



Cognitive Science (2016) 1–32

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ISSN: 0364-0213 print / 1551-6709 online

DOI: 10.1111/cogs.12357

Uphill and Downhill in a Flat World: The Conceptual Topography of the Yupno House

Kensy Cooperrider,^a James Slotta,^b Rafael Núñez^c

^a*Department of Psychology, University of Chicago*

^b*Department of Anthropology, University of California, San Diego*

^c*Department of Cognitive Science, University of California, San Diego*

Received 11 March 2015; received in revised form 2 December 2015; accepted 15 December 2015

Abstract

Speakers of many languages around the world rely on body-based contrasts (e.g., *left/right*) for spatial communication and cognition. Speakers of Yupno, a language of Papua New Guinea's mountainous interior, rely instead on an environment-based *uphill/downhill* contrast. Body-based contrasts are as easy to use indoors as outdoors, but environment-based contrasts may not be. Do Yupno speakers still use *uphill/downhill* contrasts indoors and, if so, how? We report three studies on spatial communication within the Yupno house. Even in this flat world, *uphill/downhill* contrasts are pervasive. However, the terms are not used according to the slopes beyond the house's walls, as reported in other groups. Instead, the house is treated as a microworld, with a "conceptual topography" that is strikingly reminiscent of the physical topography of the Yupno valley. The phenomenon illustrates some of the distinctive properties of environment-based reference systems, as well as the universal power and plasticity of spatial contrasts.

Keywords: Space; Language; Conceptual mappings; Built environment; Uphill–downhill systems; Papua New Guinea

1. Introduction

Spatial contrasts are powerful. Oppositions such as *front* and *back*, *up* and *down*, *left* and *right*, and *east* and *west* are ubiquitous across languages and serve as workhorses of everyday communication and cognition (Clark, 1973; Hill, 1982; Levinson, 2003; Levinson & Burenhult, 2009; Talmy, 2000). In addition to their most basic spatial uses, such contrasts are extended to different settings and are also used to structure abstract

Correspondence should be sent to Kensy Cooperrider, University of Chicago, Chicago, IL. E-mail: kensy@uchicago.edu

concepts, cultural practices, and belief systems (Fillmore, 1997; Hertz, 2013 [orig. 1909]; Lakoff & Johnson, 1980; Núñez & Cornejo, 2012). Across the languages of the world, these spatial contrasts are diverse and are drawn from a variety of sources. Some, like *left/right* and *front/back*, are based on asymmetries of the human body, which can then be projected onto other bodies or onto objects. Other contrasts are based on asymmetries in the world. These include cardinal directions—*east/west/north/south*—which are ultimately drawn from the sun’s position but now function as a set of abstract vectors. They also include contrasts based on concrete features of the environment, such as *uphill/downhill*, *upriver/downriver*, or *landward/seaward*. In any given language, a number of such spatial contrasts may be available in the lexicon, but only a precious few are privileged in the sense that they are used frequently and take on a variety of meanings. For instance, some groups lean heavily on *left/right* while relegating environment-based contrasts like *uphill/downhill* to marginal status; others make pervasive use of *uphill/downhill* while reserving the *left/right* contrast for reference to the left and right hands (Levinson, 2003).

Importantly, these different spatial contrasts have different properties. They involve distinct cognitive operations to reckon and distinct logical properties (Levinson, 2003), and they are learned at different stages of development (e.g., Craton, Elicker, Plumert, & Pick, 1990). Moreover, though this fact has not been widely appreciated or investigated, these contrasts also differ in their affordances for use across settings. In the Western Educated Industrialized Rich Democratic (WEIRD) world (Henrich, Heine, & Norenzayan, 2010), we take for granted that our preferred spatial contrasts are equally well suited to the outdoor world and the indoor world. Body-based contrasts depend on the axes of the speaker or other people, or on axes that are projected onto objects. They are thus eminently portable, as easy to use in a windowless basement as an open field. Environment-based contrasts like *uphill/downhill*, *upriver/downriver*, and *landward/seaward* do not share this feature of easy portability because the relevant environmental features are often out of view, such as when inside buildings. Do groups that rely on environment-based contrasts still use them indoors, and, if so, how?

In Yupno, a language of Papua New Guinea’s Finisterre range, a privileged contrast is between “uphill” and “downhill” (Wassmann, 1994). To use even the most basic building blocks of the Yupno language, such as motion verbs and demonstratives, requires reckoning topography. This invites a question: “Uphill” and “downhill” may be a pervasive way of talking about location and motion *outdoors*, with topographic features in full view, but what about *indoors*, the other primary setting of Yupno life? The interior of a Yupno house is flat, dark, and often windowless, a kind of self-contained microworld; it is a setting without slopes of its own and without views of the slopes outside its walls. How do the Yupno construe the space within this everyday microworld and what role, if any, does their environment-based reference system play in this construal? In some groups relying on topographic features for spatial reference, it has been reported that uphill–downhill terms are used indoors by tracking the slopes outside. But earlier ethnographic observations have suggested that the Yupno may use such terms in a different way, by treating the house as a microcosm with a topography of its own (Wassmann, 1994). The aim of this study was to investigate this possibility in more detail.

The topographic spatial reference system found in the Yupno language is hardly a rarity. On the contrary, topographic systems are a robust areal feature of the languages of New Guinea and of Oceania more broadly (Francois, 2004; Senft, 1997), making them a major communicative and conceptual cornerstone of a region that boasts an astounding number of indigenous languages and cultures (Gorenflo, Romaine, Mittermeier, & Walker-Painemilla, 2012). Environment-based systems more generally are also widespread, for instance, in the indigenous languages of the Arctic (Fortescue, 1988), the Amazon (Aikhenvald, 2012), and the Himalayas (Post, 2011). Such systems have been noted by linguists for decades but are often grouped with systems that rely on cardinal direction terms as both examples of “absolute” spatial reference systems. In fact, though, environment-based systems have distinctive properties that set them apart from cardinal systems (Palmer, 2015), and, in turn, they may have distinctive cognitive and cultural dimensions. Questions about these dimensions abound: How are environment-based contrasts used across the settings of everyday life? How are they extended beyond their basic uses and intertwined with cultural practices? How, in short, do environment-based contrasts, like their body-based counterparts in the WEIRD world, serve as workhorses of sensemaking? Guided by this larger question, the present paper zooms in on a typologically important but still poorly understood spatial contrast—*uphill/downhill*—and investigates its use within a particular cultural setting: the traditional Yupno house.

1.1. *Topographic contrasts in the Yupno language*

Like many languages of New Guinea’s interior (see, e.g., Fedden, 2011; Heeschen, 1982), Yupno encodes *up/down* contrasts throughout its core grammar, including in demonstratives and in basic motion verbs. The terms are highly frequent in everyday language across all discourse contexts and, notably, can be used both to contrast positions on the vertical dimension (like English “up” and “down”) and to contrast positions with respect to terrain (like English “uphill” and “downhill”). Of particular interest is this second *topographic* use—a pervasive and possibly basic meaning of the contrasts—so termed because it requires reckoning slopes. That Yupno has such topographic terms is hardly remarkable. More remarkable is that they constitute a pervasive way of communicating about spatial information, including information about motion, location, and disposition on scales both *large*—for example, how to get to a specific village—and *small*—for example, which way a seated person should scoot to make room for another (Wassmann, 1994). Below we briefly review how these topographic contrasts are realized in the Yupno language.

Demonstratives in Yupno, as in all languages, characterize the relationship of their referents to the speech event in which they are uttered. Like English, Yupno has distinct proximal (like English “this” and “here”) and distal (like “that” and “there”) demonstratives; but unlike English, distal demonstratives in Yupno may also indicate whether the referent is above or below the location where the speech event is taking place (see Table 1). *Isin yut* (up.that house; “that house up there”), for instance, indicates a house uphill from the location where that phrase is uttered, whereas *imin yut* (down.that house;

“that house down there”) indicates a house below that location. Identifying objects and locations as being above or below where a speech event is taking place, these demonstratives thus provide a richer characterization of a referent’s location than the plain vanilla distal demonstrative. The “up” and “down” demonstratives are frequent in conversation outdoors. Indeed, Yupno speakers appear to prefer to use topographically marked demonstratives if possible when referring to physical objects and locations.¹

Like Yupno demonstratives, the basic verbs of motion (“come” and “go”) distinguish movement on a level plane from movement up or down (see Table 2). Yupno speakers are precise in their use of these verbs, often correcting us when we say, for instance, that we are going to the forest without using the appropriate verb “go up” for a journey to the forest. The basic motion verbs also have transitive counterparts (“bring” and “take”) that indicate whether an object is brought up, taken down, and so on. These motion verbs combine productively in serial verb constructions (see Aikhenvald, 2006, for an overview) with other verbs to signal the direction in which an action takes place. For instance, to tell someone to move a pot onto the rack above a fireplace, one can combine the verb for “put” with the verb “go up.” Through their regular use in serial verb constructions with these motion verbs, a large number of verbs (e.g., “throw,” “send,” “remove,” “walk”) specify the direction in which an action takes place. In this way, the characterization of motion up and down found in basic motion verbs can be used in conjunction with a large proportion of Yupno verbs.

There are also adverbial phrases constructed from the transitivized motion verbs that characterize the location of events and objects (see Table 2). Like the verbs of motion themselves, the adverbial forms derived from them indicate the location of events and objects topographically and deictically. Yupno also has a set of nouns indicating spatial relations (what in English would be translated with prepositions like “above” or “below”). Finally, Yupno has a pair of spatial adverbs that refer to the disposition of elongated objects or the movement of objects: Objects are situated or move *donḍon* if they are

Table 1
Yupno demonstratives

	Proximal	Distal				
		Neutral	Up		Down	
			Medial	Distant	Medial	Distant
Demonstrative root	i-	o-	(w)isi-	(w)asu-	imi-	amo-
Demonstrative determiner/pronoun ‘this,’ ‘that’	in	on	(w)isin	(w)asun	imin	amon
Demonstrative + locative case ‘here,’ ‘there,’ ‘in this X,’ ‘in that X’	idon	odon	(w)isidon	(w)asudon	imidon	amodon
Demonstrative + generic locative case ‘around here,’ ‘around there’	idenj	odenj	(w)isidenj	(w)asudenj	imidenj	amodenj
Demonstrative adverbial ‘here,’ ‘there’	ini	oni	(w)isini	(w)asuni	imini	amoni

Table 2
Yupno motion verbs

	Come			Go		
	Neutral	Up	Down	Neutral	Up	Down
Intransitive	ap-	wi-	pi-	ki-	wo-	piki-
Transitive ('bring' and 'take')	aŋap-	awi-	abi-	aŋgi-	awo-	abigi-
Derived adverbial	aŋaban	awiŋban	abiŋban	aŋgwan	awoŋban	abikwan

vertical or aligned with the slope of a hill; objects are situated or move *baratda* if they are horizontal or lie across the slope of a hill. In sum, the Yupno language is rich with resources for communicating about location, motion, and disposition with respect to slopes. For ease of exposition, in what follows we refer to these resources collectively as “topographic terms” or the “topographic system.”

1.2. The Yupno valley and the Yupno house

The Yupno valley, like much of the interior of the island of New Guinea, is a patchwork of forested hillsides and grassy slopes, steep ridges, and rushing watercourses. The valley is without roads or electricity and is home to approximately 8,000 people who live by subsistence farming. This rugged terrain—and the paths, villages, and gardens that cover its surface—is the natural home of the topographic system described above. Our focus in the present report, however, is on another setting: the flat-floored world of the traditional house.

By any measure, the traditional house is a central setting of Yupno life. Houses built in the traditional style are still by far the most common type of dwelling in the Yupno valley,² and they largely conform to a well-defined architectural template. From the outside, they are oblong thatched structures with a single door at one end (see Fig. 1). Immediately inside the door is a small anteroom with a few steps up to the main living area: a flat platform made of bamboo, with a fireplace running most of its length. Surrounding the fire on all sides is open living space. Houses are often windowless, leaving the door as the only opening to the outdoor world. Where windows are present they are small, admitting a bit of light but not furnishing views of the outside from the typical seated position at the fireplace. During the dry season, much socializing occurs in the home after dark around the fire; during the rainy season, the fireplace is a focal point of social life throughout the day and into the night.

What role do topographic contrasts play in this microworld? Two possibilities seem especially likely at first blush. A first is that the Yupno could simply check their preoccupation with uphill and downhill at the door. In addition to forms that are marked for the *uphill–downhill* contrast, the Yupno demonstrative and motion verb paradigms also include neutral forms that can be used to characterize motion, location, and disposition on level surfaces (see Tables 1 and 2). It would seem sensible to switch to these neutral forms in the level setting of the house, and instead to recruit other spatial contrasts or



Fig. 1. Yupno houses from the outside and from within. (A) Two traditional Yupno houses beside a walking path. Yupno houses are thatched, oblong structures with a single door at one end and few if any windows. (B) A cluster of houses in the village of Gua, nestled amid rugged terrain. Houses are oriented in different directions with respect to local slopes. (C) A Yupno child tends a fire in a house’s central fireplace. (D) The interior of the uphill-facing house used in all three studies. The house, following the standard template, has a doorway at one end (left) and a long central fireplace running its length.

reference points, such as visible features of the house. This first possible construal of indoor space might be called a “flat world construal.”

A second possibility is that the Yupno could treat the microworld as being continuous with the macroworld. After all, topographic terms are readily used on flat surfaces when outdoors. To do this, one partitions the flat space according to nearby slopes: Walking in the direction of a nearby downward slope is going “downhill”; an object located in the direction of a nearby uphill slope is located “uphill” (Wassmann, 1994). Indoors the Yupno could simply maintain their bearings with respect to outdoor slopes and continue to use the system as if the walls were not there. This second possibility might be called a “macroworld construal” of indoor space. It is precisely such a construal that appears to be favored by other speech communities that rely heavily on topographic contrasts for outdoor spatial reference, including the Tzeltal in Mexico (Brown & Levinson, 1993; Li, Abarbanell, Gleitman, & Papafragou, 2011) and the Belhare in Nepal (Bickel, 1997).

There is also a third possibility, originally suggested by the anthropologist Jürg Wassmann in his ethnographic studies of the Yupno (Wassmann, 1993, 1994). According to Wassmann, the Yupno conceptualize the traditional house as a microcosm of the world outdoors. He observes that the Yupno understand the valley as “an inclined oval with only one opening at the bottom” (Wassmann, 1994, p. 657; see also Wassmann, 1993), and he suggests that the Yupno understand the house in the same way. Just as the Yupno valley is conceptualized as inclining downward, with a river flowing through its center and opening out into the sea at the bottom, he claims the house is conceptualized as inclining downward, with a fireplace flowing through its center and opening out into the world at the “bottom.” Wassmann describes how this conceptual mapping can be glimpsed in the language used to refer to parts of the house: the area of the house toward the door is the “downhill” part and the area away from the door is the “uphill” part (Wassmann, 1994, p. 655–6). This third possible construal of space indoors is what we will call a “microworld construal.”

In certain respects such a “microworld construal” would be surprising. Most importantly, it would be at odds with how topographic terms are used indoors elsewhere and would even seem to defy the logic of absolute spatial systems. In other respects, it would be entirely plausible. For one, it would involve well-attested, everyday, and universal cognitive processes through which conceptual structure is mapped across domains (Fauconnier & Turner, 2002; Gentner, 1983; Hofstadter & Sander, 2013; Lakoff & Johnson, 1980). Moreover, it would resonate with prior ethnographic observations about how indoor space is often layered with meaning and is construed in non-obvious ways (e.g., Bennardo, 2000; Enfield, 2007; Jarzombek, 2013; Keating, 1995). It would also fit with anthropological reports describing systematic links between the microcosmos and macrocosmos. One such link that has been described is that, in some cultures, houses have prescribed orientations with respect to the macroworld. The Aymara of the Andes, for example, orient their houses toward the east, even in cases where it is extremely impractical to do so (Núñez & Cornejo, 2012). Similar prescriptions abound across cultures, continents, and time periods (see, among others, Bourdieu, 1970; Frake, 1975; Jarzombek, 2013). In some such cases, by virtue of the houses’s orientation with respect to the macroworld, parts of the dwelling are invested with meaning (e.g., Bickel, 1997; Bourdieu, 1970; Jarzombek, 2013). Finally, it has sometimes been proposed that the indoor world is construed as a microcosm of the world outdoors (e.g., Cunningham, 1964), precisely the type of phenomenon Wassmann proposes in the Yupno case.

Wassmann’s observations are thus plausible, but they leave a number of questions unanswered. A first is whether the phenomenon has been accurately characterized. When a Yupno house faces roughly downhill—as appears to be a weak tendency, though not a normative one, in the Yupno valley—it makes sense to use the door as a convenient proxy for the downhill direction (c.f. Tversky, 1981).³ But what happens when there is a clear mismatch between the indoor world and the world that surrounds it, as happens whenever a house’s door points uphill? In such cases a microworld construal suggests an interpretation of the area toward the door as “downhill,” while a macroworld construal suggests the opposite interpretation, of the area toward the door as “uphill.” If the

microworld construal breaks down in such cases, it suggests it may not be a robust construal of the house as a microcosm but something more mundane: a convenient orienting heuristic. If the microworld construal proves robust, this raises a second question, about its status in communication and cognition. Is it the stuff of everyday language and thought, a routine—even pervasive—way of talking about space indoors? Or is its role more restricted, perhaps used only rarely or in certain contexts?

1.3. Overview of three studies

In three studies we investigated how Yupno speakers understand and use topographic terms within the traditional house. Our interest in this question was sparked by the provocative possibility described above that the Yupno rely on a microworld construal of indoor space. Our first study used a reference disambiguation task to examine how topographic terms are interpreted in houses with different orientations with respect to the macroworld topography. The goal was to examine whether the Yupno do in fact adopt a microworld construal of indoor space and to determine whether this construal is robust across houses. In a second study we examined the spontaneous reference strategies—topographic or otherwise—that Yupno adults use when describing spatial arrays indoors and compared these to the strategies they use when describing the same spatial arrays outdoors. The goal was to see whether topographic terms are indeed used indoors and, if so, whether their use indoors differs from their use outdoors. Finally, in a third study we examined the spontaneous reference strategies that Yupno children use indoors. The aim of the third study was to investigate whether children differ from adults in how they use the topographic system indoors, if indeed they use it at all.

2. Study 1: Disambiguation of “uphill” and “downhill” indoors

For our first investigation, we devised a simple test of how topographic terms are interpreted indoors. We had adult participants sit at the fireplace, in the middle of an array of objects, and respond to brief prerecorded requests such as “Point to the uphill orange” or “Bring up the bag.” The task was designed such that these requests were ambiguous: There were always two candidate referents—in the above examples, two oranges or two bags—one on the side of the participant closer to the door and one on the other side, farther from the door. We conducted the task in two houses: a *downhill-facing house*—a setting in which the microworld and macroworld construals predict the same disambiguation of “uphill” and “downhill”; and an *uphill-facing house*—a setting in which the microworld and macroworld construals predict different responses (see Fig. 2). We thus created a strong test of the preference for different ways of construing indoor space by directly pitting the microworld and macroworld construals against each other. In sum, in Study 1 we asked two questions: (1) Do Yupno adults systematically interpret topographic terms indoors? (2) And, if so, does this systematic interpretation

follow a microworld construal—according to house features—or a macroworld construal—according to surrounding terrain?

2.1. Participants, materials, and design

The study was carried out in Gua village in 2009. Sixteen Yupno adults (8 men, 8 women), tested individually, participated voluntarily in exchange for a small gift. Participants sat on either side of the house’s central fireplace, with a row of four commonplace household objects—an orange, a tomato, a mug, and a netbag—to their left and another row of the same four objects to their right (see S1). Which side of the fire the participant started on (right or left when looking into the house from the door) was counterbalanced across participants. After the participant was seated within the eight-object array, the experimenter sat behind the participant and played simple imperative sentences, prerecorded by a native speaker of Yupno, from a laptop. Each sentence required the participant to either point to or grab one of the eight objects.

The stimulus sentences (see S2) were designed such that a single topographically marked term disambiguated which of the two candidate objects, toward or away from the door, was meant. In four of the sentences, a demonstrative (“up there”/“down there”) disambiguated the referent; in the other four sentences, a verb of motion (“come up”/“come

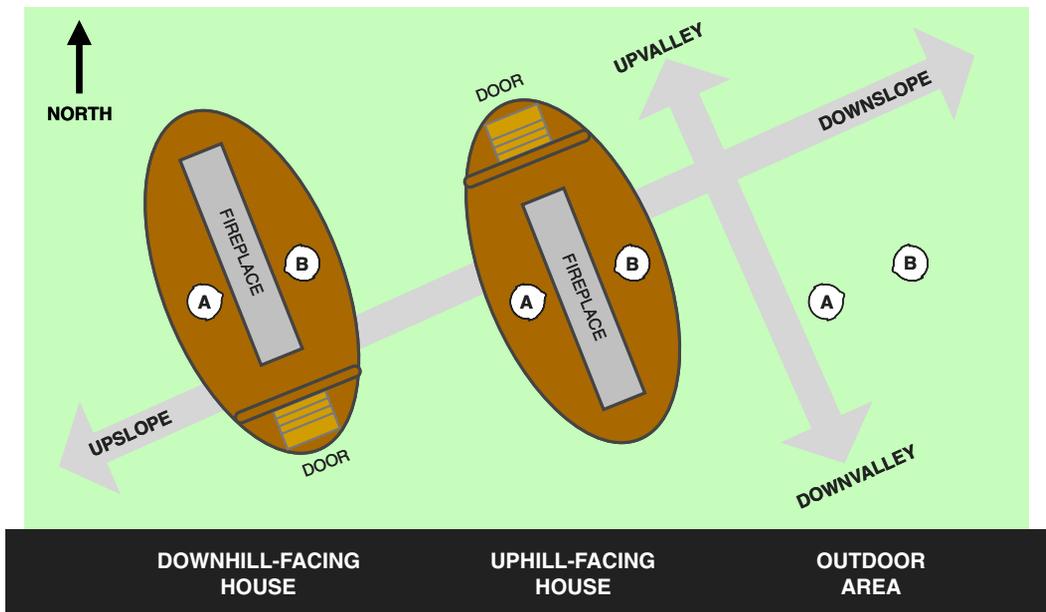


Fig. 2. Schematic depiction of the settings used in the present studies: the *downhill-facing house* (used in Study 1); the *uphill-facing house* (used in Study 1, 2, and 3); and the *outdoor area* (used in Study 2). The heads depict the facing orientations of participants in the different sitting positions. All A heads share the same orientation with respect to the outdoor surroundings, as do all B heads.

down”) disambiguated the referent. Each participant completed 16 trials, in two blocks of eight trials each. A block of trials consisted of all eight sentences presented in random order. After finishing the first block, the participant moved to the other side of the fire to complete the second block.

Across participants, two different traditional houses were used. A first house, hereafter the *downhill-facing house*, faced a macroscale downhill direction (approximately south-south-east). A second house, hereafter the *uphill-facing house*, faced the opposite direction, toward a macroscale uphill (approximately north-north-west) (see Fig. 2). Both houses had level floors and conformed to the basic architectural template described above: a small anteroom at the entryway, a raised main oval platform, and a central fireplace running the length of the house. Responses in the uphill-facing house are of particular importance, as in this setting the micro- and macroworld construals are directly pitted against each other. Note, finally, that if topographic terms are in fact not used systematically indoors, participants should respond at random in both houses.

2.2. Results

Participants understood the task and acted on the correct type of object on all trials. In the downhill-facing house, participants interpreted the terms systematically: Participants identified objects toward the door as “downhill” and objects away from the door as “uphill” on a mean of 95% (median = 100%; $SD = 11\%$) of all trials (Fig. 3). A chi-square test confirmed that the number of responses (122/128) favoring this interpretation was far more than would be expected by chance ($\chi^2 = 105.13$, $df = 1$, $p < .0001$). Given the orientation of the downhill-facing house, however, the nature of this systematicity is ambiguous: The responses are equally consistent with the microworld and the macroworld construal. All eight participants produced more responses consistent with a construal of the doorway as “downhill” than with a construal of the doorway as “uphill” (one-tailed exact binomial test, $n = 8$, $p = .004$).

In the uphill-facing house, participants also interpreted the terms systematically: Participants identified objects toward the door as “downhill” and objects away from the door as “uphill” on a mean of 84% (median = 94%; $SD = 19\%$) of all trials (Fig. 3). A chi-square test confirmed that the number of responses (108/128) favoring this interpretation was far more than would be expected by chance ($\chi^2 = 60.5$, $df = 1$, $p < .0001$). Given that the micro- and macroworld construals were directly pitted against each other in this house, the nature of this systematicity is unambiguous: These responses were overwhelmingly consistent with the microworld construal and overwhelmingly inconsistent with a macroworld construal. Responses were only consistent with the macroworld construal on a mean of 16% (median = 6%; $SD = 19\%$) of all trials (Fig. 3). Seven of the eight participants produced more responses consistent with the microworld construal than with the macroworld construal (one-tailed exact binomial test, $n = 8$, $p = .04$), and the other participant responded at random.

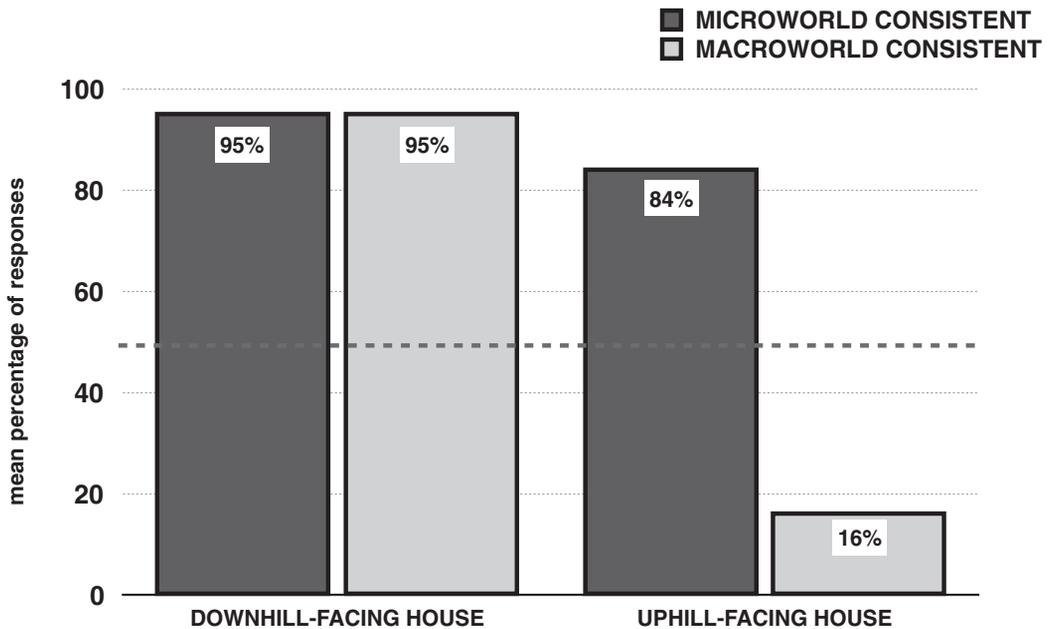


Fig. 3. Results of the disambiguation task used in Study 1. Participants disambiguated *uphill/downhill* terms systematically in both houses. The dashed line indicates chance responding. In the downhill-facing house, the nature of this systematicity is ambiguous because the favored response pattern is consistent with both the micro-world and macroworld construals. But in the uphill-facing house the nature of the systematicity becomes clear: Participants understood “downhill” to mean “toward the door” and “uphill” to mean “away from the door,” despite the fact that such a construal is directly at odds with the topography surrounding the house.

2.3. Summary and discussion of Study 1

Using a simple reference disambiguation task, we found that Yupno adults interpreted topographic terms systematically indoors and that they overwhelmingly did so according to a microworld construal. That is, participants construed the house as having a conceptual topography of its own: Objects closer to the door were construed as “downhill” and objects away from the door were construed as “uphill.” Critically, our participants favored this construal even in the uphill-facing house, a setting that presents a clear mismatch between the conceptual uphill–downhill axis of the house and the veridical uphill–downhill axis of the world surrounding the house. The microworld construal passed this strict test; it is robust across different houses and not just a useful orienting heuristic.

The results from this first study thus provide support for Wassmann’s (1994) proposal that the Yupno understand the house much as they understand the Yupno valley, as “an inclined oval” (p. 657). However, given the nature of the task—a simple disambiguation paradigm—the findings are also limited. Most important, they do not address the question of whether the microworld construal is the stuff of everyday communication or something more restricted. It remains possible that, while the microworld construal of indoor space is part of broadly shared cultural knowledge and can be elicited under contrived

conditions, in conversation Yupno speakers rely on any number of other ways of referring to space indoors, such as concrete features of the house. In the next two studies, we used a referential communication task to examine how Yupno speakers *spontaneously* construe indoor space.

3. Study 2: Spatial reference strategies in adult discourse

For our second study, we developed a referential communication task—the “Pig and Corn” task—modeled on tasks used previously to examine spatial reference strategies (e.g., the “Man and Tree” task described in Pederson et al., 1998; or the “Ball and Chair” task described in O’Meara & Baez, 2011). In our task, one participant—the director—describes an arrangement of small toy figures to a second participant—the matcher—who sits to one side of the participant but on the other side of an opaque barrier. The matcher’s goal is to reconstruct the array with a corresponding set of the figures, based on the director’s instructions. We chose three-dimensional objects rather than photographs (as most commonly used in the “Man and Tree” and in the “Ball and Chair”) because the Yupno are largely unfamiliar with two-dimensional graphical representations. The task allowed us to see how Yupno participants would spontaneously describe the spatial features of the arrays—specifically the locations and orientations of the figures.

The task was carried out in the same uphill-facing house used in Study 1, as well as in an outdoor location. The outdoor setting was selected to be matched to the indoor setting. The two are situated on the same basic landform—a relatively flat space in the main settlement area of Gua—but are out of view of each other because of intervening fences. In the outdoor location we set up two sitting positions: one such that participants faced the same macroscale orientation that they would when sitting on the *right side* of the fire in the uphill-facing house (Fig 2, position A); the other such that participants faced in the same macroscale direction as when sitting on the *left side* of the uphill-facing house (Fig. 2, position B). This set-up allowed us to make a close comparison between how spatial reference is done indoors and outdoors. Note that there are two orthogonal uphill–downhill axes at play outdoors. To distinguish these, we borrow geological terminology. The first axis is the *upvalley–downvalley* axis (Fig. 2; see also S5), a comparatively gentle incline parallel to the Daldal river, which runs through the valley in which Gua is situated. This axis runs approximately north-north-west (upvalley) to south-south-east (downvalley) and is the axis with which the uphill- and downhill-facing houses are aligned. The second axis is the *upslope–downslope* axis, a steeper axis running perpendicular to the Daldal river. This axis runs approximately southwest (when in Gua, upslope) to northeast (when in Gua, downslope). In sum, in Study 2 we asked two questions: (1) Do speakers indoors spontaneously use topographic terms according to the microworld construal observed in Study 1? (2) How pervasive is the topographic reference strategy relative to other ways of referring to space?

3.1. *Participants, materials, and design*

The study was carried out in the village of Gua in 2013. Sixteen Yupno adults (8 men, 8 women) participated voluntarily in same-sex pairs in exchange for a small gift. (Only one participant, a man in the outdoor condition, had also participated in Study 1.) Four pairs participated outdoors (4 men, 4 women), and four pairs participated indoors (4 men, 4 women) in the uphill-facing house used in Study 1. Participants were seated side-by-side facing the same direction but separated by an opaque sheet hung between them. Indoor pairs were seated facing toward the central fireplace—the standard sitting practice in the community—with a few feet of workspace between them and the border of the fireplace. Pairs began on either the right side of the house or the left side of the house, with the starting position counterbalanced across pairs. When seated on the right side (position A), participants faced east-north-east; when seated on the left side (position B), participants faced west-south-west. Outdoor pairs were seated in a flat grassy area, situated near—and on the same landform as—the uphill-facing house. In one of the outdoor starting positions, participants faced east-north-east (position A, matching the facing direction of participants on the right side of the uphill-facing house); in the other, they faced west-south-west (position B, matching the facing direction of participants on the left side of the uphill-facing house) (Fig. 2). Again, the starting position of the outdoor pairs was counterbalanced.

At the start of a session, both participants were given matching sets of five plastic figures: a large pig, a piglet, a rooster, a dog, and a row of corn. One participant was selected to be the first director. An experimenter arranged two figures in a practice array in front of the participant. The director was then asked to describe the array to the matcher so he or she could build the same array on the other side of the sheet. Because of the sheet, participants were not able to see each other or each other's workspace. After attempting the practice array, the sheet was lifted so the participants could compare the director's given array and the matcher's constructed array. The same director then completed the first trial. After each trial, the sheet was lifted so that participants could compare arrays. The roles alternated after each array, with the director on one trial becoming the matcher on the next. After the first block of four trials, the set-up was moved to the other sitting position, and another block of four trials was completed. In total, each participant served as the director for four trials and the matcher for four trials. All arrays consisted of two figures, either two animals or one animal paired with a row of corn (see arrays in S3). The order of arrays within blocks was fixed, but which block of arrays participants started with (1–4 or 5–8) was counterbalanced across pairs.

3.2. *Results: Qualitative analysis*

All speech was transcribed and analyzed from the video. As expected, participants used a range of strategies to describe the spatial properties of the arrays. Consistent with prior work on Yupno spatial reference (Wassmann, 1994), outdoor sessions were replete with topographic terms. In the first example (see Appendix 1 for transcription abbreviations;

complete transcripts for all examples available in S4), the director is describing an array consisting of a piglet and a dog, both facing toward the director's right, with the piglet closer to the speaker and the dog farther away (array A4 in S3).

Example 1. Outdoors, participants facing WSW (position B)

“Point the nose of the small pig toward Raisa's area up there (*isi-don*, “up.that-loc”). Going up (*a-wo-ŋban*, s.obj-go.up-3s.DS), put the dog like that too.”

The director first identifies the orientation of the piglet by combining a demonstrative (*isidon*) with reference to a nearby landmark—Raisa's area—that lies in the same direction. She then identifies the location of the dog as above the pig, using a topographically inflected motion verb in adverbial form (*awoŋban*). Note that both of the uphill–downhill axes described previously are in play in this example. The first topographic reference uses the upvalley–downvalley axis, a fact which is disambiguated by concurrent reference to an external landmark. In the second reference, which uphill–downhill axis is meant is not marked explicitly. Such ambiguities are common.

In the next example a different pair, seated facing the same direction as the first, makes use of the same two uphill–downhill axes. The director is describing an array consisting of the large pig and the rooster (see array A6 in S3). Both figures are facing to the director's left, with the rooster closer to the director and the pig farther away.

Example 2. Outdoors, facing WSW (position B)

“The big pig first is looking downwards (*gw-imi-deŋ*, secondary-down.that-gen.adv). The rooster too, coming down (*a-biŋ-ban*, 3s.obj-come.down-3s.DS)—it is looking downwards (*imi-deŋ*, down.that-gen.adv).”

The director starts by noting the orientation of the pig as facing downhill (downvalley) using a topographically marked demonstrative (*gwimideŋ*), a form sometimes used for reference along a secondary slope (see note 1). He then identifies the rooster as being below the pig, using a topographically inflected motion verb in adverbial form (*abiŋban*) to refer to the pig's location downslope. Finally, the director notes the orientation of the rooster, again using a topographically marked demonstrative (*imideŋ*). From the above examples it is clear that, in the outdoor sessions, topographic terms are a pervasive resource for describing the spatial arrays and that they are used to contrast more than one uphill–downhill axis.

More interestingly for present purposes, the indoor “Pig and Corn” sessions were also replete with topographic language. In a first indoor example, the participants are seated facing the same macroscale direction as participants in the previous examples. The participant is describing an array consisting of a rooster and a row of corn (see array A2). The rooster is on the speaker's right and facing toward the speaker; the corn is to the left of it, aligned with the speaker's shoulders.

Example 3. Indoors, facing WSW (position B)

“Put the rooster’s head here, facing the side where you are sitting. Put the corn horizontal (*barat-da*, flat-adv). Put the rooster’s head coming up (*w-akan*, come.up-3s.DS.D) here, toward where you are sitting. Put the corn plant horizontal (*barat-da*, flat-adv) toward that door area down there (*imin*, down.that).”

The example shows how the move indoors turns the use of topographic terms, as it were, upside-down. At the end of his description, the director indicates that the corn, which is aligned with the length of the fire, is going “down” to the door. Note that, had this been outdoors, the same direction (upvalley) would not be described as going “down” but rather, as in example 1, as going “up.” As this and similar examples demonstrate, positions and orientations toward or away from the door were systematically construed according to a microworld rather than macroworld construal. Overwhelmingly, the spontaneous use of topographic terms indoors thus mirrored how they were disambiguated in Study 1.

Curiously, however, this is not the only topographic reference used in Example 3. Earlier the rooster is described as “coming up” toward where the participants are seated—that is, away from the fireplace, toward one of the sidewalls of the house. Had this instruction taken place outdoors such an instruction would have been inappropriate. According to the surrounding topography, the rooster is actually going downslope, toward the Daldal river. In fact, though, this usage fits a clear pattern in the indoor data, one that was unexpected but systematic: on both sides of the fire, positions toward the fireplace were considered “downhill” and positions away from the fireplace, toward the sidewall of the house, were considered “uphill.” The indoor world, like the outdoor world, thus has two uphill–downhill axes, both determined by features of the house rather than by surrounding terrain: the first is a longitudinal axis running from the door (“downhill”) to the other end of the house (“uphill”); and the second is a lateral axis running from the fire (“downhill”) out to the sidewall (“uphill”) on either side of the fireplace.

The director here also twice uses another topographic term, the spatial modifier *baratda*. As described in 1.1, *baratda* forms a conceptual pair with another word *dojdoj*, both of which can be used to characterize the disposition of elongated objects. Generally, *dojdoj* is used when an object is aligned with an uphill–downhill axis, whereas *baratda* is used when an object is not so aligned. In the outdoor sessions, *dojdoj* is systematically used for objects aligned with the upslope–downslope axis—that is, the steeper of the two uphill–downhill axes. In the indoor sessions, *dojdoj* is used for objects aligned with the house’s lateral axis, though this pattern is not without exceptions. Finally, Example 3 also serves to illustrate other strategies that are frequently used indoors: first, anchoring reference to the *participants*—including the director and matcher—and, second, anchoring reference to *landmarks* within the house, in this case the door.

The same use of two microworld axes and the same mix of strategies are evident in the next example, from a different pair. The participants are seated on the opposite side of the fireplace. The director is describing the same array (A2) as in the previous example.

Example 4. Indoors, facing ENE (position A)

“Okay, turn the corn and put it toward the door. Put it toward down there (*imi-deŋ*, down.that-gen.adv). Okay, put the rooster turned toward that wall up there (*isin*, up.that).”

The director first indicates the placement of the corn as “down there” toward the door. This is consistent with the microworld construal of the longitudinal axis. Then the rooster is described, again, as oriented toward the sidewall of the house “up there.”

Finally, several participants indoors also made limited use of another topographic construal, in which the other side of the fire is characterized as “the side up there.” In fact, the term that means “other side,” *isigap*, includes the topographic demonstrative *isi* (“that up”). Conservatively, we consider this a separate topographic construal though we discuss below the possibility that it is related to the construal of the fireplace as “downhill.”

3.3. Results: Quantitative analysis

3.3.1. Analysis criteria

All speech was transcribed but only directors’ strategies were quantified.⁴ Matchers spoke rarely, and how much they spoke differed radically from dyad to dyad. Every use of a *spatial reference strategy* was then identified. A spatial reference strategy, as we use the term, is not the same as a “frame of reference” (FoR). Previous work using similar tasks has often attempted to classify different spatial strategies according to the FoR they involve, most often following the three-way typology of geocentric (or absolute), object-centered (or intrinsic), or egocentric (or relative) (Levinson, 2003). We use an analysis based on strategy, which is more fine-grained and also skirts two problems. The first is that it remains unclear whether use of topographic terms indoors should be considered geocentric or object-centered (see Levinson, 2003, p. 81 for discussion). The second is that, as acknowledged elsewhere, a number of the strategies frequently used in this type of task do not fit tidily within the FoR typology (for discussion, see O’Meara & Baez, 2011; Pederson et al., 1998; and Terrill & Burenhult, 2008, p. 572, note 17). These problematic strategies include reference to participants, reference to landmarks, and use of deictics, all of which are common in our data.

We only tallied as strategies those parts of the description that would be useful in correctly building the array—that is, information about where the figures were *located* or how they were *oriented*. Participants sometimes referred to other spatial aspects of the arrays, such as the distance between the figures, but these references were not tallied.

We identified the following types of strategies⁵:

- 1 **Topographic:** References that contrast “uphill” from “downhill,” including demonstratives, motion verbs, spatial nouns, and modifiers, as described in Section 1.1.
- 2 **Landmarks:** In the indoor data, these include references to the door, the area of the house opposite the door, the fireplace, the sidewall, and other aspects of the house anatomy; in the outdoor data, these include references to people’s houses, particular gardens, named landforms, and other identifiable landmarks.

- 3 **Participants:** References to the director, the matcher, or to the experimenters sitting across from the participants.
- 4 **Deictics:** References to, for example, “this side” or “here.” This tally does not include deictics that are topographically marked or discourse deictics.
- 5 **Array features:** References based on some aspect of the array itself, such as the “front” of one of the animals.
- 6 **Egocentric:** References that involve projecting axes from the observer, either a left and right side or a forward and backward direction.
- 7 **Other:** Any other strategy, including miscellany such as reference to previous trials.

Note that a single utterance is not necessarily limited to a single spatial reference strategy—in many cases multiple strategies are compressed into a short stretch of discourse. In Example 3 above, for instance, the director instructs the matcher to “Put the corn plant horizontal toward that door area down there.” According to the present analysis, this single utterance involves three strategies: two are topographic (“horizontal,” “down”) and one uses a landmark (“door”). Finally, we also examined each use of a topographic term to see whether it was consistent with one of the microworld construals, with the macro-world construal, or ambiguous.

3.3.2. Results

First, we examined whether speakers used the topographic terms according to patterns consistent with the macroworld terrain when outdoors and with a microworld construal of space when indoors. Outdoors, participants used a total of 75 topographic strategies, and 61 of these (81%) were consistent with one of the two *macroworld* uphill–downhill axes described previously. Of the other 14 references, 13 were consistent with neither, and 1 was unclear. Indoors, participants used 68 topographic strategies in all, and 62 of these (91%) were consistent with a microworld construal of space: 31 were uniquely consistent with a microworld construal; 31 were simultaneously consistent with both a microworld or macroworld construal.⁶ Of the other six references, two were uniquely consistent with a macroworld construal, three were consistent with neither, and one was unclear. Thus, participants spontaneously used topographic strategies indoors according to a microworld construal, as observed in Study 1. In many cases, these strategies were in direct contrast to how they would be used outdoors.

Next we examined the frequencies of the different spatial reference strategies both indoors and outdoors. Two measures of frequency were used. The first is the mean percentage out of all strategies used that a given strategy type accounts for. This will be referred to as the “percentage of strategies” measure; informally, it is a measure of how much of the referential burden a particular strategy carries. The second is the percentage of trials on which a particular strategy is used. This will be referred to as the “percentage of trials” measure; informally, it is a measure of how often each strategy surfaces across trials.

Outdoors, directors used a total of 161 spatial strategies, for a mean of 5.03 strategies ($SD = 3.50$) per trial. Indoors, directors used a total of 213 spatial strategies, for a mean of 6.66 ($SD = 4.49$) strategies per trial. The mean percentages that each strategy type

accounted for are shown in Table 3. Only the three most prominent strategies—topography, landmarks, and participants—are shown and all other strategies are grouped together. The percentage of trials (of 32 total trials) that each strategy appeared on are shown in Table 4. Overall, topography emerged as a pervasive strategy both outdoors (accounting for 47% of all strategies and used on 75% of trials) and indoors (accounting for 35% of all strategies and used on 78% of trials). Indoors, reference to landmarks—that is, features of the house—was also common.

A handful of other noteworthy findings emerged from the quantitative analysis. First, participants were much more likely to make reference to *external* landmarks when outdoors (50%, or 16/32 trials) than when indoors (3%, or 1/32 trials) ($\chi^2 = 18.02$, $df = 1$, $p < .0001$). This finding is consistent with the idea that speakers treat the house as a self-contained microworld rather than as a space that is continuous with the outdoors. Finally, across both outdoor and indoor sessions, use of egocentric terms was a marginal strategy. Projective uses of “right” and “left”—that is, uses that involve projecting the speaker’s left-right coordinates onto the array—were only used on two trials (of 64) and only after difficulty earlier in the session.⁷ Projective uses of “front” and “back” were also rare, occurring on only three trials (of 64).

3.4 Summary and discussion of Study 2

The “Pig and Corn” task succeeded in eliciting rich spatial discourse, as similar tasks have done across a range of speech communities. Topographic reference emerged as a pervasive spatial strategy both outdoors and indoors. In both settings, speakers used the topographic system in its entirety, including demonstratives, motion verbs, nouns of spatial relation, and spatial adverbs. Outdoors, topographic terms were used to contrast two uphill–downhill axes: a gentler upvalley–downvalley axis and, perpendicular to it, a steeper upslope–downslope axis. Indoors, consistent with Wassmann’s observations and with our findings from Study 1, topographic terms were used according to a microworld construal. Strikingly, however, this construal proved to be richer than previously thought, involving two primary “uphill–downhill” axes. First, speakers used topographic terms to contrast positions toward (“downhill”) or away from the door (“uphill”), along the longitudinal axis of the house. Because the house is oriented with the door facing uphill (specifically, upvalley), this use of topographic terms is exactly opposite what was found in the outdoor sessions. Second, speakers used the terms along the lateral axis to charac-

Table 3
Mean percentage of strategies in Study 2 and 3

Group	Topography	Landmarks	Participants	Other strategies
Study 2				
Adults (outdoors)	47%	17%	11%	25%
Adults (indoors)	35%	32%	15%	18%
Study 3				
Children (indoors)	52%	13%	15%	20%

Table 4
Percentage of trials in Study 2 and 3

Group	Topography	Landmarks	Participants
Study 2			
Adults (outdoors)	75%	53%	41%
Adults (indoors)	78%	66%	47%
Study 3			
Children (indoors)	88%	38%	41%

terize positions toward the fire (“downhill”) and away from it (“uphill”), toward the sidewall of the house. This second axis is the same on both sides of the fireplace. In addition to these two primary axes, participants also sometimes construed the other side of the fire as “up.” The pervasiveness of topographic terms was comparable indoors and outdoors, both in terms of the percentage of strategies they accounted for and in terms of the percentage of trials on which they appeared. However, in the indoor data, use of topographic terms was roughly as common as use of landmarks—in this case, concrete features of the house such as the door and the fireplace.

4. Study 3: Spatial reference strategies in child discourse

For our third study we conducted the “Pig and Corn” task with Yupno children 10–12 years of age. Yupno children’s spatial discourse is of interest for a few reasons (for discussion, see Dasen & Mishra, 2011). For one, not much is currently known about children’s understanding of semantic *extensions* of spatial terms. It is possible that the micro-world construal we observed among adults, as a non-obvious transformation of a basic reference system, may present conceptual difficulties for children. Child discourse is also interesting in that it may open up a window on the prominence of different spatial reference strategies within a speech community. Prior work using referential communication tasks has found that adults are more sensitive to ambiguity than children (Yule, 1997). One possible explanation for the frequent use of house features in Study 2, then, is that adults were attempting to reduce ambiguity by supplementing a topographic reference strategy—which, as described above, is often ambiguous—with extra information. If this interpretation is correct, children may show even more reliance on topographic strategies than did adults. In Study 3, then, we asked two questions: (1) Do Yupno children master the microworld use of the topographic system already at a young age? (2) Do Yupno children, like Yupno adults, use topographic terms pervasively indoors?

4.1. Participants, materials, and design

The study was carried out in the village of Gua in 2013. Eight Yupno children (4 boys, 4 girls; 10–12 years old) participated voluntarily in same-sex pairs in exchange for a small gift. All completed the task in the same uphill-facing house used in the previous two

studies. The procedure was exactly the same as in Study 2. All arrays again involved two figures but some were modified slightly, and, to make the task more child-friendly, the order of the arrays was changed so that no rows of corn appeared until the second block of four trials (see S3). We did this because rows of corn occasionally presented challenges for the adults, who often projected a facing direction onto them, causing confusion.

4.2. Results: Qualitative analysis

As with the adults, all speech was transcribed and analyzed from video. Children also used topographic strategies pervasively indoors, deploying the same terms in much the same ways. In the first child example, the director is describing an array consisting of a large pig facing away from him and, on the pig's left, a row of corn oriented perpendicular to the pig (see C6 in S3).

Example 5. Indoors, facing ENE (position A)

“Put the pig above (*kwin-da*, above-adv) with its nose going down (*piki-akan*, go.-down-3s.DS.D) toward that fire down there (*imin*, down.that). Put the corn down (*pikwan*, go.down-3s.nearfut) toward that side down there (*imin*, down.that).”

For his first instruction, the director describes the location of the pig as “above” (away from the door) using a spatial modifier (*kwindá*) and then describes its orientation using both a topographically marked demonstrative (*imin*) and a topographically inflected motion verb (*pikakan*). He then instructs the matcher, using both a motion verb (*pikwan*) and a matching demonstrative (*imin*), to put the corn “down” (toward the door). Both of the house axes—the longitudinal and the lateral axis—that are employed by adults are evident in this short sequence and both are used in ways consistent with a microworld construal.

In line with prior observations, children's instructions were often more ambiguous than adults'. In the next example the speaker is describing an array in which the dog (further away from him) and the piglet (closer to him) are both facing to his right, away from the doorway (see C2).

Example 6. Indoors, facing ENE (position A)

“Put the pig and dog turned toward the side up there (*isi-dej*, up.that-gen.adv).”

The instruction to put the pig and dog turned toward “the side up there” is consistent with a microworld construal of the longitudinal axis—both figures are facing away from the door. But the matcher has no way of knowing that this is the axis meant. In fact, the matcher in this case orients the figures along the correct axis, but faces them in the *opposite* direction, as if adopting a macroworld construal of the “side up there.” The matcher in this pair regularly reckoned “uphill” and “downhill” with respect to outside terrain, causing a cascade of confusion from which the pair never recovered.

Finally, as with the adults, a handful of children also treated the other side of the fire as “up.” However, one speaker in particular did not signal this construal with *isigap*

(up.that.area) or other disambiguating information, leading to confusion (see additional Example 7 in S4).

4.3. Results: Quantitative analysis

First, we examined whether, like the adults, the children would spontaneously use topographic terms according to a microworld construal. Of the 67 topographic strategies used, 48 of these (72%) were consistent with a microworld construal of space: 31 were uniquely consistent with a microworld construal; 17 were consistent with either a microworld or a macroworld construal. Of the remaining 19, five were uniquely consistent with the macroworld terrain, two were consistent with neither, and 12 were unclear. While broadly consistent in their use of a microworld construal of space, then, children were numerically less consistent than adults. However, since we did not conduct the task with children outdoors, it is not clear whether this inconsistency is due to more difficulty in using the topographic system in general, or more difficulty using the microworld construal in particular.

Next we examined the frequency of the different spatial reference strategies. Directors used a total of 136 spatial strategies, for a mean of 4.25 strategies ($SD = 3.32$) per trial. The mean percentages of strategies are shown in Table 3. Again, only the three most prominent strategies—topography, landmarks, and participants—are shown and all other strategies are grouped together. The percentage of trials on which each strategy appears are shown in Table 4. Overall, topography emerged as a pervasive strategy, accounting for 52% of all strategies and used on 88% of trials.

As with the adults, egocentric strategies were marginal among the children. Projective “right” and “left” were used on two trials (of 32), and again only after other strategies failed. Projective “front” and “back” were never used. The children also never referred to landmarks beyond the house’s walls.

4.4. Summary and discussion of Study 3

Yupno children indoors used the same set of spatial reference strategies used by adults indoors. Like adults, children used two primary microworld construals of topographic terms indoors: a first to characterize the longitudinal axis of the house and a second to characterize the lateral axis on either side of the fire. Like the adults, children also occasionally used a less frequent construal in which the other side of the fire is characterized as “up.” The first question we asked in Study 3 was whether children would, already at the age of 10–12, master the microworld construal. We found that children used topographic terms in a way broadly consistent with the microworld conception of the house, but overall were less consistent than adults. However, the nature of this inconsistency requires further study.

In Study 2, adults indoors were relatively balanced in their use of both landmarks and topography as prominent strategies. For children in Study 3 this was not the case: topographic terms accounted for four times the mean percentage of strategies that landmarks

did (52% compared to 13%), and they were used on more than twice as many trials (88% compared to 38%). These results support the interpretation that explicit reference to house features may be an ad hoc strategy recruited by adults to counter ambiguities that arise when using the topographic system, particularly in the “Pig and Corn” task. Overall, the results from Study 3, together with those from Study 2, demonstrate that topographic reference is a pervasive form of spatial reference within the Yupno house.

5. Discussion

The traditional Yupno house may be free of physical slopes or views of the terrain outside its walls, but the topographic system is not abandoned at the door. Instead, it is transformed: Terms that are used outdoors with respect to physical slopes are used indoors with respect to a “conceptual topography” based on house features. Despite undergoing this surprising transformation, topographic terms remain a prevalent spatial reference strategy. Synthesizing our findings from the three studies described above—and joining them with observations about everyday language use—we first summarize, in 5.1, how topographic contrasts are recruited to construe the indoor setting. Then, in 5.2, we take up questions about the cognitive vitality of these construals. Finally, in 5.3, we examine the many-layered puzzle of why the traditional Yupno house has the peculiar conceptual topography that it does.

5.1. *The conceptual topography of the Yupno house*

We identified three uses of topographic contrasts indoors. The first construal is of an uphill–downhill axis running the length of the house, from the door—construed as “downhill”—to the end of the house opposite the door—construed as “uphill.” This is the topography originally noted by Wassmann and confirmed in our reference disambiguation task in Study 1. The second construal runs from the fireplace—construed as “downhill”—to the sidewall—construed as “uphill”—and is symmetrical on both sides of the fire. This construal, which we were previously unaware of, appears to be on equal footing with the first. Finally, a less frequent construal involves treating the opposite side of the fire as “up.”

As is clear from the examples discussed above, use of the topographic system indoors often entails ambiguities. Matchers regularly misinterpreted directors’ instructions, taking “uphill” and “downhill” to refer to an axis other than the one intended. Indeed, while it would be possible to give precise, unambiguous instructions using only reference to house features in the “Pig and Corn” task, this is simply not possible using only topographic terms. After all, “uphill” means many things. Note, though, that Yupno is hardly unique in employing a highly frequent contrast despite its confounding ambiguity. Consider, for comparison, the case of “front” in English—a spatial contrast which can be used with respect to the body of the observer, with respect to the body of the observed, with respect to a queue, or even with respect to an

entire room (see discussion and diagram, Talmy, 2000, p. 226; Fillmore, 1997). Though “uphill”—like “front”—is in principle ambiguous, in practice its meaning is usually clear. On different occasions we have heard the very same expression used successfully to indicate movement along both the longitudinal and lateral axes of the house. In one case, as guests arrived for a gathering, a group of children were gathered near the sidewall, about midway between the door and the far end of the house. As the house started to fill up with people, an adult told them *isin kwengin wek* (“Go up above up there”). The children moved to the far end of the house, making room for the people entering to sit down. On another occasion, a man sitting by the fire uttered the same expression (with a different inflection on the verb *wo-* “go up”) to a child sleeping behind him, whose head was by the sidewall and whose feet were touching the man’s leg. When told *isin kwengin wo* (“Go up above up there”), the child shifted his body away from the fire and toward the sidewall, removing his feet from the man’s leg. In sum, though in the “Pig and Corn” task there is rampant ambiguity about which direction is “up” or “down” inside the house, under more natural circumstances gesture, gaze, discourse context, the location of objects and people, and norms about where objects and people should be, all help to determine which direction is meant.

A peculiar property of the conceptual topography of the Yupno house is its bilateral symmetry across the axis of the fire. The same directional vector, for instance proceeding from left to right as you look into the house from the door, would be described differently on the different sides of the fire. Imagine, for example, someone walking along this axis of the house from one sidewall, over the fire, to the other sidewall. The first part of the trajectory, as the person approaches the fire would be described as going “downhill”; the second part of the trajectory, after crossing the fire and approaching the other sidewall, would be described as going “uphill.” This scenario underscores how starkly the Yupno system contrasts with cardinal direction systems. In cardinal systems, directional vectors such as *eastward* are preserved across changes in terrain, through walls, and over vast distances; no matter where you are, *eastward* refers to the same fixed, abstract directional vector (on the notion of vectors, see Bohner & O’Meara, 2012). In the Yupno topographic system, as in other environment-based systems, vectors must be continuously re-reckoned with respect to local landmarks—whether those landmarks are rivers and slopes, or fireplaces and doorways.

5.2. *Lively construals or dead idioms?*

Our evidence for the conceptual topography of the Yupno house has come primarily from language use. The linguistic patterns involved, like all patterns in language, have doubtless undergone processes of conventionalization over a long history of use. It is thus natural to wonder whether these construals retain a spark of cognitive vitality or are perhaps better described as dead idioms (for previous discussions of the cognitive vitality of figurative language, see Murphy, 1996 and Senft, 1998). There are a few reasons to think that the construals retain some vitality. First, they are *systematic*: uphill and down-

hill map to opposite directions in the house, just as they map to opposite directions outdoors. This is unlike some non-literal uses of spatial terms in English, such as when we say that a colleague's office is "a few doors down" (which does not contrast with the office "a few doors up"). Second, the very same construals are *widely realized* linguistically, cutting across expression types and across words from different classes (c.f. Levinson & Burenholt, 2009 on "semplates"). In their systematicity and wide realization, the Yupno microworld construals closely resemble orientational metaphors (Gentner, 2001; Lakoff & Johnson, 1980), which have consistently been found to retain sparks of cognitive vitality (see Casasanto & Bottini, 2014 for a review). Finally, the dead idiom possibility seems doubtful in light of our own previous work on how the Yupno construe time. Núñez, Cooperrider, Doan, and Wassmann (2012) examined the gestures that Yupno adults produced when explaining concepts of past, present, and future. Outdoors, speakers gestured in a downhill direction while referring to the past and in an uphill direction when referring to the future. Indoors—across three houses, including the uphill-facing house used in this study—participants gestured generally toward the door while referring to the past and away from the door while referring to the future. The conceptual topography of the Yupno house is thus not just a matter of how concrete space is construed. It also furnishes a new foundation for those abstract concepts, like time, that build on spatial concepts.

5.3. *Motivations for the conceptual topography*

Why do Yupno speakers treat the house as having a rich conceptual topography? Part of the answer, of course, is that to do so is the conventional way of talking about space indoors in Yupno, and because it is conventional it is an effective communication strategy. A more interesting issue is what motivated these conventions in the first place. Though this history is shadowy and leaves few traces, here we attempt to illuminate it by asking three telescoping questions. Each question considers why the Yupno construe indoor space the way they do, rather than some plausible alternative.

5.3.1. *Why does the house have the particular conceptual topography that it does?*

Assuming that a microworld use of topographic terms was somehow inevitable, why are the three construals set up in the particular way they are? That is, why is the door "downhill" rather than "uphill"? Why is the sidewall "above" rather than "below" the fireplace? Why is the other side of the fire "up" instead of "down"? One explanatory possibility is that each of these microworld construals is motivated independently of the others. Considering first the longitudinal axis, the direction toward the door may be considered downhill because of how you enter and exit the house: Entering a house involves going up stairs and leaving the house involves going down them. Indeed, both actions are described using the corresponding topographically marked motion verbs. The vector when entering, going toward the end of the house, and when exiting, going toward the door, may be extended to characterize all motion and position along this axis. Alternatively, the direction toward the door could be downhill because of the orientation of houses in

the macroworld. As discussed earlier, there is no rigid norm governing the orientation of houses in the Yupno valley, but there may have been at one time (c.f. Wassmann, 1994, p. 658). Further, for practical reasons there may be a general tendency to orient a house facing downhill (c.f. Núñez & Cornejo, 2012). While either of these explanations would provide a satisfying independent motivation for the longitudinal axis, independent accounts for the other two construals remain elusive.

There is, however, another explanatory possibility that has the virtue of parsimony: The three different construals may not be independently motivated, but rather cohere as a single, holistic conceptual mapping. In other words, the Yupno conception of the house as a microcosm may be more complete and systematic than initially suggested. Wassmann emphasized certain correspondences between how the house is schematized and how the macroworld is schematized: both have a single opening (door, outlet) to a more open area (outside, sea); both are ovals that are enclosed (by walls, by mountains); and both incline (conceptually in the case of the house, physically in the case of the valley) downward toward their opening. But he also noted another point of correspondence: Both the world and the house have an elongated structure running their length (fireplace, river). The fireplace-river mapping may seem fanciful but, in the Yupno context, where fireplaces and rivers are frequently encountered in daily life, it could hardly be more mundane. Both fireplaces and rivers cut partitions through the world; both are hollow volumes full of a dynamic substance; both are slightly sunken into the ground; and both are inconvenient or even hazardous to cross.

If a fireplace-river mapping is granted, the motivations for all three microworld construals fall into place (see Fig. 4, panel B). First, if the fireplace is like a river, and the river is conceived as having its outlet at the door, then the river must flow “down” in that direction. Further, if the fireplace is like a river, then approaching it must involve going “down.” Rivers in the Yupno valley, as elsewhere, cut deep gorges into the land. To cross a river, one has to descend a steep bank and then cross. Note, also, that at least in Gua, the axis perpendicular to the river (upslope–downslope) is steep, whereas the axis parallel to the river (upvalley–downvalley) is gentle (Fig. 4, panel A; see also S5). As discussed above, this differential steepness is reflected in how the terms *doŋdoŋ* and *baratda* are applied outdoors, with *doŋdoŋ* used for elongated objects perpendicular to the river and *baratda* for objects parallel to the river. Interestingly, indoors there is a strong tendency to use *doŋdoŋ* to characterize the lateral axis, perpendicular to the fire (in the mapping, the steep upslope–downslope axis) and *baratda* to characterize the longitudinal axis, parallel to the fire (in the mapping, the gentle upvalley–downvalley axis). This is evident, not only in the “Pig and Corn” data, but also from observations of everyday usage. For example, the standard orientation of people sleeping in Yupno houses is *doŋdoŋ*—with their feet by the fire and their heads by the sidewall of the house. We learned of this usage when people commented on our unusual *baratda* sleeping orientation, with our bodies parallel to the fireplace. Finally, if the fireplace is like a river, to reach a comparable position on the other side, one needs to not only descend a steep bank and cross, but then ascend a steep bank. Indeed, consultants have explained that the “other side” of the river is *isigap* (“that up area”) because one has to climb up from the river to get to it. In

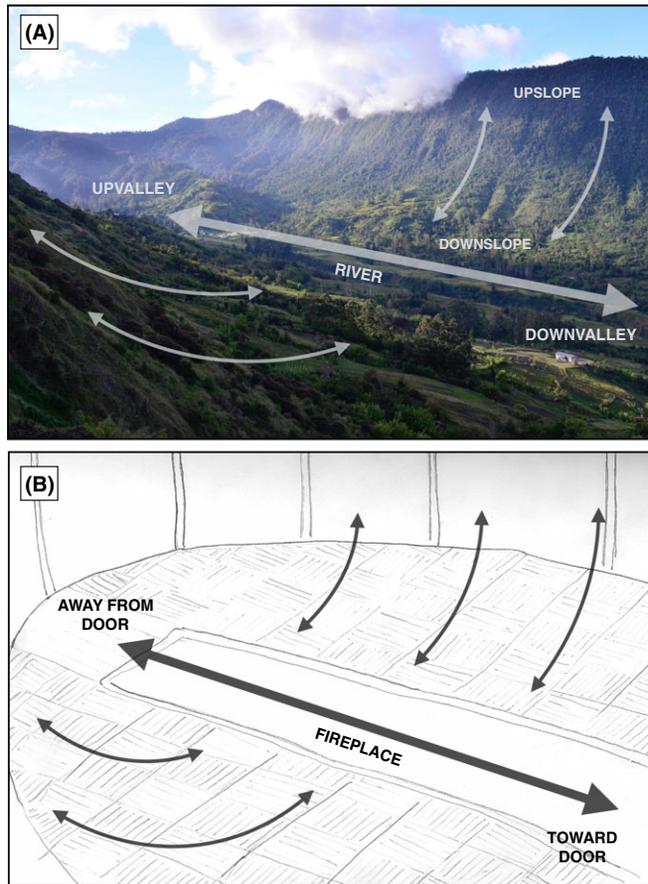


Fig. 4. An illustration of the proposed holistic conceptual mapping between valley and house. (A) A photograph overlooking the valley in which the study was conducted. The large straight arrow follows the Daldal river (hidden in a gorge), which defines the upvalley–downvalley axis; the curved arrows indicate the steeper upslope–downslope axes on either side of the river. (B) A sketch of the interior of a traditional Yupno house. The large straight arrow follows the fireplace, which defines one of the conceptual “uphill–downhill” axes within the house; the curved arrows indicate the other “uphill–downhill” axes, on either side of the fire.

other words, this usage follows straightforwardly from the fact that the floor is construed as sloping “down” toward the fireplace and back “up” on the other side. All three construals, then, may be motivated by a single holistic conceptual mapping: a systematic conception of spatial relations indoors according to the logic of how slopes and rivers relate outdoors.

5.3.2. Why use a microworld construal over a macroworld construal?

Stepping back from the house’s particular topography, a logically prior question arises: What motivates the use of a microworld in the first place? Why not use a macroworld construal? Macroworld uses of uphill–downhill terms when indoors have been attested

elsewhere. For example, Brown and Levinson (1993) report that speakers of Tzeltal continue to use the basic *uphill/downhill* distinction indoors, for example, distinguishing between two water taps by describing one as “uphill” (p. 52; see also Li et al., 2011). Why do some speech communities, like Tzeltal and Belhare, opt for a macroworld construal of “uphill” and “downhill” indoors whereas others, like Yupno, opt for a micro-world construal? A key feature of both Tzeltal and Belhare is that topographic terms have a fixed, absolute sense (like cardinal directions) in addition to their flexible, environment-based sense. But in Yupno there is no fixed, absolute use of topographic terms—instead, use is always driven by local inclination.⁸ This difference has a clear cognitive consequence: Tzeltal and Belhare speakers are used to preserving fixed vectors across changes in terrain, whereas Yupno speakers are not. Given the change in “terrain” involved in entering a house, it makes sense to re-reckon uphill and downhill in Yupno, just as it makes sense to preserve vectors from the surrounding terrain in Tzeltal or Belhare.

A critical enabling condition of the microworld construal in Yupno—and likely of microworld construals in other cases—is that Yupno houses are built to a common template. Among other features, almost all houses have an oblong structure, a fire running the length of the longitudinal axis, and a door at one end. Without a long-standing tradition of this building pattern—for example, if houses were architecturally variable from the start—the construal may never have emerged. Moreover, should the building pattern be disrupted—for example, with the introduction of non-traditional styles in the Yupno valley—the construal may fall apart, or at least become simpler. In sum, we propose two factors that may give rise to microworld over macroworld construals of environment-based terms indoors: (a) use of a spatial reference system that does *not* rely on fixed, abstracted vectors; and (b) uniformity in architectural style.

Tentative support for this account may be found in a handful of cases of apparent microworld construals of indoor space in other cultures. One is the case of the Foi of Papua New Guinea, who have been reported to use “downstream” and “upstream” to refer to different sides of houses, regardless of the house’s orientation (Weiner, 1988). Another case comes from Nemi, a language of New Caledonia, in which it is reported that “down” and “up,” which are used for topographic reference outdoors, are used indoors to contrast the axis going toward or away from the door (Ozanne-Rivierre, 1997; pg. 86). Perhaps, the best documented cases come from the languages of the Arctic (Fortescue, 1988, 2011). Though there are several variants, a common pattern involves using the term for “down river” or “down coast” to refer to the house entrance and “up river” or “up coast” to refer to the other end of the house (Fortescue, 2011, p. 1). Interestingly, the case of the Arctic languages appears to share with the Yupno case both a reliance on environmental features rather than fixed, abstracted vectors and a measure of architectural uniformity.

5.3.3. *Why use the topographic system at all?*

Stepping back even further, a deep and logically prior mystery still remains: Why use the topographic system at all? Why not construe the house as the flat world it is? Neutral

forms of demonstratives and motion verbs are available in Yupno, and speakers have access to other resources for communicating about location and orientation. In its most general form, the question can be posed as: Why do humans stretch the meaning of their spatial contrasts beyond their basic uses, extending them to construe other spatial contrasts? Why, for example, do English speakers so commonly use “up” and “down” to refer to *north* and *south*? Or, why do the Aymara use “front” and “back” to refer *east* and *west*?⁹ (see Brown, 1983 for additional examples)? Familiarity likely provides an important part of the answer. The topographic system in Yupno is part of the core grammar and is a pervasive form of spatial reference outdoors. As a result, it is a hyper-familiar template through which the world is parsed (c.f. Levinson & Burenhult, 2009). Hyper-familiar contrasts, in Yupno and other languages, are ready to hand: Speakers press them into service widely and frequently, extending their meanings across settings and into new domains. Importantly, such processes of semantic extension are not willy-nilly; in order for a new extension to take root, it needs to be motivated. In some cases an experiential correlation may invite the extension of a spatial term. In the case of the north is “up” construal, the fact that north is depicted as up on most maps provides such a correlation. In other cases, a perceived analogy between two settings or domains may guide the extension process. In the present case, the perceived correspondences between the built and natural world may have invited the mapping in the first place and allowed it to take root. Speculatively, these same perceived correspondences may also facilitate its acquisition and use in the present.

6. Conclusion

Egocentric spatial contrasts, as workhorses of the WEIRD mind, have received much attention across the human sciences. Cardinal spatial contrasts, as a major focus of work on spatial frames of reference cross-culturally, have also received considerable attention.¹⁰ Environment-based systems are often lumped in with cardinal systems because they both involve an absolute frame of reference. But, as this study has illustrated, they have distinct properties, distinct cognitive dimensions, and distinct affordances for use across settings. One moral of the present study is that these systems merit more sustained interdisciplinary attention. The number of languages in Oceania and elsewhere that rely on environment-based systems is vast; they constitute a major underexplored area of the human conceptual landscape. How these systems work, how they are stretched for different expressive purposes, and how they are embedded in everyday life are questions of urgent concern for all interested in humanity’s vanishing wealth of diversity. Finally, by illustrating a surprising phenomenon in a tiny speech community from a far-flung nook of the world, this study also crystallizes a question that is universal in scope: Why are spatial contrasts both so powerful and so plastic in human communication and cognition? Answering this question will require further investigation of spatial reference across settings and languages, and renewed attention to the ways that spatial reference implicates language and mind, culture and world.

Acknowledgments

We thank the residents of Gua for their participation, hospitality, and assistance. We also thank Jürg Wassmann and Verena Keck for many fruitful discussions of Yupno language and culture, both in the field and beyond. Finally, we gratefully acknowledge funding for this research from the National Geographic Society (grant #9131-12), the Endangered Languages Documentation Programme (ELDP), and the Friends of the International Center at UCSD, as well as funding from the NSF Spatial Intelligence and Learning Center (SBE-0541957) during preparation of the manuscript.

Notes

1. In addition to the “up” and “down” demonstratives in Table 1, the dialect of Yupno spoken in Gua village, where our studies were carried out, also has more specific demonstrative forms that distinguish a more vertical or “primary” up-down axis from a more horizontal or “secondary” up-down axis. We do not include these more specific forms in Table 1 because their use in the tasks discussed here is considerably less frequent than the more general “up-down” demonstrative series.
2. According to a survey of 41 buildings in Gua, where the present studies were conducted, 37 (90%) were houses as described above, with some variation in size and roof styles. The others were more modern in design and materials.
3. Yupno consultants deny that macroscale topography plays a role in deciding how to orient a new house. And, indeed, in Gua and other villages, Yupno houses face in all directions. Nonetheless, there are practical reasons for houses to face downhill as a general tendency (c.f. Núñez & Cornejo, 2012), as this orientation maximizes views of the valley and sky when facing out from the door.
4. The transcription of one outdoor trial that was an outlier in terms of overall length was truncated at a natural break point, approximately halfway through the trial.
5. Note that other strategy breakdowns may be defensible. For instance, while some authors describe reference to landmarks and reference to participants as separate strategies (e.g., Terrill & Burenhult, 2008, p. 106), others group these together as involving “ad hoc landmarks” (e.g., Bohnermeyer & Stolz, 2006, p. 308). For our purposes, the most important distinction is between topographic and non-topographic strategies; the finer division of the non-topographic strategies into further types only serves to give a richer sense of what kinds of strategies are being used.
6. Only in some cases do microworld-consistent and macroworld-consistent references dissociate. References along the *toward-* versus *away-from-door* axis dissociate in both sitting positions. References employing the *toward-* versus *away-from-fire* axis dissociate when participants are seated in position B (see Fig. 2) but not in position A. References employing the “other side as up” construal dissociate in

- sitting position A but not in position B. References to an axis of disposition (*baratda, dondon*) never dissociate.
7. At first glance, this appears to be at odds with Wassmann's (1994, p. 652) earlier findings that Yupno speakers make considerable use of "right" and "left." However, Wassmann did not distinguish uses that referred to the right and left *hands* from references that involve *projecting* a left-right asymmetry onto an array. The stimuli used in his task (a version of the "Man and Tree") included a man holding an object in one hand, which may have accounted for most mentions of "left" and "right."
 8. Use of uphill–downhill terms always involves reckoning slopes with respect to *some* scale (c.f. Palmer, 2015). The pragmatics of how the relevant scale is negotiated is a rich issue for future research on topographic reference systems.
 9. The proximate motivations for these mappings are clear in both cases: the canonical orientation of maps in the English case, and a canonical orientation facing east in the Aymara case. But the deeper question is: Why use the terms like "up" and "down" to stand in for terms that are themselves perfectly serviceable?
 10. In addition to work on Tzeltal (Brown & Levinson, 1993; Li et al., 2011), see work on cardinal systems in Australia (e.g., Haviland, 1998), Namibia (Haun, Rapold, Janzen, & Levinson, 2011), and elsewhere in Mexico (Le Guen, 2011).

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Fig S1. Set-up of the disambiguation task used in Study 1.

Fig S2. Stimuli for Study 1.

Fig S3. Arrays used in the “Pig and Corn” task.

Fig S4. Complete transcripts of all examples.

Fig S5. Satellite imagery of the terrain.