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Speech and Gesture in Spatial Language and Cognition Among the Yucatec Mayas

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Abstract

In previous analyses of the influence of language on cognition, speech has been the main channel examined. In studies conducted among Yucatec Mayas, efforts to determine the preferred frame of reference in use in this community have failed to reach an agreement (Bohnemeyer & Stolz, 2006; Levinson, 2003 vs. Le Guen, 2006, 2009). This paper argues for a multimodal analysis of language that encompasses gesture as well as speech, and shows that the preferred frame of reference in Yucatec Maya is only detectable through the analysis of co-speech gesture and not through speech alone. A series of experiments compares knowledge of the semantics of spatial terms, performance on nonlinguistic tasks and gestures produced by men and women. The results show a striking gender difference in the knowledge of the semantics of spatial terms, but an equal preference for a geocentric frame of reference in nonverbal tasks. In a localization task, participants used a variety of strategies in their speech, but they all exhibited a systematic preference for a geocentric frame of reference in their gestures.

Keywords: Spatial cognition; Frames of reference; Linguistic relativity; Gesture; Yucatec Maya

1. Introduction

What is the relationship between language and the cognitive representation of space? Are cognitive representations influenced or determined by the language we speak? In the 1930s, Sapir (1921) and Whorf (1956) proposed that language might be one of the most important influences on how people think and categorize the world. Since then, much ink has been spilled over this topic. In recent years, many studies have probed this question in linguistics and in psychology from a cross-cultural perspective. While some scholars reject what is

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often now called the Whorfian hypothesis, arguing that cognitive capacities are essentially problem based (Li & Gleitman, 2002; Newcombe, 2000), others have convincingly shown that language can influence the way both verbal and nonverbal cognitive tasks are solved (Boroditsky, 2001; Dasen & Mishra, 2010; Gumperz & Levinson, 1996; Levinson, 2003; Lucy, 1992a,b, 1997).[1] Supporters of the Whorfian hypothesis argue that language can play a significant role in structuring fundamental domains like space (Levinson, 2003; Majid, Bowerman, Kita, Haun, & Levinson, 2004). For Levinson (2003), one of the most powerful features that can influence the human mind is the semantics people share through the language they speak. Therefore, the speech community is seen as the fundamental level at which culture is instantiated, and language is taken to be what determines different ''cognitive styles'' in the spatial domain.

In recent years, speakers' preferred spatial frames of reference (FoRs) have been extensively studied in examinations of the influence of language on thought. A FoR can be minimally defined as the way spatial relationships between entities in the world are encoded in terms of the relevant angular information necessary to establish location in space. One central question is the following: Do preferences for FoR in language vary across cultures, and, if so, does this linguistic variation affect cognition? Levinson and his colleagues view language as the main semiotic device that unifies people's cognitive representations through everyday communication (Brown, 2001; Brown & Levinson, 1993, 2000; De León, 1994, 2001; Levinson, 1991, 1996a,b, 1998, 2001; Levinson, Kita, Haun, & Rasch, 2002; Majid et al., 2004; Pederson et al., 1998). Consequently, the privileged FoR used in language should be reflected in people's cognitive representations. Levinson and colleagues have concentrated on the analysis of speech in spatial discourse, focusing on the lexical semantics of spatial terms along with ethnographic evidence for spatial thinking. Central to their investigations are informal linguistic tasks such as director–matcher tasks, the results of which have been compared with the results from nonverbal tasks. The correlation between the verbal and nonverbal results has been taken as an indication of the influence of language on cognitive processes in problem-solving tasks (i.e., even when language is not present) (see Majid et al., 2004). This claim is in line with Slobin's ''thinking for speaking'' hypothesis (Slobin, 1991), which can be seen as a moderate view of the Whorfian hypothesis.

In the data collected by Levinson and colleagues from various speech communities, results from nonlinguistic tasks correlate with the preferred FoR in use in language: egocentric among the Dutch versus geocentric among the Tseltal of Tenejapa, Mexico (P. Brown & Levinson, 1993; Levinson, 2003). But when studies of these types have been conducted in Yucatec Maya communities, researchers have failed to agree on the preferred FoR (Bohnemeyer & Stolz, 2006; Levinson, 2003 vs. Le Guen, 2006, 2009).

Ethnographic evidence suggests that there are gender differences in how Yucatec Maya talk about space—in particular, in the semantics of the cardinal directions terms among men versus women. One might think that this would prevent women from using the geocentric FoR, but both men and women tend to use gesture to a large extent to talk about space and places. This issue is explored in this paper.

The specificities of the Yucatec Maya setting provide us with a convenient testing-ground for a three-way comparative analysis, with (a) two groups, men versus women, tested for (b)

their linguistic knowledge of spatial terms, and (c) their preference for FoR in both verbal and nonverbal tasks. The results presented in this paper show large gender differences in verbal tasks, specifically because the women in our sample do not share a part of the spatial vocabulary with men. But this gender difference is not reflected in the overall preference in my sample for a geocentric FoR found in both a nonverbal task and a task involving gesture. Among this group of Yucatec Maya speakers, knowledge of spatial terms is not a good predictor of spatial representations, whereas gesture is. I will argue that the gestural modality supports the use of a geocentric FoR and that this modality is the only one reliably available for women to construct their geocentric mental representations.

Cross-cultural studies of the interaction between space and gesture have often undertaken the examination of pointing gestures (Enfield, 2009; Enfield, Kita, & De Ruiter, 2007; Kita, 2003a; Levinson, 2003), but very few studies have been directly concerned with the impact of the geocentric FoR on gesture production (Haviland, 1993, 1998, 2000a; Kita, 2003b). This paper contributes to filling this gap.

1.1. Language, gesture, and FoR

A FoR can be defined according to Levinson (2003, p. 2) as a coordinate system used to localize a referent (a figure) with respect to a ground. After an extensive review of the existing literature, Levinson proposes that there are three main FoR for encoding spatial relationships between entities in the word, that is, types of angular information used to localize objects in space: the ''intrinsic,'' the ''relative,'' and the ''absolute.'' Although Levinson's proposal about these three frames is adopted in this paper, his terminology will not be followed. Instead, ''egocentric'' is substituted for ''relative,'' and ''geocentric'' is used for ''absolute.''[2] In Yucatec Maya all three FoR are potentially linguistically available. In order to understand the implications of these various frames, consider a simple example of how one can situate a woman in relation to her car, as in Fig. 1.

Fig. 1. A woman (the Figure) in relation to her car (the Ground).

In the *intrinsic frame of reference*, locations are represented in relation to an object's intrinsic properties (front, back, sides). This relation is binary, defined only by the two objects in relation to each other. The Figure is located considering a search domain defined by intrinsic axes of the Ground. In Yucatec Maya, the intrinsic FoR is probably the frame used most frequently in everyday speech, as will be shown below. It is based on the use of relational nouns that involve body parts or terms derived from body parts as follows: Locative + Person + Body part(+Nominal suffix), as in *ti' yàan tupàach le kàamyonoo'* ''she is at the back of the car'' (lit. ''she is at its back the car'' = ''she is behind the car'').

In an *egocentric FoR*, relations between objects are calculated in relation to the speaker's point of view, that is, in relation to his left, right, front, or back. This system involves a triadic relationship where coordinates are specified in relation to the speaker's viewpoint. In our example, the woman will be, for example, to the left of the car, that is, from the point of view of the speaker. Imagine now that the speaker moves around the scene 180 degrees: Now the woman will stand to the right of the car. Crucially, in the egocentric FoR, whether the women is located to the right of the left of the car does not involve her changing her position in relation to the car. In Yucatec Maya, there are terms for ''left'' and ''right'': *ts'ìik* and *no'oh*. But in my systematic collection of spatial utterances over 24 months of fieldwork, I have found that these terms are overwhelmingly used to designate body parts in relational nouns within the intrinsic FoR, as in the example about the back of the car in the preceding paragraph; they are rarely used within the egocentric FoR (but see Bohnemeyer & Stolz, 2006, p. 306).

In the *geocentric FoR,* coordinates between entities are defined by external features of the environment (i.e., neither by the internal orientation of a ground object nor the point of view of the speaker), often with the use of cardinal directions. In the geocentric FoR, the woman would be located, for instance, ''to the north of the car.'' In Yucatec Maya, all four cardinal directions are available (*xaman* ''north,'' *nòohol* ''south,'' *lak'in* ''east,'' and *chik'in* ''west''). Ethnographic observation (Le Guen, 2006) shows that these terms are sometimes used by adult men to describe small-scale arrangements (e.g., of objects on a table) (see also Bohnemeyer & Stolz, 2006, pp. 303–306).

Finally, it is noteworthy that the *deictic system,* even if it is not a FoR (because it does not provide angular information), is nonetheless relevant for this paper because it is pervasive in Yucatec Maya spatial speech. Two main sets of deictics used in spatial descriptions are the locative deictics (*te'e(l)-* ''here/there,'' *way-* ''here'' and *ti'*, a locative focus) and the manner deictics (*bey-*, ''thus''). Deictics are used with enclitics that provide information about perceptual access (immediate, nonimmediate, anaphoric, etc.) (see Hanks, 1990, 2005, 2009). In spatial language, deictics are used frequently and they are of special importance in the present discussion because they tend to be used in conjunction with gestures, often in place of FoR terms (Levinson, 2003, p. 70).

1.2. The Bohnemeyer and Stolz study and some predictions about FoRs in Yucatec Maya

In their description of the Yucatec Maya grammar of space, Bohnemeyer and Stolz (2006) make several claims about the preferences of Yucatec Maya speakers for FoR.[3]

These claims are based primarily on the results of the so-called men and tree task, a director–matcher task where two subjects are visually separated by a curtain and have to communicate about spatial arrangements shown in photos (see Levinson & Wilkins, 2006 for details). Importantly, the focus of this kind of analysis of FoR is based on speech only.

The authors conclude from their study that ''in terms of the frames of reference (FoRs) they deploy in spatial orientation, [Yucatec Maya] speakers on the whole present a surprisingly balanced picture, with all three principled types of FoRs being used in the small-scale (tabletop) elicitation context (although not by all consultants)'' and that ''the predominant FoR among [Yucatec Maya] speakers is clearly the intrinsic FoR.'' They note, however, that many speakers used what they call ad hoc landmarks in a ''pseudo-absolute FoR'' in the task, that is, a geocentric FoR. Overall, it is hard from Bohnemeyer and Stolz's study to identify the preferred FoR used by the Yucatec Maya speakers in everyday spatial localization. Even if the intrinsic FoR is often used in the men-and-trees task, data from natural interactions collected in the community where the tasks presented in this paper were conducted show that it can sometimes be insufficiently specific.[4]

I will show that several FoRs can be used simultaneously but that there exists a hierarchy between FoRs. The use of the intrinsic FoR in speech is subordinated to the geocentric FoR used in gesture. In this case, relevant angular information is not conveyed exclusively by speech, but is transmitted through the gestural channel in accordance with the orientation of the objects relative to each other in the real world. The data presented here show that habitual spatial speech is almost always complemented by gesture when it comes to the use of FoRs.

1.3. The ethnographic context of the study

The Yucatec Maya form an ethnic group defined by linguistic criteria. Their language belongs to the Yucatecan branch of the Maya family. Yucatec Maya is spoken in Southern Mexico (in the states of Yucatán, Campeche, and Quintana Roo) and in Northern Belize. The data presented in this paper were collected from the village of Kopchen, where the author has been conducting fieldwork since 2002 on a regular basis, spending several months every year. The village is situated in the state of Quintana Roo in the so-called ''Zona Maya.'' This area has preserved many aspects of traditional Maya life, and the Yucatec Maya language is still widely spoken. Younger generations receive some schooling in Spanish, but all interactions in the village are carried out in Maya. Women over 40 years old are still monolingual in Yucatec Maya.

The village is surrounded by tropical forest, and a physical as well as a symbolic separation between humanized space and the forest is relatively obvious for the villagers. The terrain is flat, and vertical relief never exceeds a few meters. In central Quintana Roo, Yucatec Maya still perform slash-and-burn subsistence agriculture. However, young people tend increasingly to seek jobs in tourist spots on the coast. These jobs usually do not involve contact with tourists and are generally temporary, primarily aimed at raising some money in order to go back to the village and settle there (the money earned is used for paying wedding and house-building expenses).

Experience with the spatial environment by Yucatec Maya is strongly linked to age and gender. Young children are almost always at their mother's side during the first years of life (until 3–4 years old) and spend most of their time within the household (i.e., the compound surrounding the house). Young boys start to go into the forest by age 5 but only for very short trips and are always accompanied by adults. By age 15, boys begin to venture into the forest by themselves and start working in the fields like adult men. While boys are encouraged to go help their male elders in the forest, girls are encouraged to stay within the limits of the village (Gaskins, 1996, 1999). From a native point of view, the forest space *(k'áax)* is dangerous for women and young children, due to forest spirits who are said to barely tolerate them (Le Guen, 2005, 2006). It should be emphasized that the field *(kòol)*, a cleared space in the forest used to plant corn and other plants, is considered part of the forest (since, according to slash-and-burn agriculture principles, it will become forest again). In regular daily life, adult males work almost every day in a forest context, whereas women rarely leave the household. With the improvement of roads and transportation, women travel every so often to the main town of the area, Felipe Carrillo Puerto, usually to spend a morning.

The use of spatial lexical items among Yucatec Maya speakers is, as for the experience of space, heavily biased by gender. Although the intrinsic FoR is used by all, including young children, the use of cardinal directions (necessary for the geocentric FoR) is apparently gender restricted. Cultural practices trigger the use of cardinal directions terms in two main contexts: going to work in the field and performing ritual discourse.

According to my corpus of naturally occurring spatial discourse, cardinal directions tend to occur usually if not always in the spatial context of the forest and the field *(milpa)*, where adult men work on a daily basis. Women, at least in the community where the study was conducted, are virtually excluded from this space; they participate in agricultural activities only sporadically, for example, when they harvest seasonal products like beans once a year. Cardinal direction terms arise mainly in the forest space and cardinal directions seem to matter in the very design of a field for the Yucatec Maya. In Kopchen, fields are square and generally oriented east–west. On the eastern side of the field a temporary altar is customarily built, where the ritual for the supernatural owners of the place is performed, usually at sunrise (Hanks, 1993; Le Guen, 2006).

Ritual speech has its proper organization, linked to ancient and future time, and, when instantiated, requires specific spatial configuration of objects and persons and specific constraints on movements. Cardinal directions are fundamental to the establishment of ritual space (Hanks, 1984, 1990, 2000; Vapnarsky, 2000, 2003) so all the cardinal directions appear in various types of ritual speech. However, ritual speech is usually limited to a subset of the population, namely ritual specialists and elders, who are usually men. The terms ''left(-hand)'' *ts'iik(-k'ab)* and ''right-(hand)'' *no'oh(-k'ab)* are frequent in modern ritual prayers, for instance in mentions of the ''right hand of God'' *(uno'oh k'ab Ki'ichkelem Yuúm)*. But these terms have more moral than spatial implications. The term *no'oh*, which has positive connotations, probably originated from the word *noh* ''great'' and refers to the dominant hand, while the term *ts'iik*, ''left'' has negative connotations and also means ''angry, fierce, grouchy.''

2. Study 1: Corpus analysis of natural interaction data

In order to test Levinson's prediction about the influence of language on thought, we need to know how people talk about space in everyday speech—in particular, how often they use the various different spatial terms available in Yucatec Maya. To address this issue, an analysis of a corpus of video-recorded interactions is presented. All recordings were made in the same village where experiments were conducted.

2.1. Method

2.1.1. Material

The corpus is composed of audio–video recorded interactions of various types, as summarized in Table 1. Natural data recording is based on the methodology recommended by proponents of Conversation Analysis, which means that the investigator is usually

Table 1
Corpus material

Discourse Type	Subject	Session Name	Time (in min)	Number of Utterances	Participant's Gender and Number
Interview	Interview about basket-weaving technique	2008-08-27_1729-TechniqueBasket-RCR	33	111	1-F
Interview	Interview about life events	2008-08-02_1032-tsikbalTimeW.	32.07	932	1-F
Narration	Narrative about a witch and her husband	2007-09-22_1743-utsikbalilxts'eek	12.3	258	1-M
Collaborative work session	Men making pit oven (digging the hole)	2009-06-12_1854-menpaanpiib (part01)	59.49	126	4-M
Collaborative work session	Men making pit oven (part 02)	2009-06-13_1526-menpaanpiib (part02)	39.36	294	4-M
Collaborative work session	Women making tortillas	2008-06-22_1304-tsikablS-Women	38	1158	4-F
Medicinal session (massage)	Woman getting a medicinal massage	2007-09-24-uyootxS.	15.53	317	2-F
Spontaneous conversation	Couple and a man talking about the local election	2008-06-24_1126-tsikbalyinalxS.	12.4	370	1-F; 2-M
Spontaneous conversation	Old women catching up about what happened during the year	2008-06-19-Utsikbal T. & L.	29.26	807	2-F
Spontaneous conversation	Two men talking about encounters with animals in the field and the forest	2008-06-27_1853-DC-P-tsikbal	14.26	464	2-M
Spontaneous conversation	Man telling about his recent accident when he hit his head on a branch	2008-07-02_1412-bixup'uchuhoolW.	20.28	506	3-M
Total			306	5343	25

not involved in the interaction (Duranti, 1997; Saville-Troike, 2003).[5] All interactions were recorded in the village, both indoors and outdoors. In total, the recordings represent 306 min of recording (approximately 5 h) and 5343 transcribed utterances.

2.1.2. Participants

In the recorded data, activities are conducted by participants of the same gender; only one spontaneous conversation is mixed, taking place between a woman, her husband, and another man. The participants range in age from 20 to 65 years, with a mean age around 41.

2.1.3. Coding

All materials were transcribed and checked by the author and a native speaker of Yucatec Maya (Lorena I. Pool Balam). To get an idea of the frequency of spatial terms in different kinds of discourse, we looked for lexical items relevant to the three FoR, as well as for locative deictics and manner deictics. Using cross-reference automatic search in the program Elan,[6] we looked at the number of occurrences of every spatial term in the transcribed data. Results are reported in Table 2.

2.2. Results and discussion

Terms are presented in Table 2, and an English gloss is provided for each term. The last column gives the overall frequency of the items.

The results of the corpus study confirm Bohnemeyer and Stolz (2006)'s hypothesis, at least in terms of item frequency: The front/back/side terms used in the intrinsic FoR occur more often than the left/right terms. The ''left'' and ''right'' terms do not appear at all in the data analyzed. Even if theoretically the front/back/side terms can be used egocentrically and the left/right terms can be used intrinsically, a full-fledged egocentric system requires

Table 2
Spatial terms frequency from the corpus study

Terms Category	Maya Lexicon	English Gloss	Frequency
Front/back/sides terms	*táan(il)*	''front''	12
	aktáan	''front''	23
	pàach(il)	''back''	4
	tsé́el	''side''	10
Left and right terms	*ts'íik*	''left''	0
	no'oh	''right''	0
Cardinal directions terms	*lak'in*	''east''	3
	chik'in	''west''	4
	xaman	''north''	0
	noohol	''south''	0
Deictic	*te'(e)l*	''here/there''	99
	ti'	''locative focus''	143
	way	''here''	88
	be(e)y	''thus''	811

the use of ''left'' and ''right'' terms to project search domains from the point of view of the speaker. The total absence of the use of left/right terms in the data analyzed suggests that Yucatec Maya speakers prefer the intrinsic FoR over the egocentric FoR. Cardinal directions are mentioned only by adult men and each time by a single speaker (ACB for ''east'' and ICM for ''west'')[7] while talking about events occurring in the forest space. In contrast, deictics are frequent compared to other terms used in FoRs. In the case of *b(è)ey* ''thus,'' the impressive number of occurrences is due to the use of this form in Yucatec Maya discourse as an ''all purpose'' deictic to talk about manner, shape, motion, etc., as well as space.

Since most of the participants' activities, especially the work sessions, involved manipulating and localizing objects in space, one might have expected more terms for ''left'' and ''right'' and the cardinal directions. But analysis of video-recorded data, along with systematic ethnographic observations, show that Yucatec Maya speakers tend to use pointing gestures rather than words to give angular information. These gestures generally occur with locative and manner deictics, as will be explained in Section 4.2.

Does the very low frequency of terms for ''left'' and ''right'' and the cardinal directions in spontaneous conversation mean that people do not know these terms? Are there differences between men and women in knowledge of these terms, as Danziger (1999) found for the Mopan Maya? Study 2 was conducted to answer these questions.

3. Study 2: Linguistic knowledge of spatial terms task

Systematic ethnographic observation and experimental tasks (Bohnemeyer & Stolz, 2006; Le Guen, 2006) suggest that knowledge of the semantics of terms for ''left'' and ''right'' (used in the egocentric FoR) and cardinal directions terms (necessary for the geocentric FoR) is not equally distributed among the Yucatec Maya adult population. Study 2 assesses knowledge of these terms in men versus women.

3.1. Method

3.1.1. Participants

Participants in the task included nine women (ranging from 19 to 46 years old, with a mean age of 35.6) and eleven men (32 to 45; mean 38.1). Among the 20 participants, two were left-handed, one man and one woman.

3.1.2. Setting and procedure

This study is part of a larger survey in which participants were asked by the author to point to various referents in nearby space and to localize two entities in local and distant space (see Section 4.1). All participants were familiar with the author and accustomed to speaking Yucatec Maya with him; all interactions were conducted in Yucatec Maya. All the tasks were conducted indoors, in the homes of the participants.

The aim of this task was to measure participants' knowledge of the meaning of spatial words, that is, the semiotic link between the word and the referent (e.g., ''west'' means the

‘‘direction west’’). Before the experiment had formally started (although the camera was already recording), participants were asked to give their name and age, and they were also asked an informal question designed to test their knowledge of the meaning of the egocentric terms ‘‘left’’ and ‘‘right’’: ‘‘Are you a righty or a lefty?’’ (*no’oha’anech wáa ts’iîka’anech?*). To answer this question, participants were asked to show their left and right hands. Participants were then asked to point to various villages in the surrounding region (results not reported here) and to the four cardinal directions in the following order: east *(lak’in)*, west *(chik’in)*, north *(xaman)*, and south *(nòohol)*.

3.1.3. Coding

This task was not intended to measure whether participants knew the terms or had heard them before, but if they knew what the terms *refer* to, namely left and right and the specific cardinal directions. If participants could show their left hand and their right hand correctly and point to the correct cardinal directions when asked, their answers were coded as 1; if not, as 0.[8] Many participants declared that they did not know the meaning of one or more terms (e.g., *minna’atik/ma’ ink’ahóol le t’an he’ela’* ‘‘I do not understand/know this term’’). For all other terms they gave correct answers.

3.2. Results

The results presented in Table 3 show a strong gender difference. All the men knew and understood the terms for left and right, whereas only 66.7% of women knew the term ‘‘right’’ and 55.6% the term ‘‘left.’’ Chi-square tests showed that men have significantly more knowledge about left ($\chi 2(1) = 4.31$, $p < .05$) and right ($\chi 2(1) = 6.11$, $p < .05$) than women. For cardinal directions the gender difference was even stronger—only 14% of the women answered correctly compared to 82% of the men ($t(18) = 6.33$, $p < .05$). Most men knew the reference of the terms for cardinal directions, although they did better on the terms for ‘‘east’’ and ‘‘west’’ (90.9% and 81.8%) than ‘‘north’’ and ‘‘south’’ (63.6% and 54.5%). Women, in contrast, showed very little knowledge of the reference of cardinal directions: They did not know the terms for ‘‘west’’ and ‘‘south’’ at all, and only 22.2% knew the term for ‘‘east’’ and 33.3% for ‘‘north.’’ These gender differences directly reflect men’s

Table 3
Lexical knowledge of left, right and cardinal directions broken down by gender

Maya Terms	English Gloss	Male Answers in % (n = 11)	Female Answers in % (n = 9)
no’oh	‘‘right (hand)’’	100	66.7
ts’iîk	‘‘left (hand)’’	100	55.6
lak’in	‘‘east’’	90.9	22.2
chik’in	‘‘west’’	81.8	0
xaman	‘‘north’’	63.6	33.3
noohol	‘‘south’’	54.5	0

familiarity with the field space and ritual discourses where cardinal directions terms are in use (see Section 1.3 above).

3.3. Discussion

Study 2 shows that men know the meanings of left/right terms and the cardinal directions much better than women. Cardinal terms can be learned quite independently, although a cumulative scale analysis (also called ''Guttman scale'' analysis) shows that there exists a certain dependency between cardinal terms knowledge.[9] Briefly, if a person knows the term south she is more likely to know all the terms, and if one knows only east he is less likely to know other terms. The dependency goes as follows (from the more known to the lesser known terms): east > west > north > south. These results are supported by ethnographic observation. The term east, *lak'in* in Yucatec Maya, is clearly the most well-known cardinal direction because of its importance in rituals (see above). The term west, *chik'in* in Yucatec Maya, is also constructed on the same root (*k'ɨ̀n*, ''sun'') and is, once the term for east assimilated, rapidly analyzable as the opposite direction where the sun goes. The term north, *xaman* in Yucatec Maya, is associated with the north wind and known better than the term for south that has no obvious linguistic or cultural support.[10] This knowledge of cardinal directions contrasts with Westerners who learn cardinal direction terms at school as an ensemble (north is the opposite of south and west is the opposite of east).

A question that arises from a Whorfian perspective is whether the discrepancy between the genders in spatial knowledge affects speakers' performance on nonverbal tasks. Recall that Levinson (2003) found that semiotic preference in habitual language influences cognitive representations. So we could expect the sexes to rely on different FoRs in solving nonverbal problems. Study 3 was conducted to see whether this is the case.

4. Study 3: The nonverbal MPI rotation task

A nonverbal task was conducted in order to test cognitive preference in the spatial domain and compare it to the results from the verbal task. The task, called ''animals in a row,'' was based on the procedure developed by Levinson and his colleagues from the Max Planck Institute for Psycholinguistics (Brown & Levinson, 1993; Levinson, 2003; Pederson et al., 1998). It makes use of a ''rotation paradigm'' that forces subjects to make an implicit choice between two distinct types of conceptual representation of a spatial scene—in other words, their preference for FoRs in a nonverbal situation.

The task consists of presenting subjects with a stimulus array oriented in a particular direction on a table and asking them to reconstruct/orient it on a second table, after they have been rotated 180 degrees, so that the response array matches (''is the same as'') the stimulus array. The idea behind this task is, according to Levinson, that ''people who speak a language that favors one specific frame of reference will tend to *think* in similar terms, that is, they use a coordinate system of the same underlying type in language and non-verbal cognition'' (Levinson, 2003, p. 20, his emphasis). The animals-in-a-row task was designed

to reveal participants' preference for either an egocentric FoR (reproduction of the array is based on the participant's point of view) or a geocentric FoR (reproduction of the array is based on reference to cardinal directions). In the animals-in-a-row task the intrinsic FoR cannot support an accurate reconstruction of the array, and it is a priori not expected. In the case of Yucatec Maya, the results of studies 1 and 2 suggest that we can expect gender differences in the performance of this task, specifically men are expected to use a geocentric FoR, whereas it is less likely for women.

4.1. Method

4.1.1. Participants

Participants in the animals-in-a-row task ranged from age 11 to 50, with a mean age of 19 years (15 for women and 21 for men). Twenty-one men and 10 women participated. It should be emphasized that fieldwork conditions differ significantly from university laboratory conditions, and people who participated in the task did so out of good will.[11] Due to fieldwork conditions and a number of participants' refusals, women older than fifteen are underrepresented and children from 11 to 14 years old are overrepresented.[12] However, since there were no relevant criteria for eliminating any trials, all were included. The participants are all different from those of studies 2 and 3. Nevertheless, all participants live in the same village of 300 inhabitants, share a similar cultural and linguistic background, and engage in the same everyday activities depending on their gender and age.

4.1.2. Setting

The task was performed in the house of the author, which is built on the traditional Maya apsidal model.[13] Two tables were placed 5 meters apart, oriented on an east–west axis. The tables were visually separated by a black curtain. A schema of the setting is presented in Fig. 2.

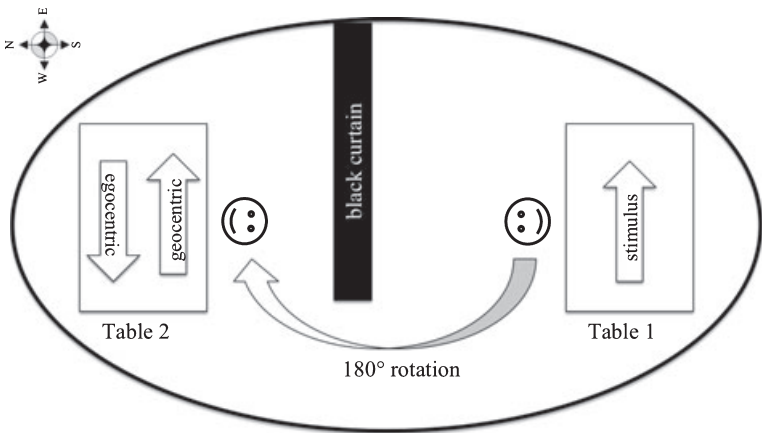

Fig. 2. Setting of the animals in a row experiment (study 3).

The choice to conduct the task indoors was driven by social and practical considerations: no adult would have agreed to perform the task in view of the other inhabitants of the village. There has been a lot of discussion of whether participants' strategies are influenced by an indoor setting (see Levinson et al., 2002; Li & Gleitman, 2002), but this point will not be discussed here (see, however, results from study 4 below).

4.1.3. Material, procedure, and coding

In the animals-in-a-row experiment three toy animals were used, as in Brown and Levinson's (1993) and Li and Gleitman's (2002) studies: a horse (*tsimin*), a cow (*wàakax*), and a pig (*k'e'ek'en*). They were all symmetric along their left/right axis. The three animals are familiar to Yucatec Maya. Experiments were conducted by the author in Yucatec Maya only; testing each participant took around 15 min.

As a training procedure, the experimenter first identified the animals and asked the participant whether he or she knew them. Then he set the animals up in a row along the east–west axis and asked the participant to look closely, because he or she would have to set them up again later exactly as they were. The participant could examine the stimulus array as long as he or she wanted. Then the experimenter took the animals and after 30 s and gave them back to the participant, who would then try to reproduce the array. This procedure was repeated until the person understood the task.

For the experimental trials, the participant was asked to do the same thing, but the array would be reconstructed on the other table. The instruction went as follows: *He'bix tamèetah te'ela', bey ken amèet te' meesa' te'elo', u'ïïgwali. Be'òora yan inch'a'ik le mehen ba'alche'o'obo', yan kpa'atik, despwèese' yan kbin te' mèesa te'elo'* ''What you just did here [i.e. reproduce the array], you will do it there, the same. Now, I will take the little animals and we will wait, then we will go to the table there [table 2].'' After asking the participant if he or she was ready, the experimenter took the animals and both waited face-to-face for 30 s. Then they both walked to the other table, rotating 180 degrees. There, the experimenter gave the animals to the participant and asked him or her to reproduce the array as it was on the other table. Results were recorded in a notebook and both experimenter and participant returned to the first table to carry out another trial. Five trials were conducted, with the animals' positions and orientation randomized.

As in Levinson et al. (2002), spatial information was avoided in instructions other than the use of the deictic expressions ''this table'' and ''that table over there.'' No motion verbs or descriptions of motion were used. Responses on each trial were coded as geocentric, egocentric, or other.[14]

4.2. Results

Overall, participants were much more likely to choose a geocentric FoR (85% of all choices, $t(30) = 7.81$, $p < .05$), that is, they recreated the array using an axis based on cardinal directions rather than their own point of view. No gender differences ($t(29) = 0.28$, $p > .05$) or age differences ($r(29) = .18$, $p > .18$) were observed. Fig. 3 presents the results

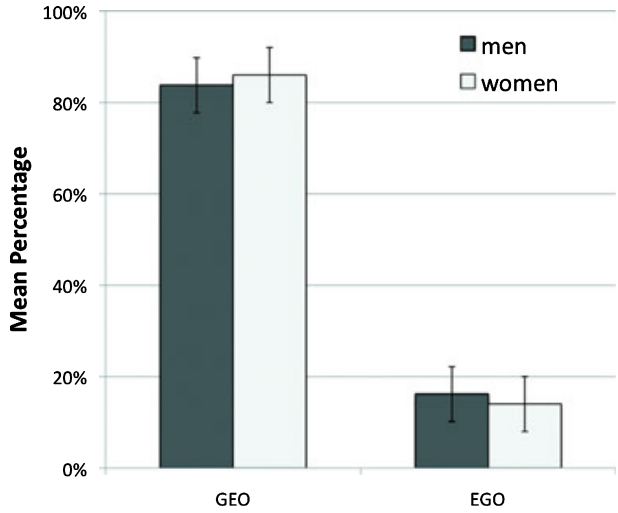

Fig. 3. Percentage of responses of study 3 broken down by gender and FoR (GEO: geocentric FoR, EGO: egocentric FoR) with standard error bars (± 1 SE).

broken down by gender and according to the possible choice of FoRs, egocentric and geocentric.

4.3. Discussion

Both men and women showed a clear preference for a geocentric FoR on the nonverbal task. These results are puzzling in the face of the results of studies 1 and 2, which showed an important gender difference in the knowledge of the semantics of spatial terms: The men in the sample know the lexical terms for cardinal directions much better than women do. Why is the gender difference in spatial lexical knowledge not apparent in the nonverbal task, given Levinson's hypothesized influence of language on thought? This question will be pursued in study 4, where I will show that language is not the only semiotic device used to convey spatial representations, precisely FoRs. Among the Yucatec Maya, gesture plays a crucial role in promoting the geocentric FoR.

5. Study 4: The localization task

Study 4 aims at determining what FoR is preferred by Yucatec Maya speakers to talk about the location of two distant entities in the world (i.e., one entity, the Figure, in relation to the other, the Ground), as they would do in real-life situations. A specific setting was chosen that allows us to contrast the use of the three possible FoRs, intrinsic, egocentric, and geocentric. Study 4 was also designed to test whether there are gender differences in the performance of such a task. Finally, this task allows us to look at potential semiotic channels other than speech for providing spatial information. This last consideration is motivated by

ethnographic data showing that when Yucatec Maya speakers give directions, their speech is often uninformative, whereas their gestures are very precise (Le Guen, 2009).

5.1. Method

5.1.1. Setting

In this task, participants were asked to locate one distant entity (the Figure) in relation to another (the Ground). Both entities are situated in the town of Felipe Carrillo Puerto, located 30 km north of the village where the experiments were conducted. Interviews were conducted by the author inside the homes of the participants.

Participants were divided into two groups. In group 1 all participants faced west and in group 2 all participants faced south. The distribution of participants into the two groups was based partly on the current layout of their house—how the hammocks were tied or where chairs were available.[15] To avoid suspicion or second guessing, if a participant was not naturally inclined to sit facing west or south the experimenter would invoke some ad hoc justification (usually regarding the placement of the camera, the light, or potential noise disturbances) and would invite the participant to sit accordingly.

5.1.2. Participants

Participants are the same as in study 2, which tested linguistic knowledge. This means that their behavior in this study can be directly compared with their linguistic knowledge. Group 1 (facing west) was composed of five women (mean age 37.6) and six men (mean age 36.3). Group 2 (facing south) comprised four women (mean age 33) and five men (mean age 40.2). All participants were familiar with the author and all interactions were conducted in Yucatec Maya.

5.1.3. Procedure

Participants were asked by the author to explain the location of a shop called Azulero (AZ) in relation to a gas station (GS) in Carrillo, the main town of the region. The question was designed to be very general; it implied only that the shop was to be treated as the figure and the GS as the ground: ''In Felipe Carrillo Puerto, where is the Azulero in relation to the gas station?'' (*Te' kàariyoo'*, *tu'ux yàan le àasuleroo' te' gasolinerao'?*). Participants were free to respond however they liked as long as they explicitly mentioned both the figure and the ground (that is, the location of the shop in relation to the GS). All interviews were audio–video recorded, with the camera always facing the participant (i.e., east for group 1 and north for group 2).

5.1.4. Material

The AZ and the GS are two adjacent entities separated by a road. All participants were familiar with them. Their arrangement is illustrated in Fig. 4. The AZ shop is situated north of the GS. Cars can enter on both the east and the north sides of the GS, so it has no single intrinsic front or back.

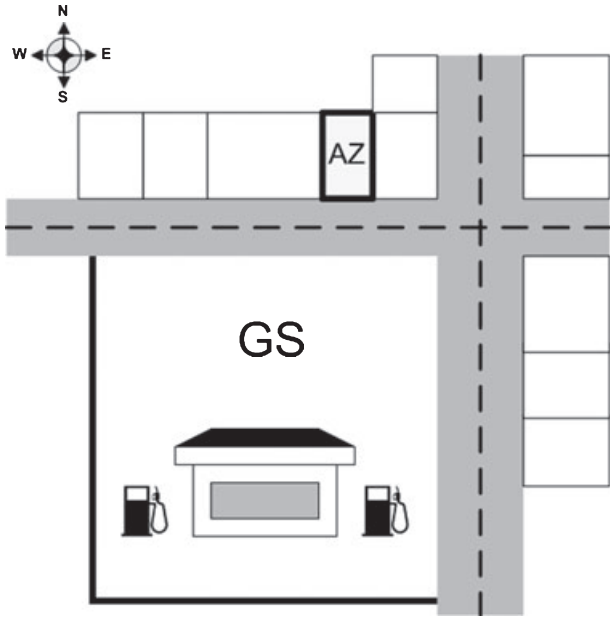

Fig. 4. The Azulero-gas station arrangement (bird's-eye view) used in study 4.

This arrangement has several advantages for our purposes:

(1) First, it allows *the three possible FoRs to be contrastively distinguished*. In the task, two entities are to be located in relation to each other. Each FoR triggers specific implications and constraints. The use of the intrinsic FoR specifies only a minimal relation between the AZ as the figure and the GS as the ground. Indeed, the GS has two contiguous open sides. The north and the east sides are both referred to in Yucatec Maya as ''its fronts'' and the two contiguous closed sides to the south and the west as ''its backs.'' Therefore, a search domain projected from the ground, as in ''AZ is to the front of the GS,'' would not specify whether the AZ is on the north or the east side of the GS. Consequently, participants cannot rely only on the intrinsic FoR to specify the precise shop's location; they must give extra information. In the egocentric FoR the relevant coordinates are provided by the point of view of the speaker, so any use of this frame should include some reference to the speaker's position when describing the array, such as ''coming/looking from *x*, the AZ is *left/right* in relation to the GS.'' No participants faced north or east in doing the task, in order to avoid ambiguity with the use of the egocentric FoR (i.e., a projection from the viewpoint of the speaker in a verbal answer such as ''in front'' would be ambiguous could be treated as ''the front of the GS'' or ''the projected front of the speaker''). Finally, as far as the geocentric FoR is concerned, there is only one correct answer: AZ is situated north of the GS.

(2) The arrangement used in study 4 concerns *real entities in the world*. The question therefore involves a *truth condition* (i.e., ''AZ is north of the GS and in no other direction from it''). This condition presumably reduces the variety of responses among participants and makes salient the Yucatec Maya FoR preference.
(3) The two entities to be located are *distant from the place of speaking*. This condition is motivated by previous findings showing that when a place is remote, egocentric speakers tend to be less accurate in their localization, whereas geocentric coders remain consistent (see Kita, 1998; Levinson, 2003, p. 258; Schegloff, 1984, p. 280).[16]
(4) Finally, the question asked is *close to real everyday communication and the cognitive tasks people engage in*—in this case, providing other people with accurate spatial information, as in direction giving. People regularly ask each other about store locations in the city, as well as about particular locations in the forest (e.g., for hunting or collecting plants).

Study 4 is designed to allow a three-way comparison: (a) gender (men vs. women), (b) modality (speech vs. gesture), and (c) lexical knowledge (know vs. do not know the spatial terms). The analysis pursues the following questions:

(1) Is there a gender difference in the use of FoRs?
(2) Does the knowledge of the semantics of the spatial lexicon predict the use of FoRs?
(3) Do speech and gesture draw on the same FoRs, or do they provide different information?

5.1.5. Coding

Participants' answers were supposed to specify the position of the AZ in relation to the GS. If participants did not mention the two entities explicitly, they were prompted by the interviewer to specify them (i.e., what is in relation to what). For instance, if a participant responded ''it is on this side,'' he or she was prompted to specify what is the AZ and which is the GS. Each utterance was considered a unit and would refer to the position of the figure (e.g., ''the AZ is north like this'') and the position of the ground (e.g., ''and the GS is like this''). Four participants gave a three-sentence description (e.g., (i) *bey aktaani' ti'a',* (ii) *e' gasolinera bey yanika',* (iii) *e' aasuleroe' beyo'* ''(a) it's like opposite to it, (b) the gas station is like this, (c) the Azulero is like this'') and two participants gave a one-sentence description (e.g., *bey laado te' gasolinera'i'* ''on this side of the gas station''). In total, all responses represent a total of 42 utterances.

The relation between the figure and the ground (i.e., the FoR) could be presented in the speech or in the gesture, or both. Responses were coded according to both the FoRs used in speech and the FoRs used in gesture. When no FoR were present in the verbal response but only deictic, the response was codec as deictic (see Table 4). FoRs in gesture were coded as geocentric if the direction indicated by the arm respected the real orientation of the relation between the AZ and the GS, that AZ is to the ''north of'' GS. Details are provided below. Then the responses from two semiotic channels were compared.

Table 4
Linguistic strategies used in the localization task verbal responses: Total number of utterances (n = 42)

Strategies Used in Verbal Response	Intrinsic FoR	Geocentric FoR	Deictic	Number of Utterances
Women	3 (19%)	0	14 (91%)	17
Men	6 (24%)	2 (8%)	17 (68%)	25
Total	9 (21%)	2 (5%)	31 (74%)	42

Note: FoR, frame of reference.

5.2. Results

5.2.1. Analysis of verbal responses

Verbal responses are reported in Table 4. This table shows that a variety of strategies were used in speech—both the intrinsic and geocentric FoRs, as well as manner and spatial deictics. But there were no egocentric responses.

Only two participants used a geocentric term (''north''); all the other participants' verbal responses were underspecified in terms of angular information. In the two following verbal answers reported below, only the participant in example 2 chose to use a geocentric term in this task, although both participants know the four cardinal directions terms as well as the terms ''left'' and ''right.''

(ex.1)	*he'l-o',*	*bey aktáan-i' ti'-a'*	*e' gasolinera bey yanik-a',*	*e' àasulero-e' bey-o'*
	PRES-TD	MAN in.front.of-TD LOC-TD	DET gas.station MAN EXIST-TD	DET azulero MAN-TD

''Here it is, it [AZ] is in front of it [GS], the gas station is like this, the Azulero like that'' [IPM (M, 39)][17]

(ex.2)	*hàa te' t-u-tséel-o' te' estee...*	*xaman ti',*	*xaman bey ti' e gasolinera-a'*
	INTJ LOC LOC-3.ERG-side LOC INTJ	north LOC	north MAN LOC DET gas.station-TD

''Hmm, on the side [of the GS] well… north of it, it is like north of the gas station'' [ACB (M, 43)]

The use of the verbal geocentric FoR in ex. 2 indicates the exact side of the GS on which the AZ is located, whereas the use of the intrinsic FoR alone used in ex. 1 does not. As predicted, the use of intrinsic FoR without complementary information does not specify whether the AZ is on the north or the east side of the GS (ex. 1). It appears that terms such as ''in front of/in opposition to'' *(aktáan)* and ''on its side'' *(tutséel)* are interchangeable in participants' responses from study 4.

Consistent with ethnographic data and the results of study 1 (see Table 1), deictics are the terms most favored by participants to localize the figure against the ground. Table 4 gives a count of the utterances that used deictic alone (as in ''the AZ lies *like this*''). Thirty-one of the 42 verbal answers (i.e., 74 percent) involved only deictics, as in example 3, a response from a 41-year-old woman:

Table 5
Gesture encoding of the AZ ''north of'' the GS by types of gestural strategies

	Gesture Encoded			
Twenty Responses	Left–Right Axis (total = 10)	Front–Behind the Body Axis (total = 7)	Away–Toward the Body Axis (frontal area) (total = 3)	Total Gesture Produced
Group 1facing west (n = 11)	10 (90%)	0	1 (10%)	11
Group 2 facing south (n = 9)	0	7 (78%)	2 (22%)	9

Note: AZ, Azulero; GS, gas station.

(ex.3) *bey-an-il gasolinera* *bey-an-il àasulero*

MAN-EXIST-NOM gas.station MAN-EXIST-NOM azulero

''The gas station stands like this, the Azulero stands like this'' [LCC (W, 41)]

The reason that speech can be so inexplicit is that the channel through which the relevant spatial information is provided by Yucatec Maya participants is *gesture*.

5.2.2. Analysis of co-speech gesture

When we look only at the verbal properties of the responses in study 4, many of the responses appear to be spatially underspecified. But when gesture is considered as well, all 20 participants show a consistent use of the geocentric FoR. Participants recreate the AZ-GS array always putting the AZ north of the GS. Table 5 presents the various strategies used to encode the AZ-GS relation over the 20 responses of the 20 participants. Interestingly, even participants who know the terms for the four cardinal directions (as shown by results from study 2) apparently do not feel any need to use a geocentric FoR in their speech, only in their gesture. Out of 11 participants who know the term ''north'' (3 women and 8 men) only two male participants encoded verbally the AZ being ''north of'' the GS, using the cardinal term *xaman*, ''north.''

Since participants in group 1 and 2 faced in different directions, we can compare the orientation of their gestures in a contrastive way. All participants encoded the AZ as ''north of'' the GS. Ten out of 11 participants facing west used the right–left axis of their body to encode the south–north axis: They pointed to their right, which was north, to set the AZ's position and to their left, which was south, to set the GS position. Participants facing south pointed behind them (north) for the GS and in front of them (south) for the AZ. Two participants from group 2 encoded the same relation but used instead a south–north axis defined by an opposition away from their body–toward their body (i.e., the two entities are reproduced in the frontal area of their body but the GS is still more away from the body, that is, more southward). The various strategies are presented in Table 5 and exemplified in Fig. 5.

Fig. 5 is a graphic representation of the gesture information shown in Table 5. At the bottom, we see, for group 1 (facing west) and for group 2 (facing south), the gestures with which they positioned the GS and the AZ. All four strategies are exemplified.

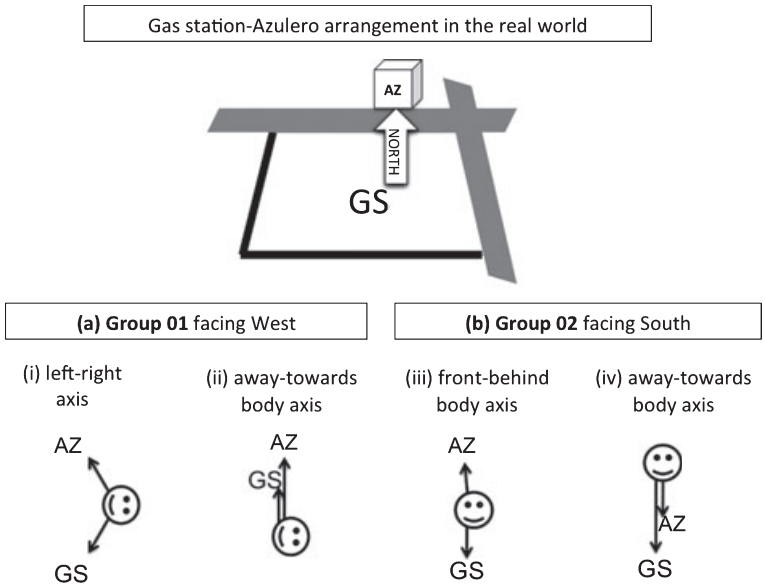

Fig. 5. Geocentric gestural responses from participants in group 1 and group 2 from study 4.

Fig. 6. ''From the GS (a) the AZ stands on the north (and) … (b) the gas station stands like this'' (study 4, male from group 1).

For reason of space, I will only present the two most frequent geocentric response strategies used by the participants in each groups, that is strategies (i) and (iii) of Fig. 5. The following examples contrast the knowledge of the participants against their gestural strategies. The four following examples show that whatever the verbal strategy being used or the lexical knowledge of the participant, the gestural strategy is always consistent with a geocentric FoR.

In example 4, illustrating strategy (i) of Fig. 5, a 33-year-old man in group 1 (facing west) uses the geocentric FoR in both language and gesture, first placing the AZ ''north of'' the GS (see (a) in Fig. 6) and then placing the GS to the south (see (b) in Fig. 6).[18]

Fig. 7. ''The AZ is (a) there (and) the GS is (b) there'' (study 4, male from group 1).

(ex.4) *(T)e' gasolinerao'... te' [xaman xan u-p'áata ti']* *(l)e gasolinerao' [bey yàan-ik-a']*
LOC gas.station LOC north too 3ERG-rest LOC DET gas.station MAN EXIST-FOC-TD

''From the gas station … [on the north it (AZ) stands from it too]$_{\text{Fig. 6a}}$, the gas station [stands like this] $_{\text{Fig. 6b}}$''

Example 5 also illustrates strategy (i) of Fig. 5. In this example a 32-year-old in group 1 (facing west) who knows the terms for all four cardinal directions uses the geocentric FoR but only in his gestures: His left hand indicates the position of the AZ to the north (see (a) in Fig. 7) while his right hand shows the position of the GS to the south (see (b) in Fig. 7). Unlike the man in example 4, he uses no geocentric terms in his speech, but only deictics (''there''); nevertheless, his gestures provide the relevant geocentric angular information (i.e., ''AZ is to the north of the GS'').

(ex.5) *Asùulero [ti' yàan te'el-a']* *(GS) [ti' yàan te'ela']*
gas.station LOC EXIST LOC-TD (gas.station) LOC EXIST LOC-TD

The AZ [is there]$_{\text{Fig. 7a}}$ (and the GS) [is there]$_{\text{Fig. 7b}}$

Participants in group 2, who faced south, equally set the opposition north–south (i.e., ''AZ is to the north of the GS'') in their gesture. Even though their gestures differ from those of participants in group 1 (who used their left-right axis, see Fig. 5), the geocentric

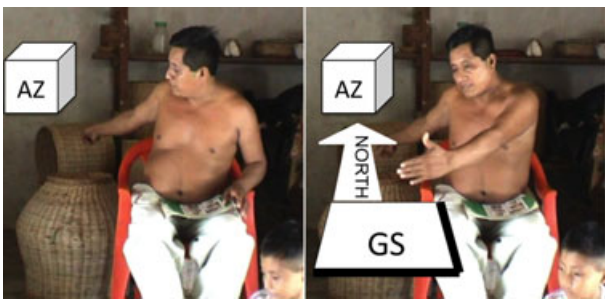

Fig. 8. ''The AZ stands exactly (a) like this … the GS stands (b) like his'' (study 4, male from group 2).

relation is preserved. The two following examples illustrate strategy (iii) of Fig. 5 where participants make use of their body to contrasts the position of the AZ in relation to the GS.

In example 6, a 40-year-old man pointed behind him (i.e., northward) with his right hand to indicate the location of the AZ and forward (i.e., southward) with his left hand, with his palm open and vertical, to position the GS. His geocentric gestures placed the AZ (see (a) in Fig 8) ''north of'' the GS (see (b) in Fig. 8). Although he knew all four cardinal direction terms, he did not encode any FoRs in his speech and used only manner deictics.

(ex.6) *Le àasulero [hach bey yan-ik-a']* *Gasolina-o' [bey yan-ik-a']*

DET azulero very MAN EXIST-FOC-TD gas.station-TD MAN EXIST-FOC-TD

''The Azulero [stands exactly like this]$_{\text{Fig. 8a}}$ … the gas station [stands like this]$_{\text{Fig. 8b}}$''

In example 7, another participant from group 2, a 19-year-old young woman (the youngest of study 4), also uses a geocentric FoR in her gestures. Her right hand first points to the north, behind her, to situate the AZ (see (a) in Fig. 9) and then she moves her hand to the south to situate the GS (see (b) Fig. 9). In study 2, this participant claimed she could not point to any of the cardinal directions. However, her gestures correctly encode a geocentric north–south relation, just like the gestures of all the other participants in groups 1 and 2.

(ex.7) *[AZ] [bey yàanika']* *[GS] bey bey inw-óol-a'*

(azulero) MAN EXIST-FOC-TD gas.station MAN MAN 1ERG-know-TD

''(AZ) [stands like this]$_{\text{Fig. 9a}}$ (and the GS) [like this as far as I know]$_{\text{Fig. 9b}}$''

Note that pointing behind one's body when referring to distant entities is a distinctive feature of geocentric gesture in general. Such a gesture is dispreferred by egocentric coders and readers may consider it quite awkward. In the use of the egocentric FoR, the point of view of the speaker sets the way an arrangement will be understood in terms of angular information (i.e., the figure is left/right of the ground looking at them from position *x*). So when talking about a distant arrangement, egocentric speakers tend to give information about the figure and the ground from their imagined perspective (i.e., the way they imagine themselves looking at the two entities, usually with one on left and the other on the right).

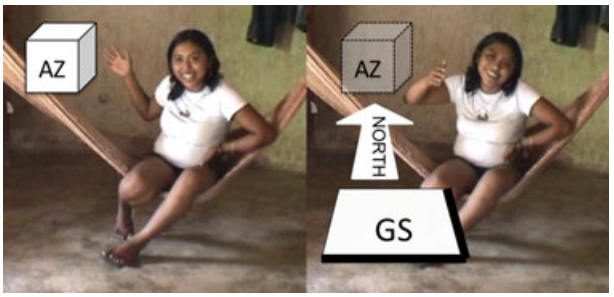

Fig. 9. ''AZ (a) stands like this (and the GS) (b) like this as far as I know'' (study 4, female from group 2).

In this case, gesture is done in the area in front of the body (Kita, 1998; Levinson, 2003).[19] In contrast, since for geocentric encoders point of view is irrelevant, they can point to the space all around their body to set a contrast between the figure and the ground (almost as a compass), as in examples 4–7.

5.3. Summary of study 4

The results of study 4 show that both men and women use a geocentric FoR accurately. Although the geocentric FoR is not overt in their speech, an examination of their gestures shows that they all systematically localize the AZ ''north of'' the GS.

Study 4 shows that, in a localization task where two entities are distant from the location of the speaker, Yucatec Maya participants use speech and gesture to convey complementary spatial information. In their responses, participants make explicit that they will encode angular information in their gesture with the use of deictics. An utterance such as ''It stands *like this*'' immediately triggers the question ''Like what?'' and directs the attention of the interlocutor to the gesture. Such practice is common in face-to-face interactions involving multimodal channels (Enfield, 2009, pp. 6–7). The results of study 4 are not in themselves surprising. Numerous studies have shown that speakers can choose to provide some information with gesture when they have the chance to do so, especially when their interlocutor can see them (see for instance Emmorey & Casey, 2001). What is specific to Yucatec Maya, I argue, is that some speakers have no other available method to express geocentric relations. Studies 1 and 2 have shown that few women in our sample know the meaning of either the egocentric or geocentric terms. Even the men in our sample who know those terms rarely use them when locating objects; they use gesture instead. To be comprehensible without the use of linguistic clues, the use of a geocentric FoR in communication should rely on the expectation that speakers share a similar geocentric mental representation and that the gestures always conform to a truth condition, that is, a point to the north always means ''north of.''

Results from study 4 also show that speakers can use various FoRs in their language, but the FoRs are organized hierarchically and the intrinsic FoR is subordinated to the geocentric FoR. For instance, the utterance ''AZ is in front of the GS'' is true when and only when speakers place AZ ''north of'' the GS, that respecting the real orientation of the entities. In other words, the AZ cannot be ''in front'' in any other directions but the north side. This hierarchy of FoRs is reflected in the verbal strategy (using an intrinsic For) being subordinated to the gestural strategy (relying on a geocentric FoR): When speakers say ''in front of,'' they use their gesture to encode ''north of.'' In this case the gesture is the channel that provides the relevant angular information.

6. General discussion

The series of experiments presented shows that although the Yucatec Maya participants, men and women, differed in their knowledge of the semantics of spatial egocentric and geocentric terms, they displayed the same preference for a geocentric FoR in a nonverbal task.

Study 1, a quantitative study that looks at the frequency of use of spatial terms and deictics in everyday speech, suggests that egocentric and geocentric terms are used rarely. Study 2 reveals a gender difference in the knowledge of the semantics of spatial terms. But this gender difference does not predict the results of the nonverbal rotation task (study 3), where the majority of participants, both men and women, chose a geocentric solution. Finally, study 4 shows that although participants used a variety of strategies in their speech, they all systematically used a geocentric FoR in their gestures. The conclusion from these four studies taken together is that language alone does not predict the preferred FoR for women, but gesture does for both men and women. In other words, men and women exhibit a geocentric representation of space that is always observable through their gesture, although generally not observable through their speech.

According to Levinson (2003)'s analysis of the results from the same nonverbal rotation task that was used here in study 3, Yucatec Maya participants use a geocentric FoR. Among the Yucatec Maya in the village of my own study, language cannot—contrary to claims by Levinson and colleagues—directly account for the results, since, as studies 1 and 2 have shown, men and women do not share a common linguistic knowledge. Women, who do not know which directions the terms for cardinal directions refer to, are virtually unable to use the geocentric FoR linguistically (although they can rely on alternative strategies when forced to, such as descriptions using landmarks).[20]

Study 4 shows a systematic use of gesture that reflects a geocentric representation of space. If habitual language use is regarded as the main element that can shape spatial cognitive representations of FoR, this linguistic system is, in the case of Yucatec Maya, composed of speech in co-dependence with gesture. It is gesture that provides the angular information necessary for establishing the FoR; this information is not otherwise available in the verbal modality, at least in the case of women.

The claim presented in this paper challenges the Levinson and colleagues' proposal about the influence of language on cognition when it considers only the use (too often reduced to the availability) of certain spatial lexicon to be enough to restructure spatial cognition. It also challenges Levinson and colleagues' proposal about geocentric or egocentric gesture taken to be as additional evidence of the result of the influence of language on cognition. In previous analysis (see Majid et al., 2004), gesture is considered to be aligned with the linguistic FoR, that is, gesture is seen as a nonlinguistic device that only ''reflect[s] aspects of a speaker's non-linguistic spatial representation'' (Majid et al., 2004, p. 111). The data presented in this paper do not challenge the claim that language (as a semiotic system) can influence one's mental representation but show that gesture is part of the semiotic system and that the gestural modality should be integrated into the analysis of spatial cognition.

6.1. Gesture as a medium for accessing mental representation: The co-dependence of speech and gesture

In recent years, numerous studies have shown that gesture can reveal a great deal about mental representations. These studies have been inspired by the work of researchers such as Kendon (1997, 2004), McNeill (1992, 2000, 2005), Kita and Özyürek (2003), and

Goldin-Meadow (2003), among others. While far from being ''an open door to the mind,'' gesture—or, more specifically, co-speech gesture (that is, gesture that accompanies speech)—provides valuable clues to cognitive processes. The role and the importance of co-speech gestures have been successfully illustrated in several domains, including metaphor (Cienki & Müller, 2008; Sweetser, 1998), the conception of time (Núñez & Sweetser, 2006), the expression of emotions (Ekman & Friesen, 1967; Martin, 2009), the expression of motion (Kita, 1998; Kita & Özyürek, 2003; Özyürek et al., 2008), and the acquisition of a new language (Gullberg, 2008). These studies have shown the crucial importance of gesture to the study of mental representation and cognitive processes.

But speakers' use of gesture in interaction is not only decisive in conveying meaning; it also helps speakers to monitor their interactions (Kendon, 2004; Özyürek, 2002; Özyürek, Willems, Kita, & Hagoort, 2007; Sweetser, 2006). In interactions about space, addressees can access the speaker's mental map through monitoring their gestures and update their own, and specific to the geocentric system, gesture can be corrected (see, for instance, Hutchins [1995] discussion of distributed and shared cognition).

Kendon and others after him (Enfield, 2009; Goldin-Meadow, 2003; McNeill, 1992) have argued for a view of speech and gesture together as constituting composite utterances; they consider the gestural modality ''as an integral part of the act of producing an utterance'' (Kendon, 2004, p. 5). In Yucatec Maya, it seems that at least in the spatial domain, gesture should be considered seriously as a relevant semiotic channel though which information about FoR is transmitted and sustained between interlocutors, especially in the case of women. This claim has deep implications for communicative interactions. It means that Yucatec Maya interlocutors have to monitor and memorize the precise orientation of every gesture when they are given directions.[21] What can in part motivate this use of gesture is the fact that gesture provides angular information much more accurately than cardinal directions can. Accuracy of angular information is particularly decisive in the geocentric FoR, where it is related to truth conditions (Levinson, 2003).

The results of studies 1–4 provide a somewhat different picture of the FoR preference of Yucatec Maya from previous studies that studied FoRs through speech alone (Bohnemeyer & Stolz, 2006). These results help account for why previous tasks have revealed a variety of strategies.[22] The Bohnemeyer and Stolz (2006) study, as well as several tasks conducted by the author (Le Guen, 2006), show that participants do often rely on the intrinsic FoR in their speech, but often unsuccessfully (i.e., the interlocutor does not understand), since this FoR does not provide enough accurate angular information without the gestural channel to support it. Since Yucatec Maya use gestures to provide relevant angular information in their spatial utterances, when speakers are in a situation where they cannot use gesture (for instance, during a director/matcher task like the ''men and tree'' task, where they are separated by a partition), they sometimes struggle, and rely on a variety of verbal strategies such as using ad hoc landmarks (trees, houses in the village, etc.). Bohnemeyer and Stolz characterize this strategy has a ''pseudo-absolute [=geocentric]'' system (2006, p. 305). This strategy is completely coherent with a geocentric conception of space that encodes the relationships between entities in the world on the basis of their real-world orientation or their relations with respect to external features of the environment. The results of the studies

presented here, far from denying the importance of the intrinsic FoR for speakers of Yucatec Maya, suggest that speakers routinely supplement this FoR with gestures and subordinate the intrinsic FoR to a geocentric FoR.

6.2. Gesture as a communicative medium that defines ''cognitive styles''

For Levinson and colleagues (Levinson, 2003; Majid et al., 2004), gesture has often been interpreted as an additional evidence (e.g., besides nonverbal task results) that language influences cognitive representations. This paper posits that gesture represents a semiotic medium in addition to language through which mental representations (e.g., the geocentric FoR) are communicated and maintained. The idea that language is not a unique medium through which communication takes place is not controversial, but previous studies seem to have presupposed that language can be independent from other semiotic channels—that is, that everything should ultimately be expressible in a linguistic form. From a research perspective, this has often meant forcing participants to verbally express spatial relationships. The assumption that everything should be verbally expressible relies on a Western historical construction encouraged by the appearance of writing. Too often it is assumed to be true without being submitted to cross-cultural testing.[23] Among Yucatec Maya, the multimodal nature of communication in the space domain is crucial and FoR information is distributed between speech and gesture.

How is the use of the geocentric FoR transmitted and passed on to younger generations? In the village where the studies were conducted, many Yucatec Maya children younger than 15 years of age, and women, do not have knowledge of semantics of the cardinal direction terms and the geocentric system is not supported by linguistic input. It is, however, abundantly supported by gesture in everyday interactions. Levinson points out that even when the geocentric FoR is frequently on display in language, as among Tzeltal speakers, ''gesture is part of the reason why children as young as four years old in Tenejapa have some grasp of the absolute [geocentric] system—without this ancillary semiotic channel it is hard to see how they could begin to master such abstract concepts as cardinal directions'' (2003, p. 269; see also P. Brown & Levinson, 2009; Haviland, 2000b). Gesture is, then, a communicative medium through which culture-specific patterns of thought can be transmitted. The learning process is far from straightforward, however, and ethnographic evidence suggests that there is a lot of guessing among children (Le Guen, 2006). It takes time to learn the meanings associated with gesture as a full semiotic device in its own right.

6.3. How does the use of the geocentric FoR originate?

Cultural settings and forms of communicative interactions play a crucial role in defining modes of spatial representation, especially in the case of the geocentric system. As Levinson points out: ''A system of fixed orientations is a social fact in the Durkheimian sense: it is a system that is arbitrary, might be otherwise, but whose existence constrains individuals. It can be learned only though communication'' (1998, p. 20). Communication here implies specific linguistic practices, that is, the use of gesture in face-to-face

interactions. No wonder the use of a geocentric FoR is also in accordance with local practices, the environmental setting, and fine-grained knowledge of the local space. Yucatec Maya are mostly peasants and foresters and rely on cosmological principles that involve reference to cardinal regions. The geocentric FoR is highly relevant at several levels. Even if all three FoRs are available in Yucatec Maya, study 4 clearly shows that the intrinsic FoR is subordinated (in direction giving) to the geocentric FoR; this is also often true for the egocentric FoR, where the left and right can be aligned with a geocentric axis (see Le Guen, 2009).

Some authors have suggested that the environment—more specifically, the geophysical properties of local settings such as significant landmarks like mountains or rivers—could trigger the use of the geocentric FoR (Li & Gleitman, 2002). This claim is hard to justify in the case of Yucatec Maya. The Yucatec peninsula is a flat forest environment with no mountains or above-ground rivers. A more refined definition of the environment as ''settings of communication,'' which highlights for example the difference between rural and urban contexts, appears to be a better predictor of FoR preference, as shown by Pederson (1993) for speakers of Tamil.

The gestural modality must play a crucial role in maintaining the use of the geocentric FoR, but it also imposes several constraints. The first is obviously the need for face-to-face interaction. It follows that the geocentric system is more likely to be restricted to small communities. But there is no obvious answer to why this particular frame is actually in use rather than some other (Yucatec Maya could just as well use an egocentric FoR with similar constraints). Perhaps we will have to resign ourselves, as Levinson (1998, p. 20) suggests, to viewing the use of the geocentric FoR as a cultural convention inherited from one generation to the next. Adult men (and ritual specialists to a lesser extent) who learn and use the geocentric FoR in their speech surely play a crucial role in ''imposing'' this system on the larger community and maintaining it in spatial communication.

7. Conclusion

Results from the four studies discussed in this paper allow us to make some inferences about Yucatec Maya's cognitive model of space. It appears that men and women are equally able to form similar mental models of spatial relationships, but they differ in their ability or willingness to express them in words. Gesture reveals a culture-specific preference for geocentric coordinates in both men and women, although this preference can only be observed in the speech of adult men. Gesture provides information about culture-specific patterns of spatial cognition that cannot be determined from linguistic data alone or from judgment tasks conducted only in speech.

The analysis of gesture also raises questions about culturally specific ways of dealing with spatial information and how spatial information is communicated and transmitted. Linguistic knowledge of FoR terms is clearly gendered among Yucatec Maya participants, but this difference has no crucial impact in everyday forms of communication, namely face-to-face multimodal interactions, where gesture is the medium used to convey the angular information needed for locating entities. This extreme case of interaction (where the gestural

medium provides critical information often lacking from language) is not intuitive in Western contexts, where the role of gesture in face-to-face communication has often been strongly devalued in recent history, perhaps replaced by an emphasis on the importance of written communication (see Kendon, 2004, p. 62–72, for discussion). As pointed out by many scholars, cautious studies of the interface between language and cognition, especially from a cross-cultural perspective, should not underestimate the role of cultural and communicational practices. This paper shows that a careful analysis of culturally specific multimodal forms of communication can offer insights about the way language and gesture function as interdependent semiotic devices to influence spatial cognition.

Notes

1. Mishra, Dasen, and Niraula (2003) and Wassmann and Dasen (1998) talk about ''moderate linguistic relativity.''
2. The reason essentially lies in the fact that the term itself (relative) is quite confusing (see for instance the discussion between Levinson and Haviland in Lucy's (1998, pp. 106–107) commentary). Any spatial localization is always done in relation to something (hence is always ''relative'' to an origo). Even geocentric directions are given relative to the position of the ground, sometimes the speaker's position (e.g., ''north from where we are''). The term ''egocentric,'' on the other hand, is more explicit in referring directly to the speaker's point of view. The use of the term ''geocentric'' instead of ''absolute'' is motivated by the fact that etymologically, it refers to external referents and is directly contrastive with egocentric. Furthermore, according to Levinson, ''geocentric'' has a broader meaning than ''absolute,'' the latter being restricted to the use of cardinal directions and involving a conceptual slope (absent in the area where the study has been conducted).
3. The experiments of Bohnemeyer and Stolz (2006) and this author were carried out in villages situated in the same region in central Quintana Roo. All the villages are in the ''Zona Maya'' (an historical and official region around Felipe Carrillo Puerto) and share cultural and linguistic backgrounds.
4. For instance, terms such as *pàachil*, ''behind,'' which is used to refer to the ''back'' of a house, can also mean the ''surrounding'' of the house. To understand, listeners must take into account pragmatic clues from the context. Bohnemeyer and Stolz note this in discussing their results; they comment, for instance, that a purely intrinsic description cannot differentiate mirror-image spatial arrangements: ''additional, non-intrinsic information is needed to differentiate between those spatial relations depicted in Pictures 2.3 and 2.5'' (2006, p. 303).
5. Audio–video recorded materials are used in accordance with the ethical rules that apply in the collection of ethnographic data and the rights of the individuals and of the community.
6. Elan is a free program designed by the MPI and available online: http://www.lat-mpi.eu/tools/elan/

7. Participants' names are anonymized with the use of initials.
8. It should be stressed that cardinal directions cannot be measured as one specific angle. As in elicitations conducted with other Yucatec Maya informants (see Le Guen, 2006), cardinal directions are defined by the angle of the sun between the two equinoxes.
9. I am indebted to Wijbrandt van Schuur for this analysis.
10. In their justification, some women interviewed said that they knew the term for ''north'' because they had overheard it in men's discourse about weather (e.g., *xa-mane' te'ela', kinwu'yik kuya'ala te'elo' ti' kutàal ke'eli'*, ''North is there, I heard that they say it's from there the cold comes,'' SCC, 39 years old). Indeed, in Yucatec Maya, the cold wind coming from the north is often described as *xaman ɪ̈k'* (''north wind''). As for *lak'in* ''east,'' no justifications were provided, but ethnographic data can provide some insights. As mentioned earlier, most of the rituals performed in the field but also in the village are oriented toward the east, so uses of this term are more likely to arise in ritual contexts. Furthermore, the term *lak'in* is built on the root *k'ɪ̈n*, ''sun.'' But if the lexical resemblance to *k'ɪ̈n* ''sun'' is what triggers knowledge of this term, we might expect *chik'in* ''west,'' which is also built on the root *k'ɪ̈n*, to be recognized as well, but this is not the case.
11. All participants were indirectly rewarded according to their social status and personal relationship to the experimenter.
12. J. Bohnemeyer (unpublished data) applied the same task in a village close to the one where this study was conducted and his results display the same preference for the geocentric FoR. His task was run with a group of 16 people (two men and four women below 30 years old and five men and five women above 30 years old).
13. This type of house has two semi-circular ends.
14. Other responses were rare and often seemed due to inattention. They were omitted from the analysis.
15. The internal and external spatial configuration of Yucatec Maya houses often changes over time depending on the number of inhabitants (e.g., if new children are born or a young man gets married and his wife comes to live with his parents), significant events (considerable modification can occur in the anticipation of marriages, anniversaries, etc.), or simply the taste of the owners (see Le Guen, 2006 for more details).
16. According to Schegloff, North American English speakers can point to refer to entities in space without considering their real position, using space in a metaphorical way. Schegloff notices that ''If the place referred to is not visually accessible, then it appears that the point is not necessarily in a direction selected to be the 'actual direction' of the referent relative to the scene of the talk. For example (…) different 'places' (which happen to be in different directions from the talk scene) are accompanied by points in the same direction, and two persons referring to the same place while talking together point in different directions'' (Schegloff, 1984, p. 280).
17. Glosses used in the transcriptions: 1, 2, 3: person mark; DET, determinant; ERG, ergative marker; EXIST, existential; FOC, focus; INTJ, interjection; LOC, locative; MAN, manner; NOM, nominalizer; PRES, presentative; TD, terminal deictic.

18. Brackets in the text of the example represent where in the speech the stroke gesture falls (in the figure).
19. In the use of an egocentric FoR, since coordinates are determined by the point of view of the speaker, a point behind the body would mean that the speaker would have to turn around 180 degrees to look behind him/her.
20. See Le Guen, 2006, who presents a director-matcher task showing that men, women, and children all rely mainly on landmarks when they have to move a toy man on a maze.
21. An illustration of the pervasiveness of this form of information among speakers: During fieldwork I was often invited to drive a car with Yucatec Maya passengers. To guide me, my informants would constantly say ''this way'' or ''that way,'' using a gesture (outstretched arm) to indicate the following turn. As one can imagine, this form of direction giving is especially problematic (and dangerous) when the speaker is in the back seat! Even when speakers know egocentric or geocentric terms and I ask them to give only verbal information, they still have a hard time not using large gestures.
22. The introduction of gesture into the examination of FoRs might help to support, challenge, or fine-tune some previous claims. For instance, Danziger (1999) shows a gender difference in mirror-image differentiation among Mopan Maya speakers (closely linguistically and culturally related to Yucatec Maya). She attributes this variation to a gendered habitual language use, a difference also found among the Yucatec Maya. But Danziger goes further in claiming that this sociolectal variation has an impact on the conceptual construal of space. It would be interesting to examine Mopan Maya gesture to determine whether men and women indeed differ in their cognitive representation of spatial relations or only in their language.
23. Western cultures have relied heavily on writing system for several centuries now (Goody, 1986). A writing system consists of a symbolic representation of speech and is therefore an abstraction of a unimodal mode of communication, described as a ''secondary orality'' by Ong (1988). Reliance on writing has contributed to the neglect of other modalities, including gesture.

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Supporting Information

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

Video S1. Male oriented West (group 1, study 4, ex. 4) indicating the position of the AZ with regard to the GS.

Video S2. Male oriented West (group 1, study 4, ex. 5) indicating the position of the AZ with regard to the GS.

Video S3. Male oriented South (group 2, study 4, ex. 6) indicating the position of the AZ with regard to the GS.

Video S4. Female oriented South (group 2, study 4, ex. 7) indicating the position of the AZ with regard to the GS.

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