precede the local-slope senses; they appear together (Brown, 2000). This is of course contrary to what one might expect on the grounds that the vertical is universally perceptually given and presumably universally encoded in languages (Clark, 1973), whereas the uphill/downhill distinction is culturally specific. But in the sample, all the children use the uphill/downhill nouns initially in their land slope sense only, even though they sometimes hear adults use them in their vertical sense; in addition some children use the verbs *mo/ko* 'ascend/descend' in the absolute horizontal senses as early as they use them in the vertical sense (as in 'climb a tree'). A clear case of such absolute usage ('ascend' on flat ground) is the following:

<17> Ant is 3;5, Lus is 2;0: [they are playing with a toy car on flat ground outside house]

Ant; *bajt jobel ja' ini, bajt jobel.*
gone San Cristobal it_is this, gone San Cristobal.
'It's gone to S.C., it's gone to S.C.' [toy car]

Lus; *moem bel*
ascend-STAT goDIR
'It has ascended awaywards' [re car mentioned as going to S.C., to the south]

Although utterances like Lus's in <17> are relatively rare at this early age and are certainly outnumbered by utterances using vertical senses for 'ascend/descend' verbs, the children already display, by around age 2, the ability to use them in either sense.

Question 3: In the Horizontal Absolute Uses, Is the Local-Slope Usage Earlier Than the Cardinal Direction Usage?

Here the answer is clearly yes, as one would expect on the grounds that the perceptual support of a local, visible slope with its experiential implications for motor exertion would facilitate the acquisition of the local-slope meanings (e.g., 'up this incline'). These land-slope meanings of the 'up'/'down' vocabulary are at first restricted to a relatively small set of contexts, as de León (1994) found in her Tzotzil data as well. In the Tenejapan village under study, the relationship between local-slope and the cardinal directions (north/south) varies across households, as does the arrangement of houses and relevant other places. Households normally consist of at least two houses, one for sleeping in, one for cooking and eating in. In some households, these houses are uphill/downhill from each other, in others they lie 'acrossways' from another. Where the local-slope deviates markedly from the North/South axis, the language allows utilization of 'uphill/downhill' terms to describe the local slope. In the households where this is the case, both adults and small children use the local-slope for describing the angle of events occurring on the flat patio area between houses. Children are thus not yet forced into the abstract cardinal direction use of the absolute system, because another usage with more perceptual support is available.

To summarize: Tzeltal children start using the absolute vocabulary with both land slope senses and vertical senses at the two-word stage, from about age 2;0. Initially, these terms are used nonrelationally, that is, without explicitly specifying the Ground in relation to which something is up-

or downhill. By at least age 3;0, they have mastered the semantic contrasts for the entire set of absolute terms, and the syntax of possessed nouns is mastered by at least age 3;7 (this syntax is equally relevant for both absolute and intrinsic nominals). They are using the vocabulary in an explicitly relational way by this time, specifying the Grounds where relevant, and sometimes in novel contexts (saying things such as "F is uphillwards of G" for novel F's and G's). At this point in contrast they do not yet seem to be using the intrinsic system productively (although, as mentioned, they know the names for animate body parts and probably understand at least some of the intrinsic usage of adults around them).

Now three important points must be stressed:

1. As mentioned, the vertical senses of these 'up/down' words do not seem to necessarily precede the local-slope senses; they appear together. Thus the universally relevant vertical axis does not seem to give the child a significant lead or way in to the meaning of these terms.
2. The frequency of use in the input language, at least on initial examination, does not seem to explain the priority of absolute over intrinsic frames of reference.[9]
3. Grammatical complexity cannot explain the priority of absolute terms over intrinsic terms, since they occur in the same grammatical constructions. For example, both involve the same possessive construction type, as illustrated in <18>:

<18> Explicitly Relational Absolute and Intrinsic Possessed Nouns.

ABSOLUTE *ta y-ajk'ol na*
PREP 3E-uphill house
'at its-uphill house' [i.e., uphillwards of the house]

INTRINSIC *ta s-xujk na*
PREP 3E-side house
'at its-side house' [i.e., beside the house]
ta y-util na
PREP 3E-inside house [i.e., inside the house]
'at its-inside house'

In the possessed noun construction, absolute nouns ('its-uphill/downhill') are productively used by children at least as early as intrinsic ones.

[9]Both are relatively infrequent, at least in comparison with Indo-European spatial language encoded in prepositions (three examples of each appeared in a sample of 368 utterances, in 1.25 hours of natural interaction with a 2-year-old). There are of course difficulties in comparing the frequencies of two *sets* of vocabulary; this is a problem which needs to be further explored.

However, there are of course severe limitations to natural production data. One often cannot know just from the speech children produce how productive these vocabulary items are, because in many cases their linguistic production could in principle be based simply on memorized collocations between absolute expressions and particular locations or landmarks, despite a good range of contexts and named locations.[10] If such child usage is based on rote collocation, it would of course fail to index any of the abstract conceptual grasp of a spatial framework independent of objects and perceptual viewpoints that is the conceptual fundamentals of a real absolute system. We need therefore controlled evidence of use in completely *novel* situations, to which we now turn.

Child Data: Ages 4 to 12, Farm Animal Games. For this reason a number of referential communication tasks designed as interactional "space games" were carried out with children down to the age of 4;0 (which is about the limit of the method). The farm animal task requires one player, the director, to describe a spatial layout to another, the matcher, who—despite being visually screened from the director's scene—has to recreate the array with a matching set of toys (see Fig. 8.4 for an example of the stimuli). This is one of many kinds of naturalistic experiment devised by members of the Space Project at the Max Planck Institute;[11] in this case, it is a verbal game played between two native speakers, designed to prompt spatial descriptions. Adults describe the scenes depicted by saying things like: 'place the cow uphillwards of the tree,' 'pull the horse downhillwards,' and so forth. We found that some children are able to take the matcher role, to understand and follow the instructions utilizing uphill/downhill spatial relators in these novel tabletop tasks, from as young as age 4, albeit with a lot of repetition by the director. These children are already at age 4;0 using the abstract, cardinal-direction sense of the absolute terms.[12] For production in the same novel tasks—operating as the director—we find adult-like usage ('put the cow uphillwards of the horse, facing acrossways,' for example) in general by age 7;8. (So far there is one precocious child who can do this at the age of 5;8, and four others between 6;5 and 7;8.) By the time children can perform the director role in this game, their uphill/downhill usage is fluent, accurate, and productive and (for at least some) can be used indoors as well as outdoors. There is no doubt that for this novel task, setting up toys in arrangements they

[10]Although children by age 3;6 can use this system to spatially relate objects and events to places and people familiar to them, this might amount (as a guess) to 20 or 30 places; just when this extends to *any* place is still unclear.

[11]See Space Stimuli Kit 1.2, 1993, produced by the Cognitive Anthropology Research Group at the Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands.

[12]The farm animal games of five children ages 4 to 5 have been analyzed so far.

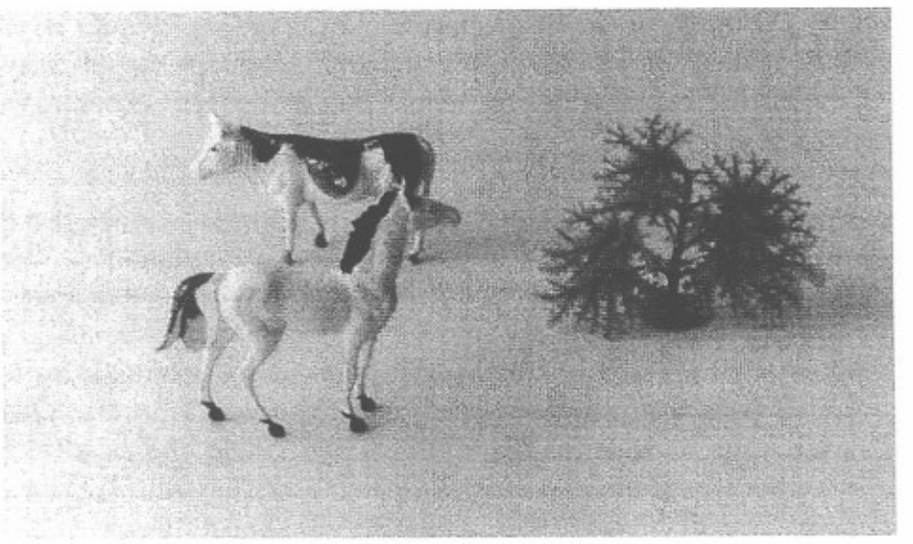


FIG. 8.4. Farm animal game stimulus.

have never seen before, the children must be using their absolute system as an abstract set of coordinates that can be applied to novel assemblages, to generate the correct application of linguistic labels. That they use the full cardinal-direction abstraction of the system underlines the precocity of this behavior from a Piagetian point of view. There may of course be various ways in which these children still do not have adult mastery of the absolute system. It may still be the case, for example, that children have not learned the pragmatic priorities that effectively disambiguate the various possible senses (cardinal-direction, local-slope, vertical) of the terms. We can expect them to be less good at the dead-reckoning that allows adults to use such a system in the dark, in an unknown town, inside an unfamiliar building. Nor at this stage do we know how much individual variability there is in children's usages, perhaps determined in part by the ecologies of their households and visiting relations with other households.[13] Answers to these questions are being pursued in ongoing research.

Thus, although most children of 8 years of age appear to have mastered the system completely, it may be that their understanding of it is less than fully adult. Nonetheless, we can be confident at this point that there is surprisingly early acquisition of a conceptually complex frame of reference, mastered for local (familiar) situations and tabletop space, indicating at least a limited productivity of these spatial terms by age 7½ or so.

[13]There is some suggestion, for example, that the acquisition pattern may not be exactly the same as what de León (1994) described for Tzotzil in the neighboring Tzotzil community of Nabenchauk, raising the possibility that it is influenced by the different north/south slope of the land in these two communities, with a crosscutting east/west 'sunset'/'sunrise' axis in Tenejapa but not in Nabenchauk.

How Do the Children Do It? There are three points to make about the situation in which Tzeltal children learn their language, which may provide them with the scaffolding allowing them to use this absolute system in novel contexts so early:

1. Perceptual support. Because the absolute system allows one to use the local-slope axis as a basis for the coordinate system, children can get direct perceptual support for some early, more local, uses of the system.
2. *Gesture*. The absolute system is supported by very accurate directional pointing, which typically co-occurs with absolute usage in adult speech, and this may systematically help the child to grasp the conceptual underpinnings of the abstract system (Levinson, in press).
3. *Input*. Although these spatial words are not particularly high frequency items in the input to small children (because caregivers often do not need to be specific about locations, and they can often use deictics), the uphill/downhill terminology is used consistently in particular contexts: (a) for describing vertical motion and vertically aligned static spatial relations, (b) for describing motion and static relations in spatially close proximity using the local-slope coordinates, and (c) for describing motion and static relations across significant distances along the absolute axis.

Absolute descriptions are sometimes also used by caregivers to small children for small-scale location on flat (e.g., tabletop) surfaces, although small children may not spontaneously use it this way (except in the space game tasks).

In the contexts where small children use and hear language, there is thus a very consistent mapping between the 'uphill/downhill' words and particular places, directions, people, and events, which may provide the initial entry to the system. This then can later be used for more moveable objects and more ephemeral spatial relations.

We turn now to our fourth and final question, about the relative acquisition order of absolute and relative systems.

Question 4: What, If Anything, Is Unnatural? Absolute Versus Relative Systems

On the basis of the "symptoms of natural categories" specified by Landau and Gleitman (1985; summarized in <6>), both absolute and relative systems are in some senses unnatural. What we have presented so far

demonstrates that the absolute system is not delayed, in relation to relative 'front/back/left/right' systems. If it is unnatural, it seems to be less unnatural than the left/right part of our own (English/Dutch/German, etc.) projective system. Consider the evidence accumulated about the ages when children speaking European languages learn the spatial pre- or postpositions (already given in <9>), and let us compare it with the ages when Tzeltal children are learning their absolute and intrinsic vocabulary, as summarized in Table 8.4. Thus, the Tzeltal data contrast with evidence from European languages about the relative order of acquisition of intrinsic/topological and Euclidean/projective vocabulary. The same conclusion was reached by de León (1994) in relation to her Tzotzil data which showed absolute appearing at least as early as intrinsic. These Mayan language data suggest that children do not find the learning of an absolute system particularly difficult. Rather than child speakers being delayed, for example, in their 'uphill/downhill' system, in comparison with children who speak relative languages (and learn to use a 'left/right/front/back' system), the Mayan children would seem to be advanced. Tzeltal children understand their absolute system used in novel tasks on flat tabletop space by the age of about 4 to 5; they produce it in such novel tasks fluently, accurately, and productively by at least 7½ years. This

TABLE 8.4
Comparative Data on Age of Absolute/Relative Vocabulary Acquisition

	in > *on* > *under* > *beside* >	*back*$_1$ > *front*$_1$ > [a] ('boy behind truck')	*back*$_2$ > *front*$_2$ ('boy behind tree')
European:	Age 2 ----------c. 3;10 ---------->		Age 4 on[b] ---------->
Tzeltal:	Absolute ----------> 3;6 ---------->		Intrinsic --------->
European:	*own left*$_1$*/right*$_1$[c]	*other's left*$_1$*/right*$_1$[d]	*x left*$_2$ *of y for ego*[e]
	Age[f] ---------> 6	----------> 8 ---------->	11/12

Note. Order of language acquisition in Relative languages is summarized from Piaget (1928), Laurendeau & Pinard (1977), Harris (1972), Johnston & Slobin (1979), Tanz (1980), Weissenborn & Stralka (1984).

[a]Johnston & Slobin (1979, p. 538) production data, mean age of acquisition: intrinsic *in front* (English 3;9; Italian 3;10; Serbo-Croatian 3;10; Turkish 3;4), intrinsic *behind* (English 4;4; Italian 2;1 (n = 2); Serbo-Croatian 3;9; Turkish 2;10).

[b]Tanz (1980, p. 26) Correct comprehension at 66% of subjects at 4;2, 70% at 4;11 (20% Hausa pattern); Johnston & Slobin (1979) production data suggest few children of 4;4 have both deictic back and front notions.

[c]Comprehension tasks: Piaget (1928): 75% of 5;0s; Galifret-Granjon (1960) 75% of 6;0s.

[d]Comprehension at 75% criterion at 8;0 (Piaget, 1928; Galifret-Granjon, 1960), at 10;0 (Laurendeau & Pinard, 1977).

[e]Comprehension at 75% criteria at 11;0/12;0 (Piaget, 1928; Galifret-Granjon, 1960).

[f]Nearly all this data is comprehension only; Weissenborn & Stralka (1984) production data suggest 11 years for full system.

would seem to contrast favourably with Western children performing on the same sorts of tasks using a left/right system.[14]

CONCLUSION

The acquisition of a Euclidean absolute linguistic system before a topological intrinsic system does not necessarily show anything about the ordering of conceptual development. For although it is not possible to grasp Euclidean semantics without having Euclidean ideas, it is of course possible to have, for example, topological ideas that do not show in a linguistic system. We are thus not arguing that Euclidean/projective thinking is conceptually prior to topological concepts for Mayan children. But the fact that the absolute linguistic system comes in very early in Tzeltal, and apparently at least as early or earlier than the intrinsic system, raises some doubt about the importance of the Piagetian stages as prerequisites for corresponding linguistic developments. If conceptual development is independent of language and must precede it, as Piaget supposed, then the precocity of Mayan children is in serious need of explanation. If however, we admit the Whorfian possibility that language may actually play an active role in conceptual development, then we would have a natural explanation for the precocity: adults all around the Tzeltal children are presuming an absolute coordinate system in thought and action, and this is made accessible to children through language in particular. Language use is among the most highly practiced aspects of skilled human behavior, so that participation in such a linguistic system may push forward the development of a special form of Euclidean reasoning in Tzeltal children. The spatial concepts described here seem to us to be good candidates for where language might promote conceptual development of a sort and at an age that would be unlikely in cultures where no such concepts are available in everyday child-relevant contexts.

The pattern of acquisition of Tzeltal absolute and intrinsic forms seems to provide evidence against a universal course of acquisition for spatial language (based on a scale of cognitive complexity) in favor of a view that children are capable of learning cognitively complex frames of reference remarkably early, if this is what is used and what is useful in their language environment. This provides a challenge to the view of the role of language in cognition influentially promulgated by Piaget, as summarized by Gins-

[14]See Weissenborn & Stralka (1984), who found that, on a director/matcher route task, German children ages 6 to 9 cannot solve the problem due to lack of an overall frame of reference, plus left/right problems. Children of 9 to 11 years can mostly solve the problem, but cannot foresee trouble, and those of 11 to 14 years can do it and also control for possible misapprehensions. Other work has also found some evidence for priority of absolute over relative systems (see Wassman & Dasen, 1995, for Balinese and de León, 1995, for the Australian Aboriginal language Guugu Yimithirr).

burg and Opper: (1969, p. 170): "Russian psychologists [e.g., Vygotsky] have proposed that one specific type of factor, namely the child's own language, is vital for the development of behavior. Piaget's view is in strong contrast . . . Piaget feels that logical thinking is primarily non-linguistic and derives from action." Piaget himself is uncompromisingly clear (Piaget, 1974, pp. 109–110): "All this has taught me that there exists a logic of coordination of actions far deeper than the logic related to language and much prior to that of propositions in the strict sense." The work we have reported on here inclines us to a more Vygotskian perspective. Crosslinguistic work (see Bowerman & Levinson, 2000) suggests the reciprocal, mutual influence of language on cognition and vice versa not later than the age 4;0 to 5;0 predicted by Vygotsky.

Why, despite his interactionism, did Piaget reject the influence of language on the child's developing thought? Because, it seems, he held that children can produce appropriate language before they have fully internalized the underlying semantical concepts: ". . . Language is by no means sufficient to assure the transmission of ready-made operatory schemes which the child would thus receive from without by linguistic coercion" (Piaget, 1974, p. 118)—rather the child must be preadapted for them. In this Piaget is no doubt partly right, but he underestimated the extent to which language forms part of the ecology of action. The child's efforts to play a role in the social world demand an understanding of those aspects of language which crucially structure social activities (e.g., 'take this there downhill' or 'bring it across here'), aspects which are also reflected in other behavior, like the consistent gesturing accompanying spatial descriptions. Such an ecological view of the Tenejapan child suggests that there are multiple motivations, and multiple scaffoldings, for acquiring these precocious spatial understandings.

ACKNOWLEDGMENTS

A first version of this paper was presented at The Growing Mind conference in Geneva, September 14-18, 1996, and a revised version at the Biennial Meeting of the American Psychological Anthropology Society in San Diego, California, October 1997. We are grateful to Melissa Bowerman, Suzanne Gaskins, Patricia Greenfield, Paul Kay, and Wolfgang Klein for helpful comments on various versions.

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