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Spatial frames of reference in Mesoamerican languages

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ABSTRACT

This article presents the conceptual and methodological framework for the special issue *Frames of reference in Mesoamerican languages*, which reports on the use of frames of reference (FoRs) in eight Mesoamerican languages and two non-Mesoamerican control languages. The papers included here are a result of the ongoing collaborative project *Spatial language and cognition in Mesoamerica*. This article provides a background to the study of FoRs, the research methodology used cross-linguistically, the classification that serves as the basis for the coding of cross-linguistic data, and a preview of the articles in the special issue.

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1. Introduction

This special issue *Frames of reference in Mesoamerican languages* presents a collection of papers on the use of spatial **frames of reference** (FoRs) in a sample of languages from the Mesoamerican *sprachbund* (Campbell et al., 1986) and non-Mesoamerican control languages. FoRs are coordinate systems that are used in the interpretation of spatial relations between objects. The use of spatial FoRs, as discussed in this special issue, has been examined within the context of the project *Spatial language and cognition in Mesoamerica* (MesoSpace).[1] MesoSpace is a cross-linguistic investigation of spatial representation in language and cognition in 13 mostly understudied Mesoamerican languages and two additional control languages spoken just north and south of the Mesoamerican *sprachbund*. The articles presented in this special issue report on FoR use in seven of the 13 Mesoamerican languages studied in the context of MesoSpace. One article on Mopan (Mayan) is included, based on data collected outside the MesoSpace project. Two additional articles are devoted to findings from the two control languages in the MesoSpace sample: Seri (isolate) and Sumu-Mayangna (Misumalpan). All ten languages included in this special issue and their researchers, are listed in Table 1.

This collection of articles closes a substantial gap in the description of the use of FoRs in Mesoamerica. To date, there are no published studies reporting on FoR use in Mixe-Zoquean languages, nor in the Uto-Aztecan languages spoken in Mesoamerica. Research that has been reported on FoR use in other Mesoamerican languages is limited to four Mayan languages, Tsotsil, Tseltal, Yucatec and Mopan (de León, 1994; Levinson, 1996; Danziger, 1996, 2001; Brown and Levinson, 2004; Bohnemeyer and Stolz, 2006; Brown, 2006; Le Guen, 2006), two Otomanguean languages, Tlacolula Valley Zapotec (Lillehaugen, 2006) and Huave (Becerril et al. 2006) and Totonac of the Totonac-Tepehua family (Levy, 2006). This special

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Table 1
Languages and researcher represented.[a]

Language	Language family	Researcher(s)
Tarascan	Isolate	Alejandra Capistrán
Tseltal	Mayan	Gilles Polian
Yucatec	Mayan	Jürgen Bohnemeyer
Mopan	Mayan	Eve Danziger
Ayutla Mixe	Mixe-Zoquean	Rodrigo Romero Méndez
San Ildefonso Tultepec Otomí	Otomanguean	Néstor Hernández-Green, Enrique L. Palancar, Selene Hernández
Juchitán Zapotec	Otomanguean	Gabriela Pérez Báez
Meseño Cora	Uto-Aztecan	Verónica Vázquez Soto
Seri	Isolate	Carolyn O'Meara
Sumu-Mayangna	Misumalpan	Alyson Eggleston, Elena Benedicto

[a] Language names are used in this article following the naming and spelling conventions used by authors in this special issue.

issue – the result of the extensive data collection effort by MesoSpace researchers – therefore represents the first published record of cross-linguistic research on FoR use in Mesoamerica and the first descriptions of FoR use for most of the featured languages and, in some cases, of entire language families.

Data on FoR preferences in understudied languages, such as those featured in this special issue as well as those previously studied, are of interest to linguists, psycholinguists and other cognitive scientists, as the data present implications for assumptions regarding the universal nature of spatial representation in the human species. In particular, the primacy of an observer as the point of origin for the projection of FoRs has come under scrutiny. Indeed, in previous studies some Mesoamerican languages have been shown to exhibit a bias against the use of the relative FoR, which is observer-dependent (Levinson, 2003; Brown, 2006). The extensive research reported in the articles in this special issue contributes to expanding the knowledge about FoR preferences in understudied languages of the Mesoamerican *sprachbund*. In addition, authors in this special issue lay the groundwork for the exploration of whether a tendency to disprefer the relative FoR is related to another typological trait of Mesoamerican languages: highly productive meronymic systems. **Meronyms** are terms that lexicalize object parts as such. In other words, meronyms have the part–whole relation as part of their meaning (cf. Section 3.1). In Mesoamerican languages, meronyms are often body part terms, but may also refer to geometrical features of objects and to spatial regions defined with respect to such features. The particulars of meronymy in various Mesoamerican languages have been described for the Mayan languages Mopan (Danziger, 1996), Tseltal (Stross, 1976; Levinson, 1994) and Yucatec (Goldap, 1992; Bohnemeyer and Stolz, 2006), Mixtec and Trique belonging to the Mixtecan branch of the Otomanguean language family (Brugman, 1983; Brugman and Macaulay, 1986; Hollenbach, 1987, 1988), various Zapotec varieties (MacLaury, 1989; Lillehaugen, 2006; Pérez Báez, in press), as well as Cora (Casad, 1982), Totonac (Levy, 1999, 2006) and Tarascan (Friedrich, 1969, 1970, 1971). While meronyms are certainly not unique to Mesoamerican languages, they are used within the Mesoamerican *sprachbund* in a particularly productive way, as speakers may assign body part terms to a wide variety of objects and their parts, even in the case of objects that might have been previously unknown to them. This line of investigation can inform the theory of domain mapping – how speakers of a given language map objects from the source domain, such as the human, animal or plant body onto objects of the target domain, in this case inanimate objects (Brugman, 1983; MacLaury, 1989; Levinson, 1994). Also, meronyms constitute an important component of spatial descriptions. Meronymy is a core element in one of the hypotheses driving the research of the MesoSpace project: that meronymy as it occurs in Mesoamerican languages may be a linguistic predictor of a bias against the projection of FoRs derived from the observer's body – the "relative" type of FoRs, which plays a dominant role in more widely studied languages such as Spanish, English, Dutch and Japanese (e.g., Levinson, 2003). Articles in this special issue lay the groundwork for an exploration into a possible connection between meronymy and FoR preferences.

In the context of MesoSpace, FoR preferences observed in the data collected from linguistic elicitation tasks are compared to preferences in non-linguistic tasks. Data on alignments or mismatches in FoR use in language and cognition cross-linguistically contribute to the ongoing debate regarding the role of linguistic, sociocultural and environmental factors as determinants of FoR selection in cognitive tasks (see, for example, Levinson et al., 2002; Li and Gleitman, 2002; Majid et al., 2004; Li et al., 2005). Pederson et al. (1998) found an alignment between linguistic and cognitive usage preferences in seven populations: Dutch, Japanese, and urban Tamil speakers showed a preference for the relative FoR in both the linguistic and the non-linguistic task, and Arrernte, Longgu, Tseltal, and rural Tamil speakers exhibited a preference for the absolute FoR in both the linguistic and the non-linguistic task. Pederson et al. (1998) interpreted this alignment as evidence of a relativistic effect: linguistic usage determines usage in non-linguistic cognition. Among the results from contributors to this special issue, comparable alignments are found. For instance, in Juchitán Zapotec (Pérez Báez, 2011) and in Sumu-Mayangna (Eggleston and Benedicto, 2011) a bias against observer-centered FoRs was documented in both linguistic and non-linguistic tasks, and Danziger (2011) finds an alignment between Mopan avoidance of "extrinsic" FoRs in language and Mopan performance in a non-linguistic task. Such findings are of value beyond that of describing FoR use in understudied Mesoamerican languages and the control languages in this study, as they have implications for the linguistic relativity hypothesis (Whorf, 1939 [1956]; Berlin and Kay, 1969; Lucy, 1992; Gumperz and Levinson, 1996; Lee, 1996; Wassmann and Dasen, 1998;

Bowerman and Levinson, 2001; Bohnemeyer, 2008), which are of interest to linguists, psycholinguists, anthropologists and other cognitive scientists.

The following sections in this introductory article provide theoretical and methodological concepts relevant to the articles featured in this collection. More specifically, Section 2 provides an overview of the FoR typology used by MesoSpace researchers in coding and analyzing the data. Section 3 explains in detail the MesoSpace elicitation tasks relevant to the analysis of FoR preferences in language and cognition. Section 4 highlights some of the research findings as a preview to what the reader will find in the ten articles that follow.

2. Spatial frames of reference

Let us discuss some of the ways in which one would attempt to describe the location, orientation, or motion of an object with respect to another object. There are a limited number of possible ways of locating a **figure**, the "moving or conceptually movable entity", with respect to a **ground**, the object "with respect to which the figure's path, site, or orientation is characterized" (Talmy, 2000, p. 184), without imposing a coordinate system on the latter. These possibilities are inclusion, overlap, contact, and proximity or distance and are referred to as **'topological relations'** following Piaget and Inhelder (1956). All other strategies involve the imposition of a perspective, a coordinate system that partitions the space beyond the ground into distinct search domains. These coordinate systems are called 'frames of reference' and are used to interpret spatial representations. The origin of such coordinate systems is the figure in orientation descriptions and the ground in locative and motion event descriptions. FoRs also involve an **anchor**, which is an entity or event that introduces a spatial asymmetry from which the axes of the coordinate system or FoR are transposed (projected) or abstracted.

FoRs have been of scientific interest for quite some time.[2] However, the variation in the use of the various types of FoRs across languages and cultures has only recently been recognized. As far back as Kant (1991 [1768]), an emphasis has been placed on the relevance of the symmetrical anatomy of humans, as a system of reference that divides space into left and right regions (for a critique of this approach see, for example, Levinson and Brown, 1994). Similarly, in psycholinguistics and semantics, researchers have distinguished the different coordinate axes in the horizontal plane relevant to FoRs as corresponding to 'left' and 'right' as well as 'front' and 'back' (Clark, 1973; Miller and Johnson-Laird, 1976). However, it has been pointed out that while it may seem natural for humans to project quadrants of their body onto regions of space as a strategy to locate objects, it must not be assumed that all humans do so (Pederson et al., 1998). Indeed, research on languages that are not as widely spoken and studied as European languages suggests that the projection of spatial regions from a speaker's body is not universally dominant in spatial reference, and that it is a strategy that might not even be used in some languages (Levinson, 1996, 1998; Senft, 1997).

The contributors to this special issue seek to further the understanding of the various types of FoRs possible cross-linguistically and consider the patterns of use of the following FoRs in their language of study: **object-centered, direct, landmark-based, geomorphic, absolute and relative**. This classification takes as a point of departure previously proposed types of FoRs and corresponding heuristics. First, the three-way classification among intrinsic, relative and absolute FoRs developed for the purposes of crosslinguistic research by the members of the Language and Cognition group (formerly the Cognitive Anthropology Research Group) at the Max Planck Institute for Psycholinguistics henceforth, the 'Nijmegen classification' (Levinson, 1996, 2003; Pederson, 2003). Second, the introduction of the direct FoR (Danziger, 2010) as explained in Section 2.1.

The six-way classification that the MesoSpace team has been working with adds the geomorphic and the landmark-based FoRs to the absolute and relative FoRs as cases in which the ground does not function as anchor. Sections 2.1–2.6 explain in detail all six types of FoRs, noting where appropriate any differences in definition as regards to the Nijmegen classification or Danziger's four-way classification. Section 2.7 is a summary of the motivations for adopting the six-way MesoSpace classification.

2.1. Object-centered FoRs

Object-centered FoRs are understood here in a traditional, narrow sense as involving an anchor that is the same as the ground, but that is distinct from the observer's body. As such, it is similar to the object-centered FoR in Danziger (2010) and less inclusive than the intrinsic FoR in the Nijmegen classification.[3] In object-centered FoRs, the axes of the coordinate system that are involved are determined by parts of the ground, e.g., its front and back, top, bottom and/or sides. In example (1), the ball is the figure and the chair is the ground. The coordinate system is determined by the front-back axis of the chair. The location of the ball is indicated with respect to the region projected from the front part of the chair. Note that if the chair is rotated, the description in (1) is no longer valid (see Fig. 1).

(1) *The ball is in front of the chair.*

[2] The concept of frames of reference comes from Gestalt psychology (Asch and Witkin, 1948; Rock, 1992).

[3] In Danziger (2010) the object-centered FoR is defined as that where the anchor is the ground, and is distinct from a speech participant.

Fig. 1. B&C 2–10.

Fig. 2. B&C 3–10.

2.2. Direct FoRs

Direct FoRs (Danziger, 2010) are anchored to the body of an observer (which, in linguistic representations, is typically, but not necessarily, the speaker and/or addressee), but in this FoR type there is no projection of the observer's body axes onto an external ground (or figure in the case of orientation descriptions). In example (2), the ball is the figure while the ground involved in the spatial representation and the anchor of the coordinate system are the observer's body. The location of the ball is the spatial region projected from the observer's front. However, if the observer changes orientation, the description does not remain valid. It is important to point out (cf. Danziger, 2010) that descriptions that are coded as involving a direct FoR in the MesoSpace sample would be classified as intrinsic in the Nijmegen classification. The direct FoR was found to be available to speakers of Ayutla Mixe (see Romero Méndez, 2011), Sumu-Mayangna (see Eggleston and Benedicto, 2011) Seri (see O'Meara, 2011) and Yucatec (Bohnemeyer, 2011), and it was found to be a dominant strategy in Meseño Cora (see Vázquez Soto, 2011), Tarascan (see Capistrán, 2011), and Mopan (see Danziger, 2011) (see Fig. 2).

(2) *The ball is in front of us.*

In the course of the research conducted as part of the MesoSpace project, data from certain languages of the sample emerged, which presented a coding challenge. These data involve descriptions in which the ground involved in the spatial representation is distinct from the anchor, but where the anchor of the coordinate system is the observer's body (or the

Fig. 3. B&C 4–1.

observers' bodies), such as in (3a) where a ground or reference point that is distinct from the anchor must be understood even if it is not explicitly mentioned. This is because *toward me* denotes directionality toward the observer, and as such, the place from which the direction is oriented must be located somewhere – at a ground, such as the chair in (3b), even if the ground phrase is omitted as in (3a).

(3a) *The ball is toward me.*
(3b) *The ball is toward me from the chair.*

Some authors have restricted their use of the term 'direct' to those cases where the ground functions as anchor (Danziger; Pérez Báez; Polian and Bohnemeyer, respectively, 2011). Other authors have elected to code descriptions such as the one in (3a) as involving a direct FoR, in a departure from Danziger's (2010) definition. In each case, the motivations for either decision are explained in the individual articles.

2.3. Relative FoRs

FoRs in which the anchor of the coordinate system, but not the ground of the spatial representation, is the observer's body are relative. Relative FoRs involve the projection of a system of axes derived from the observer's body onto the ground (in locative and motion descriptions) or figure (in orientation descriptions) of a spatial representation. In example (4), the figure is the ball, the ground is the chair and the anchor of the coordinate system is the observer's body. The observer's body provides the axes of the coordinate system. In this case, the axis relevant to the interpretation of the utterance is the right-left axis. The observer can be the speaker, the addressee or both. The anchor cannot be the chair in this case – interpreted intrinsically, (4) would be false as a description of Fig. 3.

(4) *The ball is to the right of the chair.*

2.4. Absolute FoRs

FoRs in which the anchor is some entity other than the ground or the observer's body can be subdivided into absolute, landmark-based and geomorphic FoRs. An absolute FoR involves an anchor that is an environmental gradient or feature, which, again, is different from the ground object in the spatial representation. More specifically, it involves a set of bearings that are abstracted from such an environmental gradient (cf. Levinson, 2003, pp. 90–91). One basic and possibly universal type of absolute FoR in the vertical dimension is anchored to gravity. However, since it occurs in most, if not all languages without any known exceptions, we will not concern ourselves here with instances of absolute FoRs as they exist in the vertical dimension. Example (5) involves an absolute FoR where a coordinate system is derived from the virtual locations on the horizon where the sun rises and sets, resulting in a coordinate system that distinguishes four cardinal directions, 'east,' 'west,' 'north' and 'south,' on two transversal axes. The ground is the chair, which is different from the anchor, the events of sunset and sunrise in this case.[4] A description involving an absolute FoR is not dependent on the orientation of the observer

[4] It is important to note that not every celestial system is necessarily an absolute system. If the denotations of the terms are subject to subtle seasonal adjustments with the changes in virtual location of sunset and sunrise over the year, the system is landmark-based and intrinsic according to the Nijmegen classification. Also, not every celestial system is necessarily based on (just) sunset and sunrise as systems may be derived, for instance, from the positions of other stars or constellations, or even combinations of various celestial phenomena.

nor on that of the ground, and only a rotation of the ball and chair configuration would invalidate a description involving an absolute FoR (see Fig. 4).

(5) *The ball is north of the chair.*

2.5. Landmark-based FoRs

In landmark-based FoRs, the anchor is a landmark, defined as an entity located in the local environment. The place occupied by this entity defines the head or tail of a vector that serves as one half-axis of the coordinate system. The orientation of the anchor is irrelevant to landmark-based FoRs, whereas object-centered, relative, and geomorphic FoRs (described below) depend on the orientation of their anchors). A landmark may be *ad hoc*, as would be a door or a window present in the discourse context, or a stable entity conventionalized within a community, as would be a prominent building or a neighboring town. Landmark-based FoRs are classified as a subtype of the more broadly defined 'intrinsic' type in the Nijmegen classification. Unlike absolute FoRs, landmark-based systems do not involve abstraction. In example (6), the ball is the figure, the chair is the ground and the landmark that serves as the anchor of the coordinate system is the church. The direction in which the church faces is irrelevant to the validity of the description. However, a change in the location of the figure-ground configuration with respect to the landmark can affect the validity of a description in a landmark-based FoR.

(6) *The ball is toward the church from the chair.*

2.6. Geomorphic FoRs

In geomorphic FoRs, the anchor is an environmental gradient or feature such as a river or an incline, but unlike in cases of absolute FoRs, there is no abstraction involved. Instead, one or more (half-)axes of a geomorphic FoR are copied from the environmental anchor. Unlike in landmark-based FoRs, the orientation of the anchor is of relevance. In example (7), *the ball* is the figure, *the chair* is the ground and the anchor of the coordinate system is a river. Whether (7) is true or not depends on the direction in which the river flows.

(7) *The ball is upstream from the chair.*

To recap, absolute, landmark-based and geomorphic FoRs have different rotational sensitivities. They all coincide in that the anchor is an entity other than the observer's body but the anchor has distinct properties in each of these three types of FoRs. In a relative FoR the coordinate system is anchored to the body of an observer, and projected onto a ground (or a figure in the case of orientation descriptions) that is distinct from the observer's body.

2.7. Motivations for an expanded classification

A schematic view of the FoR classification used by contributors to this issue is provided in Fig. 5 and compared there to other classifications used in the literature.

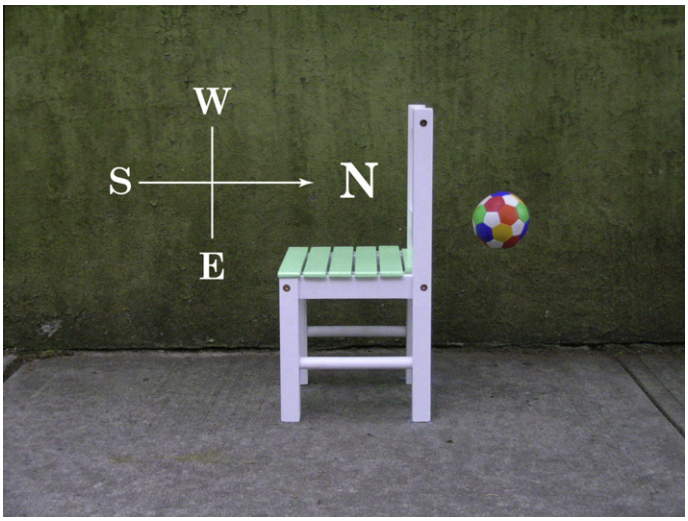

Fig. 4. B&C 3–2.

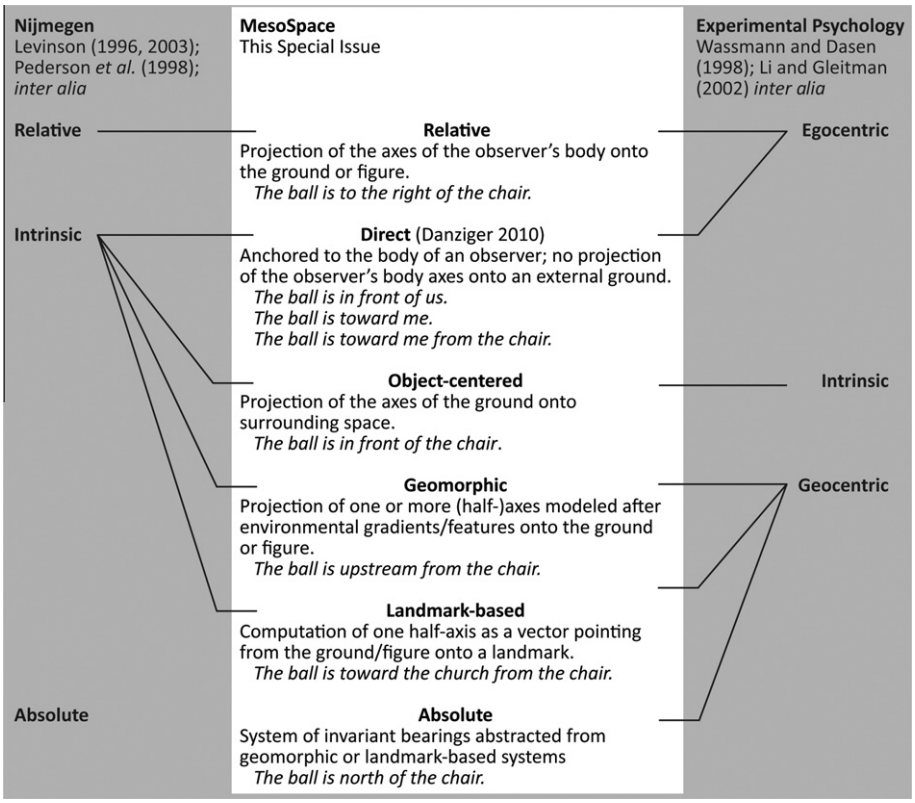

Fig. 5. Comparative table of FoR classifications.

The 'intrinsic' type in the left column is the traditional (pre-Levinson 1996), narrow intrinsic type. As mentioned, the Nijmegen classification extends the label 'intrinsic' to cover not only the direct and object-centered, but also the landmark-based and geomorphic types. This grouping is primarily typologically motivated: the strategies it groups together as 'intrinsic' often co-occur in the same languages and are on the whole much less restricted in their distribution as compared to the relative and absolute types. However, other researchers – in particular, Li and Gleitman (2002) and Li et al. (2005), but also, e.g., Wassmann and Dasen (1998) – group absolute, landmark-based, and geomorphic as 'geocentric', contrasting this against a narrowly defined intrinsic type and an 'egocentric' frame type. The rationale of this classification is the identity of the anchor: frames anchored to the body of the observer are 'egocentric', frames anchored to the ground 'intrinsic', and frames anchored to the environment 'geocentric'. Propositions such as 'The ball is in front of me' are treated as egocentric, rather than intrinsic, in this classification, since they involve a frame anchored to the body of the observer. In contrast, in the Nijmegen classification, such frames are treated as intrinsic, not relative, since they do not involve projection onto an extrinsic ground. Danziger (2010, 2011) introduces the label 'direct' for this type of frame which the author considers as a fourth FoR type alongside the three types of the Nijmegen classification. There is no one-to-one correspondence between relative and egocentric FoRs, just as there is no one-to-one correspondence between absolute and geocentric FoRs. (The absolute type of the Nijmegen classification is assumed to evolve out of landmark-based or geomorphic systems by way of abstraction, a type of metaphorical semantic/conceptual transfer.)

The egocentric-intrinsic-geocentric classification has the advantage of mapping more neatly (as compared to the classification proposed by Levinson et al.) onto the response types of standard experimental tests on FoR use in internal cognition. But it has the disadvantage of cutting across the category boundaries that govern the typological distribution of FoR use in language. Thus, lumping relative and direct FoRs together ignores the fact that, whereas there is no attested case of a language that lacks direct FoRs, by now quite a few examples have been established of languages that lack relative FoRs.[5] Similarly, the landmark-based type is a strong candidate for a universal, whereas the absolute type is clearly lacking in many languages (but see Vázquez Soto, 2011). The fine-grained coding schema used by the MesoSpace researchers makes it possible to analyze the data both according to the relative–intrinsic–absolute Nijmegen classification and according to the egocentric–intrinsic–geocentric classification.

[5] Relative FoRs have been reported to be absent in the Australian languages Arrernte, Guugu Yimithirr, Jaminjung, and Warrwa, the Austronesian languages Kilivila and Longgu, the Mayan languages Tseltal (but see Polian and Bohnemeyer, 2011) and Mopan, and the Khoisan language Hai//om (see Pederson et al. 1998; Levinson, 2003; Levinson and Wilkins, 2006, *inter alia*).

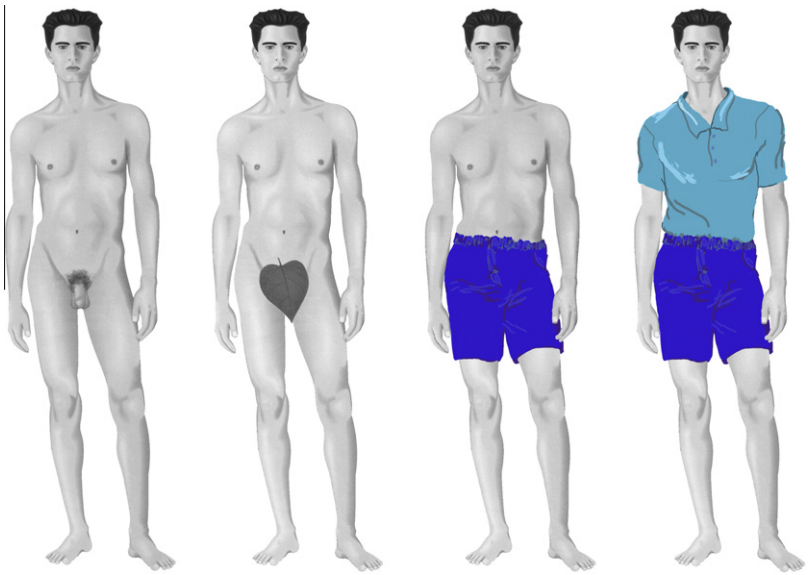

Fig. 6. Subset of human body illustrations used as stimuli.

As stated in the introduction, MesoSpace set out to investigate whether Mesoamerican languages indeed disfavor the use of relative FoRs and make greater use of non-relative FoRs. Whatever the attested preferences are, MesoSpace explores whether they are linked to productive meronymic systems, or the lack thereof, in a language. In particular, the hypothesis predicts that a bias against the relative FoR is motivated by productive meronymy in the language. In order to test this hypothesis, the research methodology described in detail in Section 3 below was designed to develop, for each of the languages in the research sample, a thorough understanding of the part-naming system and of FoR preferences, taking as a point of departure the FoR classification described above. The data collected from the tasks described below in conjunction with the FoR preferences described in the articles of this special issue lay the foundation for further more in-depth studies that test the MesoSpace hypothesis.

3. Methods

MesoSpace research is grounded in the approach to semantic typology developed at the Max Planck Institute for Psycholinguistics (Pederson et al., 1998; Levinson et al., 2003; Bohnemeyer et al., 2007). This approach evolved from work in ethnosemantics, such as Berlin and Kay's (1969) research on the existence of semantic universals in the domain of color terms, which looks at the linguistic organization of a particular semantic domain and investigates to what extent that organization is determined by culture-specific criteria and to what extent it is determined by universal principles of categorization. As such, the Nijmegen method of semantic typology requires a unified set of stimuli applied across a number of linguistic communities following a standard elicitation protocol.[6] The collected data is then transcribed and coded.[7] The MesoSpace set of stimuli was designed following these principles and, for the purposes of addressing the project's research questions, targeted both meronymic systems and FoR preferences in language and cognition. For the sake of brevity, we discuss only the stimuli and related elicitation tasks relevant to the articles presented in this special issue: (1) elicitation tasks focusing on body part terms, artifact meronyms, and meronyms as ground denoting nominals, (2) the Ball and Chair referential communication task, and (3) the New Animals recall memory task (Bohnemeyer, 2008).

3.1. Research and analysis of meronymic systems

Three elicitation tasks were designed to gather data to produce descriptions of the meronymic systems of the languages in our sample. A set of 19 illustrations was assembled for the purpose of eliciting labels for human, animal and plant parts. Most of the illustrations of the human body were borrowed from existing illustrations of nude male and female bodies developed at the Max Planck Institute for Psycholinguistics (Enfield, 2006). Additional versions of these illustrations were created with different degrees of clothing to make the illustrations culturally acceptable in cases where nude figures were not.[8] Fig. 6 shows a sample of these human body illustrations in the stimulus set. Three additional images of animals and one of an insect –

[6] There is an exception to a completely unified approach in the case of the paper on Mopan that is included in this special issue (see Danziger, 2011).

[7] We acknowledge critical views to this approach as stated in Lucy 1997 and Danziger 2001. A priority in the design of the MesoSpace methods was that data needed to be comparable cross-linguistically.

[8] We are thankful to James Eldridge Smythe for creating the clothed versions of the illustrations.

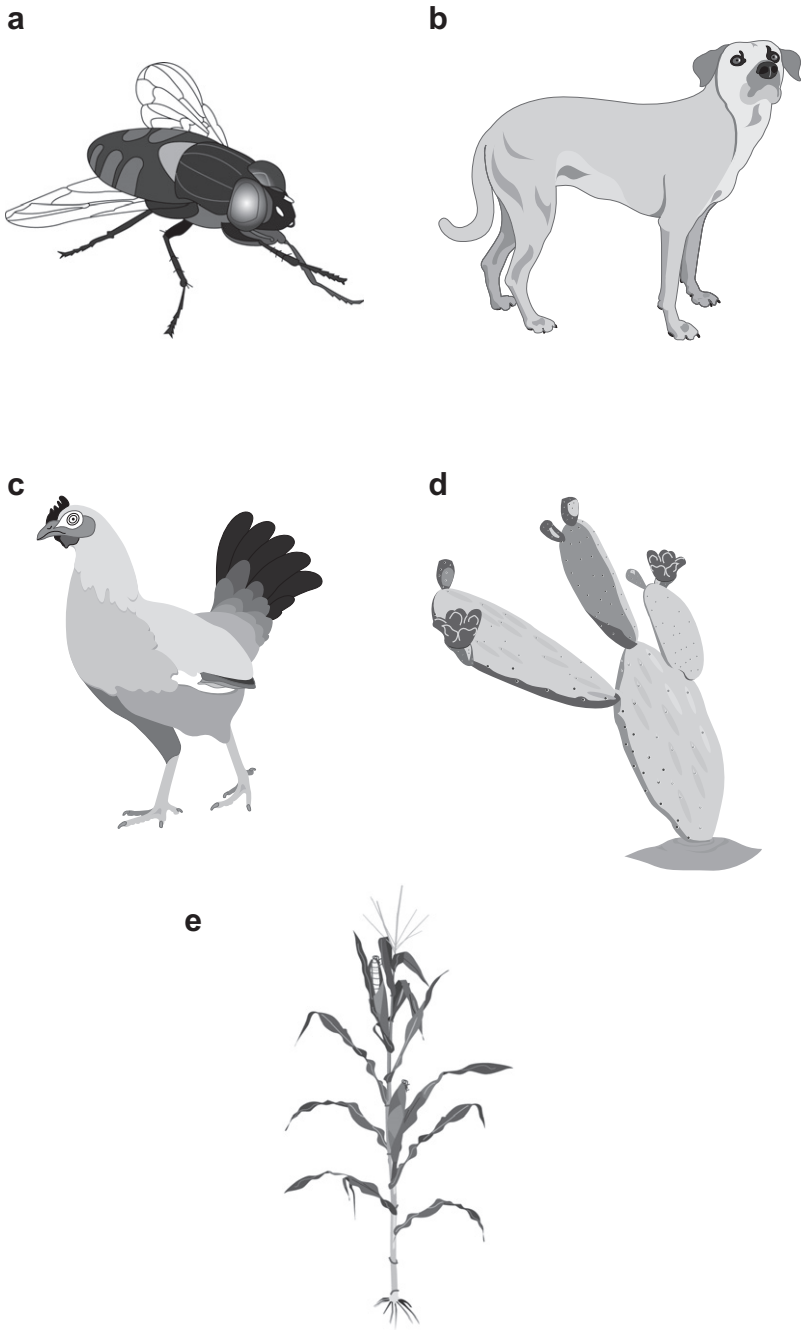

Fig. 7. Subset of animal and plant illustrations used as stimuli.

a dog, a chicken, a fish, a fly – and four images of plants – an avocado, a tree, a corn plant and a cactus – were created as stimuli for elicitation of meronyms beyond those applicable to the human body. Fig. 7 shows a subset of these. These illustrations, generally one per page to allow for adequate workspace, were presented to consultants, who were asked to color identifiable parts and name them. This task was the first of the three to be administered, and was conducted with five to ten native speakers of each of the languages in the sample to develop an extensive inventory of meronyms in each language.

This task was followed by a similar exercise to elicit meronyms using artifacts as stimuli. In addition to documenting which body part terms extend to objects, this second task was designed to discern whether meronyms are assigned to object parts based on object geometry or based on functional properties. For this task, researchers obtained actual objects from within a community's environment, yet in keeping with the semantic typology method, these objects were to be comparable

across communities and therefore languages. Culturally relevant objects were included in the stimulus: a machete, a hoe, a basket, a clay pot, and a griddle. In addition, a car and a television were included in the stimulus as test cases where clashes between geometry-based and function-based terms might occur especially as a result of contact with Spanish, which names parts primarily based on their function. Researchers were provided with coding sheets on which to record the data (Bohnemeyer, 2008).

The third task relevant to meronymic systems was designed to explore the syntactic and morphological properties of expressions of location with regard to parts. More specifically, consultants in this task were asked to locate an improvised figure with respect to actual objects taken from those provided by the illustrations, or to a particular part of an object. For instance, a ball of clay would be placed somewhere on a machete as a stimulus to elicit an answer to the question 'Where is the piece of clay?'. The data obtained through this task consist of locative constructions. These data serve to make two main descriptive observations. One, whether meronyms, and mainly body part terms, that denote the ground with regard to which a figure is located, can occur alone or whether they combine with an adposition or a second meronym in expressions of location. And two, whether the syntactic and morphological properties are the same or not in expressions of topological relations as compared with projective relations.

To summarize, two tasks were used to elicit body and object part terms to produce an inventory of meronyms and their extensions in each language, based on a uniform set of stimuli. A third task explored the use of body part terms as ground-denoting nominals with the purpose of understanding the structural properties of locative constructions in each language. Together, these sets of data provide the foundation for addressing the MesoSpace hypothesis regarding the proposed connection between the presence of meronymic systems and a bias against the use of the relative FoR.

3.2. Frames of reference in discourse

Two tasks were conducted to explore FoR preferences, a linguistic and a non-linguistic task. This section explains the linguistic task, intended to identify the types of FoRs used in discourse involving spatial descriptions of a figure located within a space projected from a ground in small scale (or tabletop) space (as opposed to geographic scale space).

For the purpose of the task, a set of 48 photographs named the Ball and Chair (B&C) pictures (Bohnemeyer, 2008) was designed as an improvement of the Men & Tree (M&T) matching game designed by Eve Danziger and Eric Pederson of the Cognitive Anthropology Research Group at the Max Planck Institute for Psycholinguistics (Danziger, 1992). Both B&C and M&T are referential communication tasks designed to explore FoR use in discourse. As the name suggests, M&T featured photographs of a toy man and a toy tree in different configurations. This stimulus had several shortfalls that were addressed in the design of B&C. First, in M&T, the tree was intended to function as ground, and the man was intended to function as the figure. However, the toy man was too salient as a referential ground and was often interpreted by speakers as the ground. The B&C pictures, in contrast, feature a small ball as figure and a significantly larger chair as the ground. The use of these two objects eliminates ambiguity as to which object is to serve as the figure and which is to serve as the ground. Second, the tree in M&T lacked an inherent orientation which hampered the use of an intrinsic FoR. To solve this problem, a chair was used in B&C because it has a clear front, back and sides and therefore an inherent orientation for speakers to use in describing the location of the ball with respect to the chair. The use of real objects in the B&C picture series offsets a third problem in the M&T series: the toy tree and men were representations of real objects within the representational format of a photograph, which further complicated the task. While both tasks use photographs for the purpose of ensuring uniformity in the stimuli presented to consultants, the B&C photographs show real objects. One additional shortfall of M&T as it was implemented was that the pictures were removed from the array as they were matched, thereby reducing the number of possible contrasts as the exercise progressed. In B&C, the director was asked to mark with a coin the photographs that were matched, and the matcher was asked to not move any of the photographs in any given set in order to maintain all contrasts possible throughout the trial.

The B&C pictures are organized into four sets of 12 photos for a total of 48 photos (one set of 48 pictures for each consultant); each set contains various contrasts in the configuration and orientation of the ball and the chair, as depicted in Table 2 (see Figs. 8–15).

As a referential communication task, B&C involved two speakers per trial, one acting as director and the other acting as matcher. Both speakers are seated side-by-side at a table, both facing the same direction. A screen is set between the two speakers to prevent any eye contact between them and so that they cannot rely on gesture to solve the task. Each trial involves placing one set of 12 photos on the table at a time in front of each of the speakers. The sets were presented sequentially, meaning all participants worked with set 1 during the first trial, followed by set 2 in the second trial and so on, until they completed all four sets. However, within each trial, the photos of the set in turn were placed on the table before each speaker in semi-random order within a 3×4 grid, and also not in the same order on both tables as shown in Fig. 16.

The director is then asked to select a photo and describe it to the matcher, who in turn must select the same photo from within his or her own set, based on the oral description provided by the director. Each experimenter was to provide a standardized set of directions to each dyad of native speaker consultants in the target language so as to ensure uniform explanation of the task across all of the language communities in the language sample. The protocol is given below in English:

> This is a game with photographs. You each have the same set of pictures, and the game is for one person to choose pictures one by one and to tell the other person which picture s/he has chosen, WITHOUT LOOKING, just with language, try

Table 2
Configurational contrasts in the ball and chair stimulus.

Set	Photo Pairing		Set	Photo Pairing	
1	*Figure 8. B&C 1.2*	*Figure 9. B&C 1.10*	3	*Figure 12. B&C 3.9*	*Figure 13. B&C 3.10*
2	*Figure 10. B&C 2.8*	*Figure 11. B&C 2.10*	4	*Figure 14. B&C 4.5*	*Figure 15. B&C 4.6*

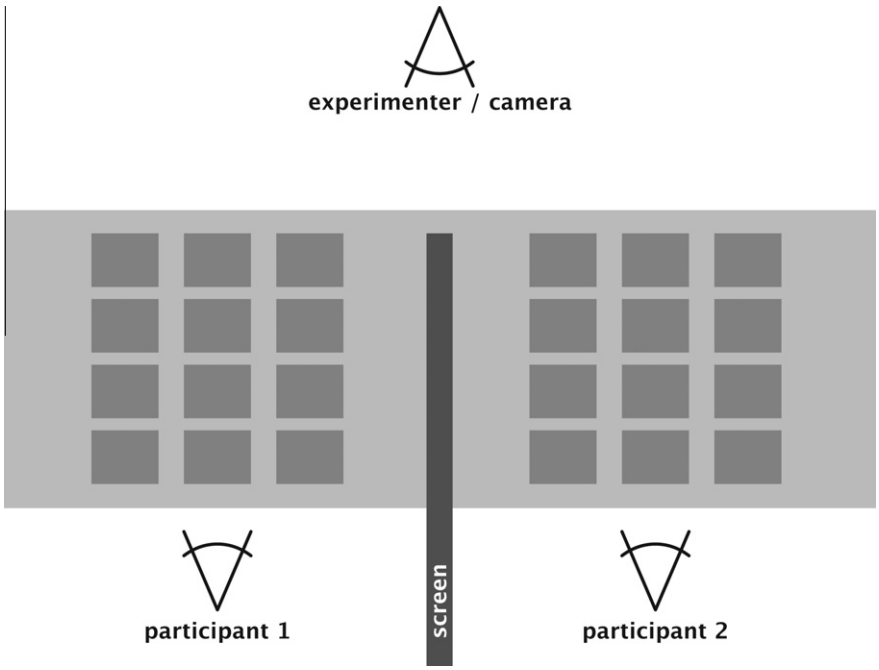

Fig. 16. Ball and chair game layout.

not to point or gesture, so that the other person can pick out the one that matches from their own set. You can talk back and forth as much as you want, for as long as it takes you to make sure you have picked the matching photo. I'll show you how to do it while you play the first game with this set (Bohnemeyer, 2008, p. 31).

There was also a standardized protocol as to how each experimenter was to record accurate matches as well as mismatches. The task was run with at least five dyads, and with each dyad, the interaction was digitally audio recorded with individual tracks for each speaker to ensure adequate audio quality. As a backup, each trial was also video recorded (for most, but not all of the languages), and a pen-and-pencil record of the responses was kept as well.

3.2.1. Ball and chair data coding and analysis

All recorded data was transcribed and coded using a uniform coding sheet. The coded data included two types of predication: the first being the description of the orientation of the chair, the second being the location of the ball with respect to

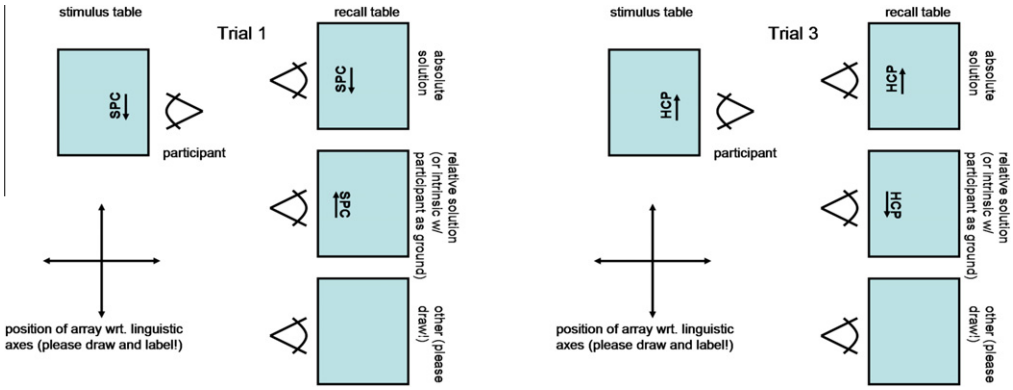

Fig. 17. Sample new animals arrays. Adapted from Bohnemeyer (2008). Key: s, sheep; p, pig; c, cow; h, horse.

the chair. In both cases, two analytical steps were taken. First, the relator was isolated – whether it be a meronym, adposition, adverb, verbal affix, "satellite" or a combination of any of these – then the predication and the image were analyzed together to determine the FoR used by the director to specify the configuration of the ball and the chair. It is assumed that the director's description is truthful of the picture at issue (descriptions that appear to be false are excluded from the analysis). The range of FoR types that make the description true in the scenario shown in the picture is then determined with the help of native speaker participants and noted.

Ultimately, the descriptive product of this exercise was a spreadsheet listing all occurring spatial relators isolated in a designated column, and coded according to the FoR with which the spatial relators occurred. This constitutes an extensive inventory of spatial relators and FoR preferences in discourse from descriptions of objects located in small scale space for each of the languages being investigated. Subsequently, the data were analyzed quantitatively to determine which FoRs were used and the number of photo descriptions that relied on the use of each of the FoRs attested. Each contributing author provides details regarding the quantification of the collected data and explains the implications that such data have to the overall research question. The frequency with which each frame type was used by the speakers of a given language or variety is usually stated in terms of the percentage of the picture descriptions that make use of that frame type. However, descriptions may involve multiple propositions, which may require different frames for their interpretations. An example of a single locative description asserting two propositions which rely on distinct frames is 'The ball is east of the chair, right in front of it'. The first proposition ('The ball is east of the chair') maps into an absolute frame, the second ('The ball is right in front of the chair') into a relative or intrinsic one. Authors who did not explicitly make this distinction report frequencies in terms of percentages of propositions, although they usually state them as frequencies of descriptions for simplicity's sake.

3.3. Frames of reference in cognition

As mentioned in Section 1, one of the objectives of the MesoSpace project and therefore, of the research carried out by the contributors to this special issue, is to examine FoR preferences in language as well as in cognition. In this section we provide an overview of the New Animals (NA) memory recall task (Bohnemeyer, 2008). This task is intended to test the types of FoRs consultants use when asked to recreate an array of three toy animals under a 180° rotation. The task is closely based on the Animals in a Row (AIAR) task developed by Steve Levinson and Bernadette Schmitt of the Cognitive Anthropology Research Group at the Max Planck Institute for Psycholinguistics (Levinson and Schmitt, 1993). AIAR was designed to test the use of a relative *versus* absolute FoRs in memory recall by asking consultants to reconstruct an array of toy animals on a table, based on an array presented to them on a separate table. With the consultant standing between the two tables, reconfiguring the toy animal array required a 180° rotation, and memorizing both the order of the toys as well as their orientation.

The NA task is administered as follows. As mentioned above, a consultant is placed in between two tables that are parallel to each other and located at a reasonable distance from one another. The following procedure, standard to all researchers, is then provided to the consultants in their native language. First, consultants are familiarized with the four toy animals and are asked to identify them in their own language. The consultant is then presented with an array of three of the four toy animals placed on one of the tables, the one that serves as the stimulus table, all facing the same direction. This is illustrated in Fig. 17 which is a segment from the standard NA coding sheet showing two of a total of six arrays presented to each participant in a trial (Bohnemeyer, 2008). They are then given the following instructions in their native language:

> Look carefully. Remember just how it is! I am going to take it away and ask you to make it again. OK, have you remembered it/are you ready?

The consultant is given time to memorize the array, which is then taken off the table. After a wait of between 30 and 60 seconds, the consultant is given the three animals plus one additional animal, all together in a bunch to avoid presenting

an order or orientation of the animals. The researcher then instructs the consultant, again in their native language, "Now make it again!". The consultant then selects the three animals that were in the stimulus array, and repositions them on the opposite table, the one that serves as the response table. Based on the orientation of the consultant's response array and order of animals, we coded the response.

NA involved six trials per consultant to allow for changes in orientation of the stimulus arrays to occur in equal numbers. The task was run with at least 16 consultants in each language community. The order of the trials was switched, and for half the consultants, the order of the trials was reversed to allow for additional alternations in the orientation of the animals. No audio recording was necessary but NA trials were video recorded, unless there were cultural issues which prevented it. In addition, all responses were recorded on the standard coding sheet as trials were administered.

Both AIAR and NA have a drawback in that they only allow for two types of response patterns to emerge. One is the response pattern consistent with the use of a relative or direct FoR, both observer-centered FoRs, evident by a 180° rotation of the animal array on the response table. The second pattern is one consistent with an absolute, landmark-based or geomorphic FoR, in which the animal array maintains its orientation after the consultant has undergone a 180° rotation. Any object-centered responses are realized as either of these types of response patterns or a combination thereof (Danziger, 2001). In her contribution to this issue, Danziger showcases a new non-linguistic task designed to circumvent that limitation. Ultimately however, MesoSpace proposes primarily that languages whose speakers show a bias against responses consistent with relative FoRs in the B&C task will also show a bias against observer-centered responses in the NA task. The New Animals task can therefore be used to investigate this possible parallel in FoR preferences in discourse and in cognition.

To summarize, four tasks are relevant to the articles included in this special issue: First, a three-part investigation into the system of meronyms in the languages in the study sample; second, the B&C referential communication task, which provided detailed insights into the system of spatial relators available for use in locative descriptions, and FoRs preferred by speakers of each language as they solved this task; third, the NA memory recall task, and fourth, the 3D Mirror-Image task, designed by Danziger (2011).

4. Discussion and summary

The research conducted on ten different languages and presented in the following articles makes a significant contribution to our understanding of FoR preferences in discourse in the Mesoamerican *sprachbund*. A comparison of the contributions to this special issue indicates, for instance, that there can be clear preferences for one type of FoR *versus* another as documented in Juchitán Zapotec (see Pérez Báez, 2011), whose speakers overwhelmingly favor the use of the absolute FoR and use the object-centered FoR with high frequency to the point where other FoRs are either only marginally attested or simply nonexistent in the data. Yet, FoR preferences are not this definitive in several other languages researched. Notably, the Yucatec data show that there is no default FoR that can be identified, and that as speakers have various FoRs available to them for the task, they frequently switch from one FoR to another even within a single description (see Bohnemeyer, 2011). Somewhere in between are Sumu-Mayangna and Seri whose speakers make use of various FoRs but do show a preference for the direct FoR in the case of Sumu-Mayangna, and of the object-centered and the direct FoRs in the case of Seri (see Eggleston and Benedicto, and O'Meara, respectively, 2011).

As was discussed in detail, the data collected by MesoSpace researchers motivated the use of a six-way FoR classification (cf. Section 2). As was just mentioned, Seri (see O'Meara, 2011) and Sumu-Mayangna (see Eggleston and Benedicto, 2011) exhibited a preference for the direct FoR. The need emerged to maintain a distinction between an absolute FoR, where an asymmetry of space is derived and abstracted from an environmental gradient such as cardinal directions, and a geomorphic FoR, which involves no abstraction from environmental gradients or features. Data from Meseño Cora and Tarascan show the importance of this distinction (see Vázquez Soto (2011) and Capistrán (2011), respectively). In Cora, for instance, the linguistic expressions used in describing the orientation and location of objects in space seem to point to a celestial absolute system. Yet, the analysis conducted on the basis of a fine-grained classification of FoR types suggests that the system is in fact a geomorphic one. The B&C data from Ayutla Mixe (Romero Méndez, 2011) do not show any instances of descriptions involving absolute or geomorphic FoRs, but speakers did make extensive use of landmark-based FoRs. An interesting feature about this in Ayutla Mixe is that speakers choose *ad hoc* reference points rather than conventionalized entities, even if there were plenty of geographical features that could have been used as an anchor of an FoR.

Danziger (2011) reports findings from a new mirror-image task. The author compares linguistic data from Mopan on FoR preferences with the way that Mopan speakers perform in a non-linguistic task. The results show that speakers overwhelmingly prefer using a 'binary' FoR, i.e. one in which the ground functions as anchor and the FoR involves only two entities (either direct or object-centered), in linguistic tasks, and data from the new non-linguistic task show that Mopan speakers categorize three-dimensional objects in the same way as they categorize their mirror-image counterparts (cf. Danziger and Pederson, 1998). This indicates an alignment of linguistic and non-linguistic preferences in FoRs. Danziger's results are of particular relevance to MesoSpace as the mirror-image task is able to give non-linguistic results that are sensitive to the use of FoRs in which the same entity functions as ground and anchor, whereas results from NA are only useful in providing non-linguistic correlates for frames in which a third entity and not the ground serves as anchor (relative, absolute, landmark-based and geomorphic).

Other authors also report an alignment in FoR preferences in linguistic and non-linguistic tasks. In Sumu-Mayangna (Eggleston and Benedicto, 2011), a preference in NA for response patterns consistent with the non-egocentric frames in which a third entity, and not the ground, serves as anchor (absolute, landmark-based and geomorphic) is in line with trends observed in linguistic use. In Juchiteco (Pérez Báez, 2011), the almost non-existent use of the relative and direct FoRs in B&C data is in alignment with the striking absence of egocentric response patterns in the non-linguistic task.

Although it is not the focus of most of the articles in this special issue, questions relevant to the long history of intense contact between indigenous languages of the Americas and colonial languages have emerged. In San Ildefonso Tultepec Otomí, the Spanish loanword *lado* is often used in locative descriptions and plays a crucial role in the use of the relative FoR in the B&C task (see Hernández-Green et al., 2011). Language contact is also of relevance to the analysis of FoR preferences in Sumu-Mayangna, as evidenced by the role that the loanword *sait* 'side' from English – not Spanish – plays in FoR interpretation. Polian and Bohnemeyer (2011) show that there continues to be a bias against the relative FoR in Tseltal (following data presented in previous studies, e.g., Brown and Levinson, 2004; Brown, 2006). However, an increase in the use of the relative FoR is apparent as compared to the rates of its use in previous studies, pointing to the possibility that this increase might be the result of contact with Spanish. Further potential evidence of contact with Spanish can be seen in the data from Ayutla Mixe (Romero Méndez, 2011), where some of the speakers solving the B&C task tried to use utterances involving relative FoRs even though there was significant confusion as to the denotation of the terms *akä'äny* 'left hand' and *anä'äjny* 'right hand'.

The data collected from four Tseltal-speaking communities further show that FoR preferences were community-specific (Polian and Bohnemeyer, 2011). In particular, the frequency of use of the absolute FoR varied widely across the three communities. This puts into question any previous claims about a general preference of the absolute FoR in Tseltal, and any assumptions that speakers of varieties of one single language might use the same strategies in spatial description.[9]

As for the larger hypothesis driving the MesoSpace study – that meronymy may be a linguistic predictor of FoR preferences as it may correlate with a bias against the relative FoR – support comes from all languages in the MesoSpace sample. In no case was the relative FoR the preferred FoR type in either orientation or location descriptions. There were some cases where the relative FoR was used at percentages that were not negligible. Such is the case of Cora and Yucatec, where the use of the relative FoR hovers around 17% in descriptions of orientation (see Vázquez Soto (2011) and Bohnemeyer (2011), respectively). Also in Yucatec, the relative FoR was used in 18% of the location descriptions. Again, in neither case was the relative FoR the preferred strategy. In other cases, the bias against the use of the relative FoR is much more dramatic. In the case of Tarascan (Capistrán Garza, 2011), the relative FoR was used in 1% of orientation descriptions and 4% of location descriptions. Similarly, in Juchiteco (Pérez Báez, 2011), the relative FoR was not used at all in orientation descriptions and was only used in 3% of location descriptions. This last case is especially relevant to the hypothesis at hand, given that significant work has now been done to show that Juchiteco has a highly productive system of meronymy, which provides a textbook case of a correlation between productive meronymy and a bias against the use of the relative FoR.

Each article in this special issue places the language-specific analysis within the context of an improved classification of FoR types. While not all papers touch on each of the issues explained in this closing discussion, all explain in exhaustive detail, the preferences in FoR use documented in the language. On the whole, the articles that follow provide much needed description of eight Mesoamerican languages and two languages spoken near to the Mesoamerican cultural area, which will now enable future research and analysis on various topics of relevance and interest to a wide scientific audience: the correlation between meronymy and FoR preferences as proposed by the MesoSpace project, the correlations between linguistic and non-linguistic processes, and the role that various factors – social, cultural, environmental, and language contact – may or may not have on shaping spatial conceptualization in humans.

5. Role of the funding source

The research on Tseltal and Yucatec (Maya), Ayutla Mixe (Mixe-Zoquean), Otomí and Juchitán Zapotec (Otomanguean), Meseño Cora (Uto-Aztecan) and Tarascan (isolate), Seri (isolate) and Sumu-Mayangna (Misumalpan) introduced in this article is based upon work supported by the National Science Foundation (Award No. BCS-0723694) *Spatial language and cognition in Mesoamerica* (PI J. Bohnemeyer). The research on Mopan (Maya) was supported by an award from the University of Virginia. Much support was provided by the Centro de Investigaciones y Estudios Superiores en Antropología Social (CIESAS) as MesoSpace co-sponsors in the organization of team-wide workshops. Any additional funding provided to authors is indicated in individual articles.

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[9] A related discussion can be found in Pederson (1993) which describes rural and urban Tamil-speaking communities with different FoR preferences: the rural community with an overwhelming preference for absolute FoRs and the urban community with a strong preference for relative FoRs.

Study of Indigenous Languages of the Americas. The comments we received from that session were of great value and very useful as the research was prepared for publication in this special issue. The MesoSpace material has been reviewed at various times by colleagues at the Max Planck Institute for Psycholinguistics, Steve Levinson, Penny Brown, Angela Terrill, Niclas Burenhult, Olivier Le Guen and Mark Sicoli, to whom we are grateful. Thank you to the anonymous reviewers who reviewed the articles in this special issue. Many thanks also go out to Eve Danziger and Paulette Levy for their participation and feedback during the first MesoSpace workshop. In addition, we are especially grateful to Eve Danziger for her very useful comments on preliminary drafts of this paper.

References

Asch, S.E., Witkin, H.A., 1948. Studies in space orientation: II. Perception of the upright with displaced visual fields and with body tilted. Journal of Experimental Psychology 38, 325–327.
Becerril, G.M.L., Miranda, J.V., Herrera, C.S., 2006. El sistema de referencia en ombeayiüts (huave) y algunas implicaciones deícticas [The frame of reference in Ombeayiüts (Huave) and some deictic implicatures]. Paper presented at the IX Encuentro Internacional de Lingüistica en el Noroeste, Sonora, Mexico, November.
Berlin, B., Kay, P., 1969. Basic Color Terms. University of California Press, Berkeley.
Bohnemeyer, J., 2011. Spatial frames of reference in Yucatec: Referential promiscuity and task-specificity. Language Sciences 33 (6), 892–914.
Bohnemeyer, J., 2008. Elicitation task: frames of reference in discourse – the Ball & Chair pictures. In: Pérez Báez, G. (Ed.), MesoSpace: Spatial language and Cognition in Mesoamerica. 2008 Field Manual. University at Buffalo, Suny, pp. 34–37, <http://www.acsu.buffalo.edu/~jb77/MesoSpaceManual2008.pdf>.
Bohnemeyer, J., Stolz, C., 2006. Spatial reference in Yukatek Maya: a survey. In: Levinson, S.C., Wilkins, D.P. (Eds.), Grammars of Space. Cambridge University Press, Cambridge, pp. 273–310.
Bohnemeyer, J., Enfield, N.J., Essegbey, J., Ibarretxe-Antuñano, I., Kita, S., Lüpke, F., Ameka, F.K., 2007. Principles of event representation in language: the case of motion events. Language 83 (3), 495–532.
Bowerman, M., Levinson, S.C. (Eds.), 2001. Language Acquisition and Conceptual Development. Cambridge University Press, Cambridge.
Brown, P., 2006. A sketch of the grammar of space in Tzeltal. In: Levinson, S.C., Wilkins, D.P. (Eds.), Grammars of Space: Explorations in Cognitive Diversity. Cambridge University Press, Cambridge, pp. 230–272.
Brown, P., Levinson, S.C., 2004. Frames of spatial reference and their acquisition in Tenejapan Tzeltal. In: Assmann, A., Gaier, U., Trommsdorff, G. (Eds.), Zwischen Literatur und Anthropologie: Diskurse, Medien, Performanzen. Gunter Narr, Tübingen, pp. 285–314.
Brugman, C., 1983. The use of body-part terms as locatives in Chalcatongo Mixtec. Survey of California and Other Indian Languages 4, 239–290.
Brugman, C., Macaulay, M., 1986. Interacting semantic systems: Mixtec expressions of location. In: Nikiforidou, V., VanClay, M., Niepkuj, M., Feder, D. (Eds.), Proceedings of the Twelfth Annual Meeting of the Berkeley Linguistic Society. Berkeley Linguistics Society, Berkeley, pp. 315–327.
Campbell, L., Kauffman, T., Smith-Stark, T.C., 1986. Meso-America as a linguistic area. Language 62 (3), 530–570.
Capistrán Garza, A., 2011. Locative and orientation descriptions in Tarascan: topological relations and frames of reference. Language Sciences 33 (6), 1006–1024.
Casad, E.H., 1982. Cora locationals and structured imagery. Ph.D. dissertation, University of California, San Diego.
Clark, H., 1973. Space, time, semantics, and the child. In: Moore, T. (Ed.), Cognitive Development and the Acquisition of Language. Academic Press, New York, pp. 27–63.
Danziger, E., 2011. Distinguishing three-dimensional forms from their mirror-images: Whorfian results from users of intrinsic frames of linguistic reference. Language Sciences 33 (6), 853–867.
Danziger, E., 2010. Deixis, gesture, and cognition in spatial frame of reference typology. Studies in Language 34 (1), 167–185.
Danziger, E., 2001. Cross-cultural studies in language and thought: is there a metalanguage? In: Moore, C.C., Mathews, H.F. (Eds.), The Psychology of Cultural Experience. Cambridge University Press, Cambridge, pp. 199–222.
Danziger, E., 1996. Parts and their counter-parts: social and spatial relationships in Mopan Maya. The Journal of the Royal Anthropological Institute 2 (1), 67–82.
Danziger, E., 1992. Photo-photo matching games: men and tree. In: Danziger, E. (Ed.), 'Manual' for the Space Stimuli Kit 1.0. Max Planck Institute for Psycholinguistics, Nijmegen, pp. 7–11.
Danziger, E., Pederson, E., 1998. Through the looking-glass: literacy, writing systems and mirror-image discrimination. Written Language and Literacy 1 (2), 153–164.
de León, L., 1994. Exploration in the acquisition of geocentric location by Tzotzil children. Linguistics 32, 857–884.
Eggleston, A., Benedicto, E., 2011. Spatial frames of reference in Sumu-Mayangna. Language Sciences 33 (6), 1047–1072.
Enfield, N.J., 2006. Elicitation guide on parts of the body. Language Sciences 28 (2–3), 148–157.
Friedrich, P., 1971. The Tarascan suffixes of locative space. Language Science Monographs, vol. 9. Indiana University, Bloomington.
Friedrich, P., 1970. Shape in grammar. Language 46 (2), 379–407.
Friedrich, P., 1969. On the MEANING of the Tarascan suffixes of space. IJAL Memoir 23.
Goldap, C., 1992. Morphology and semantics of Yucatec space relators. In: de León, L., Levinson, S.C. (Eds.), Spatial description in Mesoamerican languages. Special issue of Zeitschrift für Phonetik, Sprachwissenschaft und Kommunikationsforschung 45 (6), 612–625.
Gumperz, J.J., Levinson, S.C. (Eds.), 1996. Rethinking Linguistic Relativity. Cambridge University Press, Cambridge.
Hernández-Green, N., Palancar, E.L., Hernández, S., 2011. The loanword *lado* in Otomi spatial descriptions. Language Sciences 33 (6), 961–980.
Hollenbach, B.E., 1987. Semantic and syntactic extensions of body-part terms in Mixtecan. Paper presented at the 86th Annual Meeting of the American Anthropological Association. XXVIth Conference on American Indian Languages. Otomanguean, Chicago.
Hollenbach, B.E., 1988. Semantic and syntactic extensions of Copala Trique body-part nouns. Homenaje a Jorge Suarez. México, Colegio de México, México.
Kant, I., 1991 [1768]. On the first ground of distinction of regions of space (Von dem ersten Grunde des Unterschiedes der Gegenden im Raume). In: van Cleve, J., Frederick, R.E. (Eds.), The Philosophy of Right and Left. Kluwer, Dordrecht, pp. 27–33 [1768].
Lee, P., 1996. The Whorf Theory Complex: A Critical Reconstruction. John Benjamins, Amsterdam.
Le Guen, O., 2006. L'organisation et l'apprentissage de l'espace chez les Mayas Yucatèques du Quintana Roo, Mexique. Unpublished Ph.D. dissertation thesis, Université Paris X-Nanterre.
Levinson, S.C., 1994. Vision, shape, and linguistic description: Tzeltal body-part terminology and object description. In: Levinson, S.C., Haviland, J.B. (Eds.), Space in Mayan Languages (special issue of Linguistics 32 (4), 791–856).
Levinson, S.C., 1996. Frames of reference and Molyneux's Question: crosslinguistic evidence. In: Bloom, P., Peterson, M.A., Nadel, L., Garrett, M.F. (Eds.), Language and Space. MIT Press, Cambridge, pp. 109–169.
Levinson, S.C., 1998. Studying spatial conceptualization across cultures. My space or yours: beyond the individual in the cognitive study of language. In: Danziger, E. (Ed.), Special issue of Ethos: Journal of the Society for Psychological Anthropology, pp. 7–24.
Levinson, S.C., Brown, P., 1994. Immanuel Kant among the Tenejapans: anthropology as empirical philosophy. Ethos 22 (1), 3–41.
Levinson, S.C., Kita, S., Haun, D.B.M., Rasch, B.H., 2002. Returning the tables: language affects spatial reasoning. Cognition 84 (2), 155–188.
Levinson, S.C., 2003. Space in Language and Cognition: Explorations in Cognitive Diversity. Cambridge University Press, Cambridge.

Levinson, S.C., Meira, S.The Language Cognition Group, 2003. 'Natural concepts' in the spatial topological domain – adposition meanings in crosslinguistic perspective. Language 79, 485–516.
Levinson, S.C., Schmitt, B., 1993. Animals in a row. In: Cognition and Space Kit Version 1.0. Cognitive Anthropology Research Group at the Max Planck Institute for Psycholinguistics, Nijmegen, pp. 65–69.
Levinson, S.C., Wilkins, D.P., 2006. The background to the study of the language of space. In: Levinson, S.C., Wilkins, D.P. (Eds.), Grammars of Space: Explorations in Cognitive Diversity. Cambridge University Press, Cambridge, pp. 1–23.
Levy, P., 2006. Los sustantivos relacionales en el totonaco de Papantla [Relational nouns in Papantla Totonac]. Paper presented at the IX Encuentro Internacional de Lingüistica en el Noroeste, Sonora, Mexico.
Levy, P., 1999. From 'part' to 'shape': incorporation in Totonac and the issue of classification by verbs. International Journal of American Linguistics 65 (2), 127–175.
Li, P., Gleitman, L.R., 2002. Turning the tables: spatial language and spatial reasoning. Cognition 83 (3), 265–294.
Li, P., Abarbanell, L., Papafragou, A., 2005. Spatial reasoning skills in Tenejapan Mayans. In: Bara, B.G., Barsalou, L., Bucciarelli, M. (Eds.), Proceedings of the Twenty-sixth Annual Conference of the Cognitive Science Society. Erlbaum, Hillsdale, pp. 1272–1277.
Lillehaugen, B., 2006. Expressing Location in Tlacolula Valley Zapotec. Ph.D. dissertation, University of California, Los Angeles.
Lucy, J.A., 1992. Language Diversity and Thought: A Reformulation of the Linguistic Relativity Hypothesis. Cambridge University Press, Cambridge.
Lucy, J.A., 1997. Linguistic relativity. Annual Review of Anthropology 26, 291–312.
MacLaury, R.E., 1989. Zapotec body-part locatives: prototypes and metaphoric extensions. International Journal of American Linguistics 55, 119–154.
Majid, A., Bowerman, M., Kita, S., Haun, D.B.M., Levinson, S.C., 2004. Can language restructure cognition? The case for space. Trends in Cognitive Sciences 8 (3), 108–114.
Miller, G.A., Johnson-Laird, P.N., 1976. Language and Perception. Belknap Press of Harvard University Press, Cambridge.
O'Meara, C., 2011. Frames of reference in Seri. Language Sciences 33 (6), 1025–1046.
Pederson, E., 1993. Geographic and manipulable space in two Tamil linguistic systems. In: Frank, A., Campari, I. (Eds.), Spatial Information Theory. Springer, Berlin, pp. 294–311.
Pederson, E., 2003. How many reference frames? In: Freksa, C., Brauer, W., Habel, C., Wender, K.F. (Eds.), Spatial Cognition III: Routes and Navigation, Human Memory and Learning, Spatial Representation and Spatial Learning. Springer, Berlin, pp. 287–304.
Pederson, E., Danziger, E., Wilkins, D.P., Levinson, S.C., Kita, S., Senft, G., 1998. Semantic typology and spatial conceptualization. Language 74 (3), 557–589.
Pérez Báez, G., 2011. Spatial frames of reference preferences in Juchitán Zapotec. Language Sciences 33 (6), 943–960.
Pérez Báez, G., in press. Semantics of body part terms in Juchiteco locative descriptions. In: Sonnenschein, A.H., Lillehaugen, B.L. (Eds.), Expressing Location in Zapotec. LINCOM, Munich.
Piaget, J., Inhelder, B., 1956. The Child's Conception of Space. Routledge and Kegan Paul, London.
Polian, G., Bohnemeyer, J., 2011. Uniformity and variation in Tseltal reference frame use. Language Sciences 33 (6), 868–891.
Rock, I., 1992. Comment on Asch and Witkin's "Studies in Space Orientation II". Journal of Experimental Psychology 121 (4), 404–406.
Romero Méndez, R., 2011. Spatial frames of reference and topological descriptions in Ayutla Mixe. Language Sciences 33 (6), 915–942.
Senft, G., 1997. Introduction. In: Senft, G. (Ed.), Referring to Space: Studies in Austronesian and Papuan Languages. Clarendon Press, Oxford, pp. 1–38.
Stross, B., 1976. Tzeltal anatomical terminology: semantic processes. In: McClaran, M. (Ed.), Mayan Linguistics, vol. 1. American Indian Studies Center, University of California, Los Angeles.
Talmy, L., 2000. Toward a Cognitive Semantics, vol. I. The MIT Press, Cambridge.
Vázquez Soto, V., 2011. "Uphill" and "downhill" in Meseño Cora: a geomorphic frame of reference in two strong axes. Language Sciences 33 (6), 981–1005.
Whorf, B.L., 1939 [1956]. Relation of habitual thought and behavior to Language. In: Carroll, John B. (Ed.), Language, Thought, and Reality: Selected Writings of Benjamin Lee Whorf. MIT Press, Cambridge, pp. 134–159 [1956].
Wassmann, J., Dasen, P.R., 1998. Balinese spatial orientation: some empirical evidence for moderate linguistic relativity. Journal of the Royal Anthropological Institute 4 (4), 689–711.