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Principal Investigator: Bohnemeyer, Juergen .

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Organization: SUNY Buffalo

Submitted By:

Bohnemeyer, Juergen - Principal Investigator

Title:

Spatial Language and Cognition in Mesoamerica

Project Participants

Senior Personnel

> **Name:** Bohnemeyer, Juergen
> **Worked for more than 160 Hours:**   Yes
> **Contribution to Project:**

> **Name:** O'Meara, Carolyn
> **Worked for more than 160 Hours:**   Yes
> **Contribution to Project:**
> Research assistant for project from August 2008 - December 2009.
> Conducted fieldwork on Seri.

> **Name:** P?rez B?ez, Gabriela
> **Worked for more than 160 Hours:**   Yes
> **Contribution to Project:**
> Research assistant for project from March 28, 2008 - August 29, 2008.
> Conducted fieldwork on Zapotec.

> **Name:** Romero Mendez, Rodrigo
> **Worked for more than 160 Hours:**   Yes
> **Contribution to Project:**
> Research assistant for project from November 1, 2007 - March 26, 2008.
> Conducted fieldwork on Ayutla Mixe and Mexican Spanish.

> **Name:** Benedicto, Elena
> **Worked for more than 160 Hours:**   Yes
> **Contribution to Project:**
> Conducted fieldwork on the Sumu.

> **Name:** Capistr?n, Alejandra
> **Worked for more than 160 Hours:**   Yes
> **Contribution to Project:**
> Conducted fieldwork on Purepecha (Tarasco).

> **Name:** Gutierrez Morales, Salome
> **Worked for more than 160 Hours:**   Yes
> **Contribution to Project:**
> Conducted fieldwork on Soteapanec (Sierra Popoluca).

> **Name:** Mateo-Toledo, Eladio
> **Worked for more than 160 Hours:**   Yes
> **Contribution to Project:**
> Conducted fieldwork on Q'anjob'al.

> **Name:** Palancar, Enrique
> **Worked for more than 160 Hours:**   Yes

Contribution to Project:
Conducted fieldwork on Otom?.

Name: Polian, Gilles
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted fieldwork on Tseltal.

Name: Smythe-Kung, Susan
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted fieldwork on Huehuetla Tepehua.

Name: V?zquez, Juan Jes?s
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted fieldwork on Chol.

Name: V?zquez, Ver?nica
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted fieldwork on Cora.

Name: Zavala, Roberto
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted fieldwork on Tecpat?n Zoque.

Post-doc

Graduate Student

Name: Peralta, Valent?n
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted fieldwork on Pajapan Nawat.

Name: Eggleston, Alyson
Worked for more than 160 Hours: Yes
Contribution to Project:
Graduate student to Elena Benedicto at Purdue University

Name: Hernandez Green, Nestor
Worked for more than 160 Hours: Yes
Contribution to Project:
Graduate student to Enrique Palancar

Name: Hernandez Gomez, Maria de Jesus
Worked for more than 160 Hours: Yes
Contribution to Project:
Graduate student to Enrique Palancar

Name: Herrera Castro, Samuel
Worked for more than 160 Hours: Yes
Contribution to Project:
Unfunded collaborator who is collecting data for the project on Huave,

spoken in San Mateo del Mar, Oaxaca, Mexico. He is affiliated with the Laboratorio de Ling??stica Instituto de Investigaciones Antropol?gicas Universidad Nacional Aut?noma de M?xico.

Name: Tucker, Randi

Worked for more than 160 Hours: Yes

Contribution to Project:

Research assistant for project from January 2010 - December 2010

Name: Donelson, Katherine

Worked for more than 160 Hours: Yes

Contribution to Project:

Performed statistical analysis and data processing.

Name: Lovegren, Jesse

Worked for more than 160 Hours: No

Contribution to Project:

Performed statistical analysis and data processing.

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Max Planck Institute For Psycholinguisti

Several senior members of the Language and Cognition Group at the Max Planck Institute for Psycholinguistics met with the PI and project member O'Meara in March 2008 to discuss the development and piloting of the tasks used in the project. The meeting was hosted by the Max Planck Institute.

The PI spent a sabbatical semester at the Max Planck Institute in the spring of 2010. During this stay, he gave several presentations on the project's progress to researchers at the institute and discussed a wide range of issues relating to the project's work with them.

Project member Polian was invited to a two-week stay at the Max Planck Institute for Psycholinguistics in May 2010 because of the interest in Polian's preliminary findings regarding frames of reference in Tseltal. There he met with Penelope Brown and Stephen Levinson to compare his data to those obtained by Brown and Levinson in the 1990s and determine possible sources of the discrepancies.

CIESAS

The MesoSpace project has a collaborative agreement with the Centro de Investigacaiones y Estudios Superiores en Antropologia Social (CIESAS) in Mexico. CIESAS Sureste in San Cristobal de las Casas, Chiapas hosted two week-long workshops in June 2008 and in October 2009 dedicated to the training of project members by the PI and the RA in the use of the

research tools and the analysis of the data collected with them, respectively. CIESAS DF in Mexico City hosted a meeting of the PI with 8 project members in June 2009 dedicated to the coding, analysis and dissemination of data concerning the use of frames of reference.

Spatial Intelligence and Learning Center

The PI presented preliminary Yucatec findings to a SILC audience at Northwestern University on October 6, 2008. As part of a tentative collaboration agreement, SILC researchers have offered to provide MesoSpace with advice on aspects of quantitative research methodology, and MesoSpace has offered to provide SILC with data on which to base follow-up experimental research. Potential future collaborations have been under consideration. SILC is an NSF Science of Learning Center.

Other Collaborators or Contacts

Dr. Penelope Brown (Researcher, Language Acquisition Group, Max Planck Institute for Psycholinguistics) participated in discussion related to the design of the stimuli and the experimental procedure for the project tasks during the meeting at the Max Planck Institute for Psycholinguistics in March 2008. Project member Polian has been consulting with her frequently on the analysis of frames of reference data in Tseltal including during his stay at the Max Planck Institute in May of 2010.

Dr. Niclas Burenhult (Research Fellow, Language and Cognition Group, Max Planck Institute for Psycholinguistics; Research Fellow, Centre for Languages and Literature, Lund University) participated in discussions related to the design of the stimuli and the experimental procedure for the project tasks during the meeting at the Max Planck Institute for Psycholinguistics in March 2008. Dr. Burenhult has been discussing the classification of Frames of Reference in orientation descriptions with the PI, and has agreed to join the research team of the follow-up project to MesoSpace, 'Spatial language and cognition beyond Mesoamerica' (BCS-1053123), which commenced in June of 2011.

Eric Campbell and Dr. Anthony Woodbury are researchers at the University of Texas at Austin who are collecting MesoSpace data for two varieties of Chatino, a family of languages belonging to the Zapotecan branch of Oto-Manguean, spoken in Oaxaca: Zenzontepec Chatino (Campbell) and San Juan Quiahije Chatino (Woodbury, in collaboration with Dr. Emiliana Cruz (University of Massachusetts, Amherst)).

Dr. Eve Danziger (Department of Anthropology, University of Virginia) participated in discussions regarding the design and development of the stimuli and the piloting process. She also participated in the project workshop which took place in June 2008. She provided expertise in experimental design as well as her knowledge of spatial language and cognition of Mopan Mayan speakers. She was a commentator at the symposium at the 2010 Annual Winter Meeting of the Society for the Study of Indigenous Languages of the Americas (SSILA) in Baltimore. She also contributed an article to a special issue of the journal Language Sciences dedicated to the findings presented at the symposium. The issue was published in 2011, edited by project members O'Meara and P?rez B?ez. Furthermore, Danziger advised the PI on the successful follow-up proposal to the project submitted to NSF in July of 2010. The new project, 'Spatial language and cognition beyond Mesoamerica' (BCS-1053123), started in June 2011.

Dr. Dedre Gentner (Department of Psychology, Northwestern University) is a Co-PI of the Spatial Intelligence and Learning Center (SILC), an NSF Science of Learning Center. Gentner has provided feedback on the PI's Yucatec findings and agreed to collaborate with the MesoSpace project on questions of quantitative research methodology. Gentner, the PI, and project member P?rez B?ez have been intensively exploring future experimental studies focusing on possible cognitive effects of the language-specific differences in meronymy suggested by the preliminary results of the MesoSpace project.

Dr. Rik van Gijn (Senior Researcher, Department of Linguistics, Radboud University, Nijmegen; Senior Researcher, Max Planck Institute for Psycholinguistics) and Dr. Vincent Hirtzel (Associate Researcher, Laboratoire d'Anthropologie Sociale, Paris; Senior Researcher, DoBeS Documentation Project, Max Planck Institute for Psycholinguistics) have agreed to run the MesoSpace tasks with speakers of Yurakare, a language isolate of Bolivia. Like Mesoamerican languages, Yurakare appears to have a productive geometric meronymy. If this can be confirmed, the language provides an independent test case for the central hypothesis of the MesoSpace project: that the presence of highly productive geometric meronymies disfavors the use of relative frames of reference. van Gijn and Hirtzel are participating in the follow-up project 'Spatial language and cognition beyond Mesoamerica' (BCS-1053123).

Samuel Herrera Castro (Technical Academic Associate 'A', Institute of Anthropological Investigations, Universidad Nacional Aut?noma de M?xico, Laboratorio de l?ng??stica) joined the MesoSpace team in 2009 and is carrying out the MesoSpace studies on Huave, a linguistic isolate of the Pacific coast of the Mexican state of Oaxaca. Herrera presented in the special session on meronymy organized by the PI and project member Romero M?ndez at the XI Encuentro Internacional de L?ng??stica en el Noroeste at the University of Sonora in November of 2010. He is also a member of the follow-up project 'Spatial language and cognition beyond Mesoamerica' (BCS-1053123).

Dr. Olivier Le Guen (National University of Mexico (UNAM)) participated in discussions related to the design of the stimuli and the experimental procedure for the project tasks during the meeting at the Max Planck Institute for Psycholinguistics in March 2008. Le Guen and the PI continue to consult on the analysis of spatial frames of reference in Yucatec.

Dr. Stephen C. Levinson (Director, Language and Cognition Department, Max Planck Institute for Psycholinguistics (MPI)) contributed significantly to the design and implementation of the stimuli used in the project during the meeting that was held at the MPI in March 2008. He also was a central participant during several discussions on the classification of spatial frames of reference during the PI's sabbatical stay at the MPI in the spring of 2010.

Dr. Paulette Levy (National University of Mexico (UNAM)) participated in the project workshop which took place in June 2008 by sharing her expertise on spatial semantics of Totonac.

Dr. David Mark (Department of Geography, University at Buffalo) has attended numerous lab meetings during which he helped in the development and piloting of the stimuli used in the project and continues to be an important consultant on questions of geography, which are taking center stage in the follow-up project 'Spatial

language and cognition beyond Mesoamerica' (BCS-1053123).

Dr. Eric Pederson (Chair, Linguistics Department, University of
Oregon) participated in discussions regarding the design and
development of the stimuli and the piloting process. He provided
assistance in the design process of the new tasks used in the project
and advised the PI on the successful follow up proposal submitted to
NSF in the summer of 2010.

Dr. Mark Sicoli (University of Alaska, Fairbanks), who works on
Zapotec, participated in discussions related to the design of the
stimuli and the experimental procedure for the project tasks during
the meeting at the Max Planck Institute for Psycholinguistics in March 2008.

Dr. Angela Terrill (Research Fellow, Centre for Language Studies,
Radboud University, Nijmegen) participated in discussions related to
the design of the stimuli and the procedures for the project tasks
during the meeting at the Max Planck Institute for Psycholinguistics
in March 2008.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)
The MesoSpace project is investigating the representation of spatial
information in 15
indigenous languages of Mexico, Guatemala, and Nicaragua - the largest
effort in
semantic typology funded by the National Science Foundation since the
World Color
Survey in the 1970s. The project focuses on two unusual traits of
spatial reference in
Mesoamerican (MA) languages: i) the widespread absence or paucity of
use of relative
frames of reference (FoRs) and ii) the highly productive use of
geometric meronyms,
terms that describe entities as parts of larger entities, including -
but not
restricted to - body part metaphors. Body part terms are prototypical
meronyms.

Preliminary evidence from previous work on reference frames in MA
languages ?
especially in the Mayan languages Tseltal (Brown & Levinson 1993) and
Yucatec
(Bohnemeyer & Stolz 2006) ? points to a prevalence of object-centered
and geocentric
over egocentric and especially relative representations. This
distribution is of great
potential interest in the debate over the linguistic relativity
hypothesis ? the
hypothesis that language influences non-linguistic cognition ? due to
the demonstrable
alignment between preferences for reference frame use in linguistic
and nonlinguistic

representations (Pederson et al (1998); Wassmann & Dasen (1998), Levinson (2003), Haun
et al (2011), Dasen & Mishra (2010), inter alia). Two alternative accounts of this
alignment have been proposed. According to Li & Gleitman (2002), all reference frames
are innately available across languages and cultures. Population-specific preferences
in both linguistic and nonlinguistic tasks are driven by environmental factors such as
topography, population geography, literacy, and education. In contrast, the Neo-
Whorfian position argued for by Levinson, Pederson, and colleagues holds that frame
knowledge is to a significant extent cultural and language plays a key role in its
transmission and diffusion. One of the central objectives of MesoSpace is to chart the
use of reference frames in discourse and recall memory across the MA sprachbund, in
neighboring non-MA indigenous languages, and in the Spanish spoken in the area and
elsewhere and determine to what extent preferences are driven by linguistic vs. by
nonlinguistic factors.

MA meronymies are unusual in two respects: first, they represent perhaps the most
important resource for the expression of place functions (Jackendoff 1983) in many MA
languages ? in particular, in languages without spatial case markers and with few or
no adpositions. Secondly, MA meronyms are systematically assigned on the basis of the
geometry of the object and the shapes of its parts, not on the basis of the parts'
functions. For example, in Western languages, the 'blade' and the 'handle' of a knife
are labeled by terms that apply to blades and handles of other objects on the basis of
their function, regardless of shape. In contrast, in Yucatec Maya, the handle is the
'leg' of the knife. There is no word for the blade as such; instead, the two planar
surfaces of the blade are identified as its 'fronts'. These terms are applied to parts
of similar shape in arbitrary objects regardless of function.

Two different proposals have been advanced to account for the productivity of shape-
based meronymy in MA. MacLaury 1989 describes Ayoquesco Zapotec meronyms as body part
terms that are metaphorically extended to other entities on the basis of a global
analogical mapping process with the structure of an erect human body as its source
domain and the structure of the entity described by the 'holonym' in

its actual
orientation as the target domain. This mapping is orientation-
sensitive: the highest
part of the object becomes the metaphorical 'head' and the lowest part
the 'buttocks'
or 'feet', depending on its shape. In contrast, Levinson 1994
describes meronym
assignment in Tenejapan Tseltal as governed, not by a metaphorical
mapping process,
but by an algorithm that takes as input the visually segmented outline
of the whole
and labels parts on the basis of their shape and the axis of the
entity they occur on.

The MesoSpace team of researchers is examining the conceptual basis
for meronym
assignment, testing predictions derived from the global-analogy
account proposed by
MacLaury for Zapotec and the shape-analytical algorithm proposed by
Levinson for
Tseltal in their field languages. One overarching hypothesis informing
MesoSpace has
been the idea that the pervasive use of shape-based meronyms as a
resource in spatial
descriptions may bias the speakers of a language against relative
FoRs. In languages
such as Tseltal, Yucatec, and Zapotec, relative descriptions
necessarily involve
meronyms. But meronyms always permit alternative object-centered
(intrinsic)
interpretations. And since speakers are habituated to analyzing an
object's geometry
when applying meronyms to it, the intrinsic interpretations are
favored. Absolute FoRs
are not affected by this pattern since they do not occur with
meronyms. The pattern
thus favors the use of both absolute and intrinsic over relative FoRs.
If confirmed,
this nexus between meronyms and reference frames would represent
evidence of a purely
linguistic determinant of reference frame use (the availability of
frames in discourse
is trivially in part a function of the lexicon of the language;
however, meronymy may
affect the actual use of FoRs in discourse, not merely their
availability).

The MesoSpace team developed a battery of six tasks and four stimulus
sets. The
stimuli include the Ball & Chair (B&C) pictures. These pictures are a
tool for the
study of FoR use in discourse that affords the recording of accurate
profiles of both
extrinsic and intrinsic frames. Previous instruments were biased in
favor of extrinsic
reference. Another newly developed instrument is the Novel Objects
set, designed to

test MacLaury's and Levinson's hypotheses concerning the meronymy of
MA languages. A
92-page field manual provides protocols for how to carry out the
studies, descriptions
of the goals, and instructions for preliminary processing and analysis
of the data
(P?rez B?ez 2008). Following a week-long training workshop at the
Centro de
Investigaciones y Estudios Superiores en Antropolog?a Social (CIESAS)
Sureste in June
2008, the team members recorded 15 to 45 hours of 'stimulated'
discourse per language.
The recordings are in the process of being archived with the Archive
of the Indigenous
Languages of Latin America (AILLA) at the University of Texas at
Austin. Transcription
and coding are well underway. Four further workshops at CIESAS
Sureste, CIESAS D.F.,
and the National University of Mexico were dedicated to the coding and
analysis of the
data. At the most recent of these meetings at UNAM in June 2010,
project members
Capistr?n, V?zquez, O'Meara, Green, and Romero Mendez discussed issues
of coding of
the Ball & Chair data.

Project members presented preliminary results of their research on
FoRs in eight of
the languages of the sample in a special session at the Annual Meeting
of the Society
for the Study of the Indigenous Languages of the Americas (SSILA) in
Baltimore in
January 2010 organized by project members O'Meara and P?rez B?ez
(program:
http://tiny.cc/of2pj). Five of these eight presentations offered the
very first
descriptions of FoR use in the particular languages and also in their
language
families. The journal 'Language Sciences' has published the papers
presented at the
SSILA session in a special issue, edited likewise by O'Meara and P?rez
B?ez.

The PI and project member Romero Mendez presented preliminary results
on meronymy in
five languages in a special session at the XI Encuentro Internacional
de L?ng??stica
en el Noroeste at the University of Sonora in November of 2010, the
largest
linguistics conference in Mexico (program:
http://tinyurl.com/26tvgpo). The session
included a presentation on Huave by the new collaborator Samuel
Herrera. Polian and
Bohnemeyer and Tucker (the new MesoSpace RA) also presented further
work on frames of
reference in Tseltal and Yucatec at the same conference.

The PI has presented his preliminary findings regarding meronymy and frames of
reference in Yucatec in an invited keynote lecture at CILLA IV, the Conference on
Indigenous Languages of Latin America, at the University of Texas at Austin; during
invited conference presentations at the workshop 'Grammar, Space, and Cognition' at
the Freiburg Institute for Advanced Studies (FRIAS) in Freiburg, Germany, in November
2009 and at the conference 'Discourse Representation, Comprehension and Production in
a Cross-linguistic Perspective' at the Center for Advanced Study of the Royal
Norwegian Academy of Sciences in Oslo in June 2011; during refereed conference
presentations at the 32nd Annual Meeting of the German Linguistics Society (DGfS) in
Berlin, the conference STALDAC 2010: Space and Time across Languages, Disciplines and
Cultures in Cambridge, UK, in April of 2010 (this last paper is a collaboration with
O'Meara), and the conference SULA 6: Semantics of Under-represented Languages in the
Americas VI at the University of Manchester in May 2011; during an invited colloquium
at Tilburg University in the Netherlands in April of 2010; and during two informal
presentations at the Max Planck Institute for Psycholinguistics. The FRIAS, STALDAC,
and SULA6 presentations are being prepared for publication in proceedings volumes, the
first in collaboration with Tucker (the new MesoSpace RA) and the second in
collaboration with project member O'Meara. A more elaborate version of the SULA6 paper
is in preparation for submission to a semantics journal. The PI, along with 11 team
members, the RA and new team members Donelson and Lovegren (two University at Buffalo
students from the PI's lab), presented preliminary findings of a multivariate
statistical analysis at the conference CILLA V, the Conference on Indigenous Languages
of Latin America, in Austin, TX, in October 2011. A group article examining the
predictive value of linguistic, demographic, and geographic factors in the use of FoRs
in the MesoSpace sample is in preparation.

The semantic typology lab meetings have continued on a weekly basis at the University
at Buffalo. Lab meetings were regularly dedicated to discussions of project data and
organizational matters. Since the fall of 2010, a series of lab meetings has been
devoted to exploring statistical methods of analysis. These have

contributed
significantly to the development of the phylogenetic approach to multivariate analysis
in semantic typology pioneered by the MesoSpace team and first unveiled at the Oslo
and Austin conferences mentioned above. In the Spring of 2011, team member Eggleston
attended lab meetings and presented her cross-linguistic analysis of frame of
reference preferences in Sumu-Mayangnga, Nicaraguan Spanish, and European Spanish.
Throughout her stay in Buffalo, the MesoSpace team developed the basis for their study
on language internal and external factors via multivariate analysis. The PI spent a
sabbatical semester in the spring of 2010 at the Max Planck Institute for
Psycholinguistics. During this time, he continued communication with individual lab
members via the internet.

The PI's sabbatical stay at the Max Planck Institute for Psycholinguistics was
dedicated to MesoSpace and writing a book on semantic typology. The PI held extensive
discussions and presentations of the findings resulting from the MesoSpace project.
The talks examined implications of these findings and new research questions arising
from them. They contributed to the successful proposal for a follow-up project on
'Language and Spatial Cognition Beyond Mesoamerica', which was submitted to NSF in
July 2010. The new project started in June 2011.

Because of the interest in team member Polian's preliminary findings regarding frames
of reference in Tseltal, he was invited to a two-weeks stay at the Max Planck
Institute for Psycholinguistics in May ? coinciding with the PI's sabbatical stay - to
compare his data to those obtained by Penelope Brown and Stephen Levinson in the
1990s.

A grant proposal was submitted to the Smithsonian Institution's National Museum of
Natural History by project member Perez-Baez to conduct a spin-off project of
MesoSpace dedicated to Zapotecan languages. Proposed project members are researchers
who are themselves speakers of the languages of interest. The proposal was declined
funding. Other possible funding sources are currently being explored.

Findings:

Preliminary results suggest that the use of relative frames of reference (FoRs) is dispreferred throughout Mesoamerica, as predicted in the project proposal submitted to NSF. This pattern appears to extend to the two indigenous control languages (Mayangna and Seri), suggesting that it may not be a feature restricted to the Mesoamerican sprachbund. The Ball and Chair task newly developed for this project has produced evidence of pervasive use of object-centered intrinsic FoRs (as in the intrinsic interpretations of 'The ball is in front of the chair') throughout the sample languages; this pervasive use of object-centered FoRs was hitherto unattested in most of the languages. In stark contrast to the predominantly relative Western languages, but also to the best-documented case of FoR use in MA prior to MesoSpace, that of Tseltal of Majosik', Chiapas, as described by Brown (2006), Brown and Levinson (1992, 1993), Levinson (1996, 2003), and Levinson and Brown (1993), the object-centered frame type appears to be the most frequent for locating the ball with respect to the chair in most of the languages of the sample, especially in the Mayan and Mixe-Zoquean languages. In the two Uto-Aztecan languages of the sample, Cora and Nawat, and in Isthmus Zapotec, geocentric and head-anchored descriptions dominate in locative descriptions. Head-anchored descriptions use local landmarks or the bodies of the participants as heads of vectors that define axes of FoRs ('The ball is on my side of the chair', 'The ball is toward the door from the chair') (see below). There are no languages in the sample in which relative frames dominate in locative descriptions. Topological descriptions - descriptions based on notions of contact, containment, and proximity, which do not involve FoRs - also play an important role in locative descriptions (e.g., 'The ball is between the legs of the chair/near the back rest of the chair').

In contrast, for the task of orienting the Chair, the dominant type of FoR in most languages appears to be what Danziger (2010) calls 'direct' FoRs. In this type, the body of an observer - particularly the speaker and/or addressee - serves as the 'anchor' or basis of the coordinate system, which however - unlike in relative FoRs - is not projected onto an external ground (e.g., 'The chair is facing us'). In Levinson's (1996) classification, direct FoRs constitute a subtype of intrinsic FoRs. Alongside direct FoRs, landmark-based ones, in which the location (rather than the geometry) of some reference entity serves to anchor the FoR, play an important role in descriptions of orientation (e.g., 'The chair is turned towards the door'). The most unexpected of findings of the project to date are the pervasive use of cardinal direction terms and absolute FoRs in Isthmus Zapotec and the low importance of absolute FoRs in the three Tseltal varieties studied by Polian. Absolute terms dominate in the Zapotec locative descriptions, and the orientation descriptions are almost entirely absolute. No obvious correlation with age, gender, or literacy of the speakers has emerged. In the case of Tseltal, absolute descriptions play a secondary role in Ch'ajkoma, the closest of the three communities to Majosik', where Brown and Levinson's studies were conducted; absolute use in the other two is marginal. Polian met with Brown and Levinson to determine the source of the discrepancy between his data and theirs. It was found that neither the differences between the stimuli nor variation in literacy or bilingualism could account for the variation. Instead, topography was isolated as at least one likely influence. The same absolute terms <ajk'ol> 'up' and <alan> 'down' are present in all four communities. The reason these terms are

used more frequently in Majosik' than in Ch'ajkoma and much more frequently in Ch'ajkoma than in the other two communities is the relative location and orientation of each community vis-?-vis the mountain slope. This may at first seem to support Li & Gleitman's (2002) environmental determinism. However, the variable language does not vary across the four Tseltal communities. But Li & Gleitman hold that FoR use is not affected by the variable language in situations where it does vary. Their position predicts, for example, that if one were to discover somewhere in the Rocky Mountains an English-speaking community in a place whose topography is an exact mirror image of that of Majosik', then ? all else being equal - those English speakers should use the terms 'up' and 'down' in the same way the inhabitants of Majosik' use <ajk'ol> and <alan>, and those English speakers would show the same linguistic and cognitive bias in favor of absolute FoRs. The MesoSpace Tseltal data neither contradict nor support this prediction. Polian & Bohnemeyer (2011) argue that Polian's findings support environmental constraints on FoR use, but not environmental determinism.

Team member Eggleston is in the final stages of completing her dissertation using data collected through MesoSpace. The dissertation provides a qualitative and quantitative profile of FoR use in in Sumu-Mayangna (Nicaragua: Misumalpan), as well as for Nicaraguan Spanish and Barcelonan Spanish. An analysis of the fesults from the MesoSpace tasks in general logistic mixed regression model provides evidence that language is a predictor of FoR preference for the three cohorts (p < .0001). These results lend additional support to the claim that language may affect cognition. The fact that two of the languages in this study, Sumu-Mayangna and Nicaraguan Spanish, are spoken within the same region and yet prefer significantly different spatial FoR strategies discourages Li & Gleitman's (2002) assumption that population-specific FoR preferences can be directly explained in terms of environmental adaptations. The testing location and setup was the same for both the Sumu-Mayangna and Nicaraguan Spanish cohorts. However, the Spanish speakers' use of FoRs was found to differ significantly by dialect as well (p = .0191), with Nicaraguan Spanish speakers using intrinsic strategies more than their Barcelonan Spanish counterparts. While this result was unexpected, varietal differences in FoR preference have been found elsewhere (Pederson 1993).

To directly test the competing hypotheses concerning linguistic and nonlinguistic determinants of reference frame selection, the MesoSpace team has carried out two multivariate statistical analyses of the Ball & Chair data (sets 2 and 4) collected from six of the MA languages of the sample (Ayutla Mixe (Romero-Mendez), Ch'ajkoma Tseltal (Polian), Juchiteco Zapotec (Perez Baez), P'urh?pecha/Tarascan (Capistran), San Ildefonso Tultepec Otom? (Palancar, Green, and Hernandez Gomez), and Yucatec (Bohnemeyer)), the two non-MA indigenous languages (Seri (O'Meara) and Sumu-Mayangna (Benedicto and Eggleston), and three varieties of Spanish: Mexican (Romero Mendez), Nicaraguan (Eggleston), and European Spanish (from Barcelona) (Eggleston), along with demographic data from the speakers. These analyses compare the (dyads of) speakers to one another, examining to what extent they cluster in their use of reference frames by native languages, second language,

level of education, and literacy. This represents a novel approach to the use of multivariate statistics in semantic typology. Previous research (e.g., Levinson & Meira (2003); Majid, Boster, & Bowerman (2008)) instead compared items in terms of the similarity of their treatment across languages. The idea to go with an analysis by participants was inspired by Eggleston's dissertation work mentioned above. The PI and the new Buffalo team members Donelson and Lovegren developed a similarity matrix that compares the frequencies with which the participants used eight different response categories (seven frame types plus topological or perspective-neutral descriptions). These can be interpreted as points in an eight-dimensional space. The distances between these points (in the Manhattan or City-Block metric) are a representation of the similarity of participants (or dyads) in terms of their use of reference frames. Lovegren performed a phylogenetic analysis of the resulting similarity matrix in the program Splitstree 4 (Huson & Bryant 2006), using the Neighbor-net algorithm (Bryant & Moulton 2004). The advantage of techniques such as Neighbor-net over more widely known alternatives such as Multidimensional Scaling (MDS), Factor Analysis, or Principal Component Analysis is that they avoid the distortion or loss of information that comes as a price of the reduction to a small number of dimensions or factors.

The Neighbor-net analysis shows that the speakers of the various languages differed from one another above all in their use of two types of frames: relative and geocentric frames. An MDS analysis of the same similarity matrix conducted by Donelson in R confirmed this, showing a strong positive correlation between the first dimension of the MDS plot and the frequency of geocentric frames (Spearman's Rho 0.9545343) and a weaker negative one with the frequency of relative frames (Spearman's Rho -0.7995417). (The second dimension of the plot correlated positively with the frequency of topological descriptions.) An analysis of the Neighbor-net in terms of the demographic variables suggests that native language is the strongest predictor of frame use, in line with the Neo-Whorfian predictions. All of the native speakers of Spanish find themselves in the region of the net characterized by high relative scores, with the exception of one dyad of Nicaraguan Spanish speakers. And with the exception of this Nicaraguan Spanish dyad, the region of high geocentric scores is populated exclusively by speakers of the indigenous languages. Lovegren has calculated the mean distances between the participants that share a value on any of the demographic variables. He found that the densest cluster occurs in the performance of the speakers of the three varieties of Spanish. That is, the most powerful predictor of reference frame use was having Spanish as one's native language. The second densest cluster was observed among participants that do not speak Spanish at all (as first or second language), and the third-best predictor was being a native speaker of any of the indigenous languages. Only in fourth place did a cluster predicted by a non-linguistic variable emerge: the absence of formal education. This can be seen as an impressive, albeit preliminary, confirmation of the Neo-Whorfian hypothesis. The analysis in its current form was previewed during the PI's invited lecture at the conference 'Discourse Representation, Comprehension and Production in a Cross-linguistic Perspective' at the Center for Advanced Study of the Royal Norwegian Academy of Sciences in Oslo in June 2011 and presented by the PI and 14 coauthors at the conference CILLA V, the Conference on Indigenous Languages of Latin America, at the University of Texas at Austin in October 2011. The team is currently working to

incorporate data from more languages of the sample, extend the analysis to the recall memory data collected with the New Animals task, and perform inferential tests on some of the findings. Submission of a group article to the journal Cognitive Science is planned for the beginning of 2012.

Another unexpected result of the research of the MesoSpace project has been the finding of frequent violations of the principle of canonical orientation (POCO; Levelt 1984, 1996) in several of the languages of the sample. POCO states that in order for the location of a figure to be described with respect to a given ground in an object-centered FoR, the ground ? or at least those parts of it the description projects regions from - must be in canonical orientation. For the top-bottom axis, and spatial regions selected along it, canonical orientation inside a gravitational field generally means alignment with that gravitational field (see Friederici & Levelt 1990 for an experimental study under zero-g conditions). That this principle is no more than a strong tendency was implicitly demonstrated in a series of experiments reported in Carlson-Radvansky & Irwin (1993, 1994).These studies focused on the relator above of English, manipulating stimuli and the participants' orientation to create configurations in which above applies under an object-centered, relative, or absolute interpretation to the exclusion the other options ('disaligned') or under two or all three interpretations simultaneously ('aligned'). A production study showed that 95% of participants describe the figure as 'above' the ground in case the three interpretations align. If exclusively the vertical orientation of the observer changes, the number drops to 93%. If the figure is above the ground in absolute terms alone, but neither in intrinsic nor in relative terms, the number of above responses comes down to 76%. And 30% still describe the figure as 'above' the ground in case exclusively the intrinsic perspective applies. There is ? so far mostly anecdotal ? evidence that disaligned intrinsic uses of vertical terms may be more common in MA than in European languages. The only language of the MesoSpace sample for which a preliminary quantitative analysis has been performed to date is Yucatec Maya. 12 of the 48 pictures of the B&C task feature the chair in non-canonical orientation (i.e., not standing up). 10 of these afford disaligned intrinsic descriptions. 36% of the Yucatec descriptions of these 10 pictures feature intrinsic FoRs, compared to 4% of the English descriptions collected from five pairs of University at Buffalo undergraduate students in a pilot. (The English numbers diverge from those in (Carlson-Radvansky & Irwin, 1993) due to the differences between the two tasks.) Moreover, Yucatec speakers would produce intrinsic descriptions not merely under disalignment, but also in situations where absolute descriptions are in fact available, but would involve the inverse relator. These findings are the first pieces of evidence suggesting that POCO may be language-specific. It seems likely that this contrast is directly attributable to the much greater overall importance of object-centered frames in Yucatec: 56% of all pictures elicited object-centered locative descriptions in Yucatec, compared to just 22% in English. The PI and Tucker presented an analysis of the Yucatec data on the intrinsic use of vertical relators at the XI Encuentro Internacional de Linguistica en el Noroeste at the University of Sonora in November of 2010, the largest linguistics conference in Mexico. An ongoing line of investigation in this research concerns the role of meronyms as a possible predictor of intrinsic uses of vertical relators. Vertical relators in Yucatec and

other MA languages are meronyms, and Yucatec meronyms are assigned primarily on the basis of the object's canonical orientation rather than its actual orientation, thus giving rise to a potential for intrinsic references to the vertical independently of the object's orientation vis-?-vis the Earth's field of gravity.

The B&C data also produced evidence of 'referential promiscuity', defined by the unrestricted availability of spatial FoRs and the lack of a default perspective, in Yucatec. Speakers switched freely between FoRs and often combined multiple types in single descriptions. Bohnemeyer (2011) describes this style of FoR use. He argues that only absolute and relative FoRs allow speakers to maintain a default perspective that remains unchanged across contexts and referential grounds. There are also language communities that have been described as making use exclusively of intrinsic FoRs, such as Mopan Maya (Danziger 2001) and Kilivila (Oceanic, Papua New Guinea; Senft 2001, 2006). On the PI's proposed typology, referentially promiscuous languages such as Yucatec (other candidates include the Kwa language Ewe of Ghana and Togo (Ameka & Essegbey 2006) and the Bantu language Kgalagadi of Botswana (Levinson 2003)) share with intrinsic-only languages the absence of a default perspective, but with predominantly relative and predominantly absolute languages the availability of extrinsic FoRs.

Bohnemeyer & O'Meara (in press) have examined the use of FoRs in orientation descriptions in the Seri and Yucatec B&C data. They show that FoRs play an equally important role in representations of the orientation of entities as they do in representations of their location and direction of motion. They propose that orientation is conceptually encoded, not in terms of metaphorical path functions (Jackendoff 1983), but in terms of vectors, a separate type of primitive conceptual function. Equipped with the notion of vectors, they introduce a distinction between two classes of FoRs: classical 'angular-anchored' FoRs and the previously unrecognized 'head-anchored' FoRs. In English, angular-anchored relative FoRs dominate in both locative and orientation descriptions. In contrast, in Seri and Yucatec, object-centered angular-anchored FoRs dominate in locative descriptions, but head-anchored FoRs dominate in orientation descriptions.

The PI has developed a model-theoretic semantics for the interpretation of spatial descriptions in reference frames, building on Zwarts & Winter's (2000) vector space semantics. Instead of attributing the truth-conditional differences between descriptions interpreted in different frames to lexical ambiguity of the relators, as Levinson's (1996) lexical-semantic analysis does, the PI's analysis treats frame-dependent spatial relators as indexicals whose use requires contextual selection of a suitable anchor, i.e., an entity after which the frame is modeled. This analysis makes the extension to orientation descriptions and the head-anchored framed type introduced in Bohnemeyer & O'Meara (2010) straightforward. The PI presented this analysis at the conference 'SULA 6: Semantics of Under-represented Languages in the Americas VI' at the University of Manchester in May 2011. A write-up has been submitted to the conference proceedings; an elaborate version is in preparation for submission to a semantics journal.

A recall memory task ('New Animals') has produced evidence of a

preference for geocentric memory coding in 12 of the populations and 'mixed' responses without a clear bias for either geocentric or egocentric coding in the others. None of the populations displayed a preference for egocentric coding. The task requires participants to commit arrays of farm animal toys located on a table to memory and then to reproduce them on a different table after turning 180 degrees. This task is designed to study preferences for frames of reference in recall memory to see whether these align with those in discourse. New Animals is modeled closely on the Animals-In-A-Row task originally released as part of (Danziger 1993). Analysis of the results continues.

As for the second domain investigated by the MesoSpace team - productive terminologies for object mereologies - the following picture has begun to emerge based on the project members' first reports of data collected with the Novel Objects tasks: As predicted, meronyms appear to play a prominent role in identifying the parts of the Novel Objects throughout the MA sample. A similar distribution is shaping up for the southern control language Mayangna, but not for Seri spoken north of the MA area. However, it is not obvious that it is readily possible in any of the languages of the sample to extend meronyms to all parts of all of the Novel Objects. There does appear to be an element of conventionality in the use of Mesoamerican meronymies that neither the account of MacLaury 1989 nor that of Levinson 1994 predicts. For Yucatec, the critical distinction is that between volume meronyms, whose assignment appears to be subject to convention, and surface and curvature extreme meronyms, which are applied to arbitrary parts that satisfy their truth conditions (see the first-year report). Sumu-Mayangna meronyms are sorted into volumes, extensions, facets, borders, and negative spaces. Sumu-Mayangna meronymy assignment has been found to proceed according to a geometric algorithm, as Levinson proposes (1994), with semantic and structural constraints. There exists a morphological distinction between the encoding of locative and projective meronymic space for the dominant Panamahka variety of Sumu-Mayangna, while the minority Tuahka variety expresses projective meronymic space in the verbal predicate. It remains to be seen which factors limit productivity in the other languages.

An interesting finding that has emerged from the picture book tasks is that while human and animal body part terms are readily extended to parts of artifacts, their use with plant body parts tends to be rather more limited in most languages. Plant mereologies appear to be properly lexicalized throughout Mesoamerica - a finding predicted neither by MacLaury's (1989) nor by Levinson's (1994) accounts. Preliminary evidence suggests that this pattern extends to Seri, but not to Mayangna, where human/animal body part terms are more regularly applied to plant parts.

Project members presented their findings on meronymy in five of the languages of the MesoSpace sample (Ayutla Mixe, Huave (studied by the new project member Herrera), Juchiteco Zapotec, Sumu-Mayangna, and Seri) during a special session at the XI Encuentro Internacional de Linguistica en el Noroeste at the University of Sonora in November of 2010 organized by Romero Mendez and the PI. For Mixe, Huave, and Sumu-Mayangna, these presentations represent the first descriptions of meronymy. An NSF-funded follow-up to the MesoSpace project that began in June 2011 has meronymy as one of its foci, planning to carry the investigation to meronym systems in languages of South America,

Africa, and Asia.

Training and Development:

The weekly meetings of the semantic typology lab provide an environment in which project members and University at Buffalo graduate students and faculty members have benefited from discussion of methodological issues and findings of the MesoSpace project. From this forum, two lab members, UB graduate students Katherine Donelson and Jesse Lovegren, have joined the MesoSpace team and are currently breaking new ground in the application of multivariate statistical analysis to semantic typology.

The new research assistant, Tucker, has become familiar with the process of administering a large-scale grant with multiple project members. She has gained experience in research planning and continuation through the preparation of a follow-up grant proposal for the expansion of the project. She has also developed her own research project in further exploring the Principle of Canonical Orientation, which has involved the development and testing of expanded sets of picture stimuli.

Two of the project members, O'Meara and Perez Baez, organized the production of a special issue publication resulting from the symposium they organized at the 2010 Annual Winter Meeting of the Society for the Study of Indigenous Languages of the Americas. This special issue of 'Language Sciences' was published in 2011.
 MesoSpace has contributed to the training and academic advancement of twelve graduate students, six of whom are Mexican citizens. At the start of the MesoSpace project, 13 of the members were graduate students; during the course of the project, six of these graduated.
The group includes three winners of the Mary R. Haas Book Award of the Society for the Study of the Indigenous Languages of the Americas, which annually honors one unpublished manuscript ? usually a doctoral dissertation - that makes a significant contribution to the scientific study of the indigenous languages of the Americas, including the 2008 and 2009 winners. The project provides excellent training opportunities for the students. They are instructed in cutting-edge methods of semantic typology and spatial semantics and gain hands-on experience in field research and in the analysis of data under the direction of the PI and through the discussion of the results with their peers during the project meetings and the symposium on meronymy. They are also provided with multiple opportunities to publish their results in edited volumes and scientific journals, and to thus further their academic careers.

Outreach Activities:

MesoSpace advances the description of 15 indigenous minority languages of Mexico, Guatemala, and Nicaragua. All of these must be considered at least somewhat endangered and most of the smaller languages as severely endangered (e.g., Huehuetla Tepehua). All of the indigenous minority languages of the sample are severely under-described in comparison to Euro-American languages. Four of the project members are native speakers of indigenous languages and thus members of marginalized ethnic minorities who are empowered to become agents, rather than mere subjects, of the scientific study of their languages

and cultures. The project also furthers the collaboration of research
institutions in Europe, Mexico, and the U.S., thereby helping to
integrate a global academic community.

Journal Publications

Bohnemeyer, J., "Spatial frames of reference in Yucatec: Referential promiscuity and task-specificity", Language Sciences, p. 892, vol. 33, (2011). Published,

O'Meara, C., "Spatial frames of reference in Seri", Language Sciences, p. 1025, vol. 33, (2011). Published,

Vazquez Soto, V., "The "uphill" and "downhill" system in Meseno Cora", Language Sciences, p. 981, vol. 33, (2011). Published,

Eggleston, A., Benedicto, E., Mayangna Yulbarangyang Balna, "Spatial frames of reference in Sumu-Mayangna", Language Sciences, p. 1047, vol. 33, (2011). Published,

Romero Mendez, R., "Frames of reference and topological descriptions in Ayutla Mixe", Language Sciences, p. 915, vol. 33, (2011). Published,

Hernandez-Green, N., R. Palancar, E. L., Hernandez, S., "The Spanish loanword lado in Otomi spatial descriptions", Language Sciences, p. 961, vol. 33, (2011). Published,

Capistran Garza, A., "Locative and orientation descriptions in Tarascan: Topological relations and frames of reference", Language Sciences, p. 1006, vol. 33, (2011). Published,

Polian, G., Bohnemeyer, J., "Uniformity and variation in Tseltal reference frame use", Language Sciences, p. 868, vol. 33, (2011). Published,

Perez Baez, G., "Spatial frames of reference preferences in Juchitan Zapotec", Language Sciences, p. 943, vol. 33, (2011). Published,

Books or Other One-time Publications

Bohnemeyer, J., O'Meara, C., "Vectors and frames of reference:
Evidence from Seri and Yucatec", (2011). Book, Submitted
Collection: Proceedings of STALDAC 2010: Space and Time across Languages,
Disciplines and Cultures
Bibliography: Amsterdam: John Benjamins.

Bohnemeyer, J., Tucker, R., "Space in semantic typology: Object-centered geometries", (2011). Book, Submitted
Editor(s): Auer, P., M. Hilpert, A. Stukenbrock, and B. Szmrecsanyi
Collection: Proceedings of the FRIAS Language and Space Workshops: Space
in language and linguistics: Geographical, interactional, and
cognitive perspectives
Bibliography: Berlin: Walter de Gruyter

Bohnemeyer, J., "A vector space semantics for
reference frames in Yucatec", (   ). Book, Submitted
Collection: The Proceedings of SULA 6:
Semantics of under-represented
languages in the Americas VI.
Bibliography: Amherst, MA: GLSA. University of
Massachusetts Occasional Papers
in Linguistics

Web/Internet Site

URL(s):

http://www.acsu.buffalo.edu/~jb77/Mesospace.htm

Description:

The project website (hosted on the PI's professional website) contains a description of the project, a list of project members and affiliations, short descriptions of the languages included in the MesoSpace sample, along with a map locating the languages. The site also features researcher materials, NSF annual reports, and handouts from presentations of MesoSpace results.

Other Specific Products

Product Type:

Field Manual

Product Description:

This product is the 2008 Field Manual for the project. It was designed as a resource for project members regarding the objectives of the project and it provides guidelines on how to run the tasks and analyze the data.

Sharing Information:

The 2008 Field Manual is available on the project website: http://www.acsu.buffalo.edu/~jb77/MesoSpaceManual2008.pdf

Contributions

Contributions within Discipline:

The work of the MesoSpace team is shaping up to make significant contributions to (i) the scientific description of individual languages; (ii) linguistic typology, the study of the distribution of language structures, sounds, and linguistically expressed meanings across languages; and (iii) the theory of language.

(i) The project examines the use of spatial frames of reference in 15 indigenous languages of Mexico, Guatemala, and Nicaragua. Reference frames are conceptual coordinate systems used to interpret spatial representations ? linguistic and cognitive representations of the location, orientation, and motion of objects in space. For all but two of the 15 languages, no published accounts of the use of reference frames are available ? the MesoSpace research is mapping vast swathes of terra incognita here. Many of these languages are endangered, and moreover, there is evidence suggesting that the use of reference frames by the speakers of these languages is rapidly changing under the influence of contact with Spanish. The work of the MesoSpace team may represent the last best opportunity of obtaining scientific records of many of these unique cultural systems of spatial knowledge. Reports on eight of the languages of the sample appear in a special issue of the journal Language Sciences, published in the fall of 2011. In the case of the MesoSpace language most extensively studied prior to the project, Tseltal Maya, the results of project member Polian indicate important corrections to the earlier descriptions of reference frames in this language.

The project has also been exploring a second, related domain of spatial language, namely so-called 'meronyms', terms for object parts.

Many languages of the area make pervasive use of meronyms as a resource for the expression of spatial relations. Their speakers would for example locate a ball with respect to a chair by describing the vertical position of the ball as 'top' or 'head' or 'bottom' of the chair. The project documents both the use of meronyms in spatial descriptions and the conceptualization of part-whole relations or 'mereology' that underlies the assignment of meronyms to objects. These systems are strikingly different from what is found in better studied languages, and individual languages appear to vary surprisingly in terms of their mereologies. For all but four of the languages of the sample, these are the first studies of their meronymy ever undertaken.

(ii) Until recently, it was universally taken for granted by linguists and cognitive scientists that the use of spatial frames of reference is innate and does not vary with language and culture. All human populations were assumed to show the same bias in favor of egocentric, 'relative' representations found in speakers of English or Japanese, who would describe, say, a ball as being 'left of' or 'in front of' a chair depending on the viewpoint of the speaker (or, more generally, an observer). In the late 1970s, the first reports emerged indicating that Aboriginal people of Australia tend to make almost exclusively use of geocentric or 'absolute' frames, describing, in the above example, the ball as being 'west of' or 'south of' the chair. Crosslinguistic research on this phenomenon began in the 1990s. It was quickly discovered that there is in fact a bewildering array of different kinds of frames across human populations, often modeled, for example, after local topographic features such as mountain slopes or the courses of rivers. It became apparent that there is enormous variation across cultures in terms of which reference frames their members prefer for solving a given task. And this variation was found to have profound consequences for spatial cognition. Frames of reference are not mutually translatable: if one remembers the ball exclusively as being 'west of' the chair, this will not allow one to determine later where it was with respect to the chair from the perspective of the observer. Conversely, if the location of the ball is remembered in egocentric terms, its location in absolute or geocentric space cannot be inferred from this representation. Consequently, people tend to memorize spatial information in the same frames they prefer to communicate it linguistically.

These findings raise important questions about the boundary between innate and cultural knowledge in spatial cognition and the relationship between spatial cognition and language. In order to be able to address these questions, it is vitally important to survey the linguistic systems and cognitive styles used by the speakers of different languages according to standardized scientific methods and protocols. This is the job of semantic typology, a subfield of linguistic typology. The members of the MesoSpace research team have been undertaking the largest and most comprehensive survey of the use of spatial frames of reference in a large multilingual and multicultural geographic area to date. In doing so, they have also pioneered the application of methods of semantic typology to such an area. This 'areal' approach to typology opens up unique opportunities for isolating linguistic, cultural, and topographic/environmental factors influencing spatial cognition.

Preliminary results are presented in more detail in the Findings section of this report. They indicate a much more restricted use of observer-dependent, relative frames across the area compared to better studied European languages or Japanese. However, there is evidence to the effect that the use of relative frames is on the rise among younger speakers as a function of integration in the dominant Spanish-speaking national cultures. In some languages of the area, absolute frames dominate; in many others, object-centered 'intrinsic' frames are the most frequently used type. Intrinsic frames project spatial coordinates from the reference entity itself. For example, the ball is intrinsically 'in front of' the chair when it is located in a region proximate to the chair's inherent front.

The overarching theoretical goal of MesoSpace is to help adjudicate between two competing explanations that have been proposed to account for the observed covariation between reference frame use in language and thought. One view, championed by Peggy Li and Leila Gleitman of the University of Pennsylvania, holds that reference frames are indeed innate, as traditionally assumed, and that the observable differences across populations in the use of reference frames in speech and thought alike are driven by adaptations to the environment, such as the local topography. Salient land and water forms such as mountains and rivers may serve as the models or 'anchors' for so-called geocentric frames in 'upriver'/'downriver' or 'uphill'/'downhill' systems. Population density, infrastructure (road systems!), and literacy and education level are likewise factors Li and Gleitman suggest may play a role. Thus, among the populations surveyed around the world thus far, relative frames are preferred mostly among members of large-scale, industrialized, urbanized, and highly educated and literal societies, whereas the cultures in which they play a minor or no role tend to be small-scale traditional societies whose members are often less educated and literate due to the effects of economic marginalization.

In contrast, the position advanced most prominently by Stephen Levinson of the Max Planck Institute for Psycholinguistics argues that, while the ability to learn any kind of frame is probably innate, familiarity with particular frame types is mostly cultural. Reference frames are culture-specific styles of thinking and talking about space. Children growing up in a particular community must learn the use of frames appropriate in their culture by observing older children and adult members of the community. Since language is the most sophisticated system for the production of external representations of thought humans (or any other animal species, as far as we can tell today) have at their disposal, language is expected to play a powerful role in the cultural transmission and diffusion of every culture's cognitive style. In this sense, language has the power to structure and shape thought, an idea known in the cognitive sciences as 'Whorfian' in reference to the American linguist Benjamin Lee Whorf, who famously proposed it in the 1930s. However, Whorf did probably not quite have the understanding of the mind as a computational system of thought that humans and animals are innately endowed with, which was ushered in by the 'cognitive turn' of the 1950s. He has often been understood to hold that our thinking is largely derived from and determined by our native languages. Modern versions of the hypothesis of language-on-thought effects are commonly distinguished from this deterministic interpretation as 'Neo-Whorfian'.

For the languages of the MesoSpace sample, Li and Gleitman's innatist hypothesis predicts that the use of reference frames in both language and thought should primarily depend on the local topography, population density, and infrastructure, and the speaker's level of literacy and education. The native language and whatever second languages a person may speak should at most play a secondary role. In contrast, the Neo-Whorfian hypothesis of Levinson and colleagues predicts that people's use of reference frames depends primarily on the languages they speak and only in second respect on other factors such as those suggested by Li and Gleitman. Adaptations to environmental factors are undoubtedly real; but they occur, not at the 'ontogenetic' level of the development of an individual's speech and thought patterns, but at the 'phylogenetic' level of the cognitive development of the community, and thus proceed at a time-scale that exceeds any individual's personal experience.

The Mesoamerican linguistic and cultural area, with its impressive diversity in languages, cultures, natural environments, and socio-demographic profiles, offers a natural laboratory for testing these predictions ? and the MesoSpace team has been doing just that. Applying cutting-edge methods of statistical analysis, team members have shown that the reference frames participants used when verbally describing a series of photos depended more on their native language and their knowledge and use of Spanish as a second language than on their levels of literacy and education. Speakers of indigenous languages were overall more similar to one another in their behavior than to native speakers of Spanish, irrespective ? in first approximation ? of literacy and education. This preliminary result is in line with the Neo-Whorfian view and contradicts the innatist position. The team is currently working to extend the analysis to additional languages of the sample and to the performance of speakers of the various languages in a recall memory task on spatial relations.

A central typological hypothesis of the MesoSpace project is the idea that the pervasive reliance on meronyms for the expression of spatial relations may bias the speakers of a language against the use of relative frames. The rationale behind this idea is that both relative and intrinsic reference requires the use of meronyms in the languages in question. Whereas Western languages have large, specialized meronymic vocabularies assigned according to the functions of the parts, many Mesoamerican languages have general-purpose meronyms that are assigned across arbitrary classes of objects according to the geometry of the parts and the whole. For example, English speaker identify the 'handle' and 'blade' of a knife as major parts and extend the terms 'handle' and 'blade' to parts of other objects that have similar functions, such as the handle of a container or the blade of a circular saw. In contrast, in Yucatec Maya, the handle of the knife is identified as its 'leg' on the basis of its shape and position in the geometric structure of the knife. 'Leg' is not applied to the handle of a container, which is most likely its 'ear'; instead it is used for example in reference to a lamp post. There is no word that translates 'blade'. Instead, both planar surfaces of the blade of the knife are identified as the knife's 'fronts', and this term extends to other salient flat or convex surfaces of arbitrary objects, but not to the blade of a circular saw, which would be (a part of) the saw's 'belly'. Since both intrinsic and relative reference to an object require the

assignment of meronyms to it in languages such as Yucatec and relative reference is done on the basis of the geometry of the observer's body rather than that of the geometry of the reference object, the pervasive practice of assigning meronyms to an object on the basis of its shape habituates speakers against relative interpretations. This hypothesis is currently being tested by the members of the project in their respective field languages and so far has held up to these tests.

An unexpected finding is the intrinsic use of terms for vertical relations regardless of the orientation of the reference object vis-?-vis the gravitational vertical in Yucatec and, according to preliminary reports, in several other project languages. A ball resting on top of the underside of an inverted chair may be naturally described as being 'under' the chair in these languages. This phenomenon, which confounds previous assumptions about the universal dominance of gravitational absolute frames in vertical reference, could be a direct consequence of the use of meronyms for the expression of vertical relations and the overall preference for intrinsic reference in languages such as Yucatec.

Previous reports suggest that the principles governing the assignment of meronyms are not uniform across Mesoamerican languages, but may vary from language to language. It is an important part of the MesoSpace agenda to examine and compare the meronymies found across the area. For example, in Yucatec, meronym assignment depends mostly only on the canonical orientation of the object in the vertical, not on its actual orientation. In contrast, in some languages, the assignment of the terms appears to depend strictly on the object's actual orientation, such that the 'head' is whichever part is highest in the field of gravity at the time of reference. In such languages, purely intrinsic descriptions of vertical relations such as that illustrated for Yucatec above should be impossible. This prediction is currently being tested.

The typological study of the distribution of reference frames across languages and cultures must be informed by, and at the same time provides the empirical basis for, the classification of frame types as spelled out by theoretical treatments. The MesoSpace researchers have found evidence of a previously unrecognized dichotomy being 'angular-anchored' and 'head-anchored' frames discussed in the following subsection. The distribution of these types appears to vary across languages and is likewise being studied by the team.

Another typological distinction that has emerged from the work of the project is that between languages that show restrictions excluding the use of particular types of frames from important domains of reference (for example, most varieties of English do not use cardinal direction terms to locate a ball vis-?-vis a chair) and 'referentially promiscuous' languages such as Yucatec which appear to lack such restrictions.

(iii) The findings of the MesoSpace project have significant potential implications for the theory of spatial frames of reference and the debate about language as a possible formative factor in forging culture-specific habits or practices of cognition.

Work by the PI and project member O'Meara on the use of reference frames in two of the languages of the MesoSpace sample, Seri and Yucatec, suggests a new dichotomy of frame types unrecognized by previous classifications. Most traditionally recognized intrinsic, relative, and absolute frames are 'angular-anchored', in the sense that they copy a set of axes from a model entity or 'anchor' and project it onto the reference entity, which serves as the origin of the coordinate system. For example, in relative interpretations of 'The ball is left of the chair', the axes of the observer's body are projected onto the chair, and the 'geomorphic' frame of 'The ball is downriver from the chair' is constituted by the projection of an axis derived from the course of some river onto the chair. Bohnemeyer and O'Meara contrast this against a 'head-anchored' type, whose axes are computed as vectors pointing towards or away from the anchor. So-called 'landmark-based' frames are head-anchored, as in 'The ball is towards the door from the chair.' There is also an egocentric version of head-anchored types, instantiated for example by 'The ball is towards us from the chair' or the equivalent 'The ball is on our side of the chair.' Celestial frames, such as sunset/sunrise-based frames, by hypothesis originate as head-anchored systems which are subsequently commonly reinterpreted as angular-anchored once their axes are understood as abstract invariable bearings. The head-angular dichotomy has important consequences for the heuristics used to identify frame types in semantic analysis: whereas angular-anchored frames depend on the orientation of the anchor ('The ball is left of the chair' becoming false when the speaker turns 180 degrees), but not on its location, head-anchored frames conversely depend on the location of the anchor, but not on its orientation. Bohnemeyer and O'Meara show that in Seri and Yucatec, angular-anchored frames dominate in locative descriptions ('The ball is left/south of the chair'), whereas head-anchored frames dominate in orientation descriptions ('The chair is facing us/the door'). The role of reference frames in the representation of the orientation of entities has received very little attention in the theoretical literature so far. Bohnemeyer and O'Meara's account argues against the treatment of orientation in terms of metaphorical motion paths proposed in the influential work of Jackendoff 1983 and instead strengthens the case for vectors as primitives of spatial cognition and semantics.

The PI has developed a new theory of the role reference frames play in the meanings of utterances. Previous work assumed that reference frames are a part of the meanings of words such as 'left' and 'right'. If I say 'The ball is left of the chair', I may mean left from my perspective or yours, or I may mean left from the chair's perspective. Traditionally, these are assumed to be different, though related, senses of the word 'left' ? cases of lexical ambiguity or 'polysemy'. The PI has advanced a number of arguments against this idea. Most notably, the words in question fail subtle tests that should detect ambiguities such as these. The alternative the PI argues for is that expressions such as 'left' are vague regarding the distinctions between the interpretations at issue here and their interpretation is context-dependent.

The discovery of the crosslinguistic variation in reference frame use and the alignment between population-specific preferences for frames in discourse and cognition has greatly fueled the debate about the possible role of language as a causal factor in non-linguistic

cognition ? in other words, the so-called Sapir-Whorf Hypothesis or
linguistic relativity hypothesis, according to which 'language
influences thought.' Proponents of a 'Whorfian' (not 'Neo-Whorfian';
see above) or 'relativistic' interpretation of the alignment argue
that since cultures differ in their preferences or habits of spatial
cognition, their members must learn their group's preferences from
observable behavior, and thus foremost from language use. Opponents
claim instead that the observable cultural differences are shallow and
easily mutable in response to factors such as literacy and the
environment. On these accounts, spatial cognition is uniform across
populations in terms of abilities and merely diverse in terms of the
use of these abilities.

The MesoSpace work on meronyms discussed in the previous subsection
directly bears on this question. If meronyms can be confirmed to be a
linguistic factor influencing reference frame use in both language and
spatial memory and reasoning, this would strengthen the relativistic
view of habits of reference frame use as deeply culturally entrenched
and of language as playing a key role in the intergenerational
transfer and cultural diffusion of these habits.

The members of the MesoSpace team are also exploiting the unique
affordances of the Mesoamerican cultural and geographic area to test
the possible role of nonlinguistic factors in influencing reference
frame selection. Of special relevance in this connection is the work
of team member Polian on influences of the local topography on
reference frame use across four Tseltal Mayan communities discussed in
the Findings section. As mentioned in the preceding section, a
statistic analysis based on linguistic, cognitive, population-
geographic, and topographic data from the communities of the MesoSpace
sample is currently underway. The application of so-called
multivariate descriptive statistics ? programs that generate spatial
models to visualize the patterns in a large data set ? to the study of
crosslinguistic variation is currently at the forefront of typological
research. The techniques and perspectives of statistical analysis the
MesoSpace researchers have been developing are genuinely new and of
ground-breaking potential in the field of semantic typology, the study
of variation and uniformity in how different languages represent
reality.

Contributions to Other Disciplines:

Spatial frames of reference are a subject studied across the cognitive
sciences, by linguists, anthropologists, psychologists, and computer
scientists. The project's contributions to the theory of spatial
frames discussed in the previous section are thus relevant to these
disciplines as well. In a similar vein, the linguistic relativity
hypothesis is of key concern, not merely to linguists, but to all
cognitive scientists. The group's efforts to isolate linguistic and
non-linguistic factors influencing reference use thus make a
contribution with a potential impact far beyond the discipline of
linguistics.

The surprising findings mentioned above regarding the intrinsic use of
vertical relators in some languages of the sample bear on the so-
called Principle of Canonical Orientation originally proposed by
Levelt 1984, according to which intrinsic frames of reference can only

be projected from reference entities that are in canonical vertical orientation. The MesoSpace findings provide the first-ever report of evidence to the effect that this principle may be language-specific.

Contributions to Human Resource Development:

The project contributes to the training and academic advancement of seven graduate students and five junior scholars who defended their dissertations within the four years since MesoSpace was launched. Six of these are Guatemalan or Mexican citizens; four of them are native speakers of indigenous languages; and six of them are women. In all, ten of the 22 members of the MesoSpace team are women and thirteen are citizens of Mexico or Guatemala.

Contributions to Resources for Research and Education:

The project has inspired intensive collaboration between the University at Buffalo, the Max Planck Institute for Psycholinguistics, the Centro de Investigaciones y Estudios Superiores en Antropologia Social (CIESAS) of Mexico, and the NSF-funded Spatial Intelligence and Learning Center (SILC). Collaboration has more recently begun with the Laboratorio de Linguistica of the Instituto de Investigaciones Antropologicas of the Universidad Nacional Autonoma de Mexico (UNAM) in Mexico City.

Contributions Beyond Science and Engineering:

Conference Proceedings

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Contributions: To Any Beyond Science and Engineering

Any Conference

Researcher	Language	Field site	Duration of stay	Participants per task						Male consultants (total)	Female consultants (total)	Total
				Picture book elicitation		Novel Objects matching tasks		Ball & Chair task	New Animals task			
				Part identi-fication	Local-ization wrt. parts	Part identi-fication	Local-ization wrt. parts					
Pilot	English	Buffalo, New York	Spring 2008							11	41	52
Juergen Bohnemeyer	Yucatec Maya	Yaxley, Quintana Roo, Mexico	6/8/08-7/29/08	7	3	5 x 2	5 x 2	5 x 2	18			
Alejandra Captistrán	P'orhépecha	Santa Fe de la Laguna, Municipio de Quiroga, Michoacán, Mexico	8/31/08-9/13/08	6	6	5 x 2	5 x 2	5 x 2	19	10	13	23
Susan Smythe Kung	Huehuetla Tepehua	Huehuetla, Hidalgo, Mexico	6/13/08-7/24/08	4	10	5 x 2	5 x 2	5 x 2	25	9	19	28
Juan Jesús Vázquez	Chol	Tila, Chiapas, Mexico	6/20/08-7/10/08	10	5	7 x 2	7 x 2	3 x 2	10			16
Salome Gutierrez Morales	Sierra Popoluca (Soteapanec)	Soteapan, Veracruz, Mexico	7/19/08-8/12/08	6	6	5 x 2	5 x 2	5 x 2	16	10	8	18
Elena Benedicto	Sumu/Mayangna	Rosita, Nicaragua	6/11/08-7/15/08	4	4	5 x 2	4 x 2	5 x 2	10	23	11	34
Carolyn O'Meara	Seri	El Desemboque del Rio San Ignacio, Sonora, Mexico	11/11/08-12/22/08	5	4	5 x 2	5 x 2	5 x 2	16	4	19	23
Valentin Peralta	Pajapan Nawat	Pajapan, Veracruz, Mexico	10/10/08-10/29/08	4	4	6x2	6x2	6x2		5	8	13
Veronica Vazquez	Cora	Presidio de los Reyes, Nayarit, Mexico	10/16/08-11/2/08	5	5	5x2	5x2	5x2	20	14	12	26
Roberto Zavala	Zoque	Tecpatan, Chiapas, Mexico	3/7/09-3/15/09	4	4	5 x 2	5 x 2	5 x 2	10	8	9	17
Gilles Polian	Tseltal	Mesbilja, Chiapas, Mexico	Feb-09			5x2	5x2	7x2	27	19	8	27
Gilles Polian	Tseltal	Cabecera Tenejapa, Chiapas, Mexico	3/20/2009-4/2009			5x2	5x2	5x2	19	4	15	19
Gilles Polian	Tseltal	Chacoma Tenejapa, Chiapas, Mexico	Sep-09					5x2	17	9	8	17
Enrique Palancar	Otomi	San Ildefonso Tultepec, Municipio de Amealco, Querétaro, Mexico	3/28/09-04/03/09	3	1	5 x 2	5 x 2	5 x 2	23	6	17	23
Gabriela Perez Baez	Juchiteco	La Ventosa, Juchitán de Zaragoza, Oaxaca, Mexico	May 20 - June 4 2009	12	12	6 x 2	6 x 2	6 x 2	27	12	15	27
Rodrigo Romero Mendez	Ayutla Mixe	Ayutla (San Pedro y San Pablo Ayutla), Oaxaca, Mexico	10/7/2008-11/3/2008, 7/17/2009-8/10/2009	5	5	5x2	5x2	5x2	16	5	15	20
Rodrigo Romero Mendez	Mexican Spanish	Santa Ines, Texcoco, Mexico	9/18/2009-present	6	0	6x2	6x2	6x2	9	4	9	13
Eladio Mateo Toledo	Q'anjob'al	Santa Eulalia, Huehuetenango, Guatemala	5/30/2009-6/25/2009	2	2	7x2	7x2	9x2	20	10	17	27
Total												423