# In search of areal effects in semantic typology:

## Reference frames in Mesoamerica

QAALT
KNAW, December 13-14, 2012

Jürgen Bohnemeyer[a] (jb77@buffalo.edu); Jesse S. Lovegren[a]; Katharine T. Donelson[a]; Elena Benedicto[b]; Alejandra Capistrán Garza[c]; Alyson Eggleston[b]; Nestor Hernández Green[d]; María de Jesús Selene Hernández Gómez[e]; Carolyn K. O'Meara[e]; Enrique Palancar[f]; Gabriela Pérez Báez[g]; Gilles Polian[h]; Rodrigo Romero Méndez[e]; Randi E. Tucker[a]; & Verónic Vázquez Soto[e]

(a) SUNY Buffalo; (b) Purdue University; (c) UAM; (d) CIESAS D.F.; (e) UNAM; (f) University of Surrey; (g) Smithsonian Institution; (h) CIESAS Sureste

University at Buffalo
The State University of New York

1

## Synopsis

- spatial reference frames in language contact
- MesoSpace: team, goals, tools
- the Ball & Chair study
- the distribution of the response variables
- the impact of the predictor variables
- discussion and future prospects

2

## Spatial reference frames in language contact

- two central questions
  - are practices of language use contact-diffused?
  - can such practices constitute areal features ?
- a domain in which to look for answers: **spatial frames of reference**

3



- background on reference frames
  - two kinds of *place functions* (Jackendoff 1983)
    - i.e., functions from reference entities into regions
      - *topological* (Piaget & Inhelder 1956) – perspective=frame-free
        - » means in practice independent of the orientation of the ground, the observer, and the figure-ground array (the configuration)

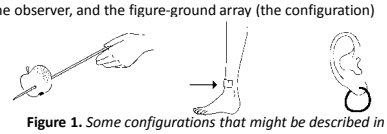


**Figure 1.** *Some configurations that might be described in terms of topological place functions*

(1.1) *The apple is on the skewer*
(1.2) *The band aid is on the shin*
(1.3) *The earring is in the ear (lobe)*



- *projective* –framework-dependent
  - the place function returns a region defined in a coordinate system centered on the reference entity
  - the axes of the coordinate system are derived from an **anchor**
    - » in **intrinsic** frames, the anchor is the reference entity
    - » in **relative** frames, it is the body of an observer
    - » in **absolute** frames, it is some environmental entity/feature

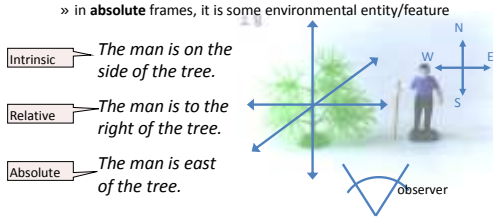



**Figure 2.** *The three types of spatial FoRs distinguished in Levinson 1996, 2003*



- alternative classifications and subtypes

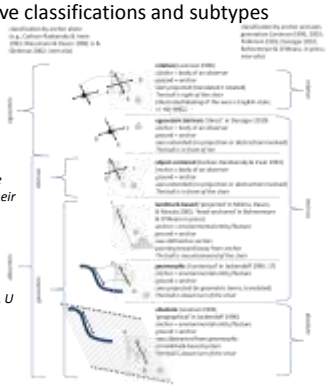


**Figure 3.** *Reference frame types and their classification (A - 'away from', B - 'back', D - 'downriver', F - 'front', L - 'left', R - 'right', T - 'toward', U - 'upriver'; Bohnemeyer & Levinson ms.)*

Spatial reference frames in language contact (cont.)

- finding: a great deal of crosslinguistic variation
  - in terms of both availability and preferences

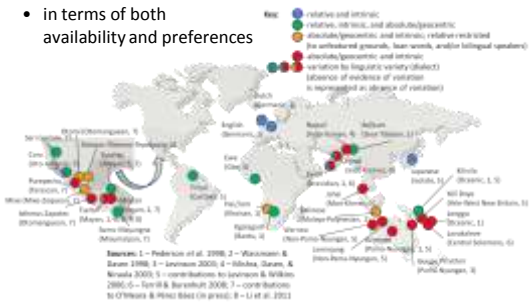
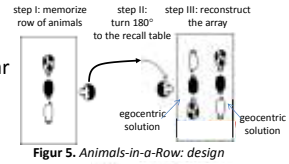


**Figure 4.** *Reference frame use in small-scale horizontal space across languages (Bohnemeyer & Levinson ms.)*

Spatial reference frames in language contact (cont.)

- alignment between language and cognition
  - preferences for particular frame types in discourse and recall memory covary




**Figur 5.** *Animals-in-a-Row: design*

**Table 1.** *Animals-in-a-Row in Levinson 2003: the large sample*

| | | | |
|---|---|---|---|
| **Linguistically Relative** | English, Dutch, Japanese, Tamil-Urban | *Prediction:* Non-verbal coding will be relative | N = 85 |
| **Linguistically Absolute** | Arrernte, Hai//om, Tzeltal, Longgu, Belhare, Tamil-Rural | *Prediction:* Non-verbal coding will be absolute | N= 99 |

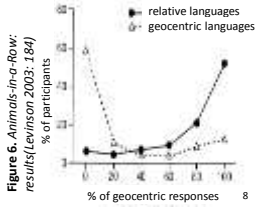



**Figure 6.** *Animals-in-a-Row: results(Levinson 2003: 184)*

Spatial reference frames in language contact (cont.)

- two competing interpretations

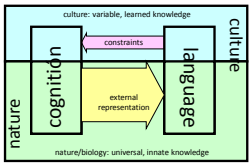



**Figure 7.** *The innatist vision*

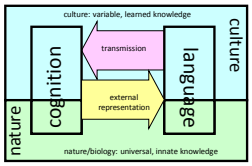



**Figure 8.** *The Neo-Whorfean vision*

**Innatist interpretation** (Li & Gleitman 2002; Li et al 2011; *inter alia)*
- innate knowledge of all FoR types
- variation only in usage preferences
- variation caused by adaptation to the environment - topography, population geography, education, literacy
- language plays no role in the cultural transmission of practices of spatial reference

**Neo-Whorfean interpretation** (Levinson 1996, 2003; Pederson et al 1998; *inter alia)*
- knowledge of some FoR types is culturally transmitted
- language plays a key role in the cultural transmission of practices of spatial reference
- the adaptation to the environment happens at the phylogenetic level, not at the ontogenetic level

Spatial reference frames in language contact (cont.)

- the role of language contact
  - the Neo-Whorfeans view language as a transmission system for nonlinguistic cognition
  - this suggests that not only a person's L1, but also their L2/3/…, may affect their cognition
  - experimental support: Boroditsky et al 2003
    - learning the grammatical gender system of a made up language influences English speaker's category associations
  - counterevidence: Finkbeiner et al 2003
    - Japanese-English bilinguals behave exactly like monolingual Japanese speakers on a manner/path similarity judgment task
      - even though Japanese is verb-framed, whereas English is satellite-framed

Spatial reference frames in language contact (cont.)

- but do reference frames diffuse through contact?
  - languages borrow from one another
    - phonetic, prosodic, phonotactic patterns; phonemes; morphemes; lexemes; lexical patterns; constructions
  - but reference frames are semantic patterns
    - which are only indirectly related to particular lexical items

| | true in which type of FoR? | |
|---|---|---|
| *The ball is in front of the chair* | relative | intrinsic |
| *The ball is left of the chair* | intrinsic | relative |

**Figure 9.** *Truth conditions of intrinsic and relative descriptions of Ball & Chair 3.9 (left) and 3.12*

Spatial reference frames in language contact (cont.)

- our test case: the Mesoamerican *sprachbund*

**Figure 10.** *Mesoamerican language map (contemporary distribution) source: http://en.wikipedia.org/wiki/Image:Mesoamericanlanguages.png; lines showing approximate boundaries of Mesoamerican area added by the authors*

Spatial reference frames in language contact (cont.)

- possible areal features according to Campbell 1979, Campbell, Kaufman, & Smith-Stark 1986
  - lack of phonemic voicing contrasts in stops and fricatives
    - shared throughout MA, with only a few exceptions
      - including Tequistlatec, Huave, and some OM
    - neighbors to the north (e.g., O' odham; Tarahumara) and south (e.g., Sumu, Mískito; Chibchan) do have them
  - no V-final constituent orders except in Mixean
    - Yuman and most Uto-Aztecan languages to the north and Chibchan and Misumalpan to the south are V-final
    - correlated with the absence of V-final order, adnominal possessors predominantly follow the possessum
      - not so in Sumu and Mískito to the south of MA; not in most UA languages to the north of MA

Spatial reference frames in language contact (cont.)

- possible areal features (cont.)
  - few or no adpositions
    - relational nouns and applicatives used instead
  - semantic calques
    - this includes the vigesimal numeral system and a rich set of meronymic metaphors

**Table 1.**
*Some pan-MA calques (CK&S-S p. 553)*

Spatial reference frames in language contact (cont.)

- particularly interesting for our purposes
  - the vigesimal system and the meronym calques at least *suggest* contact-diffused usage practices
    - although the effect is in this case "set" in the meanings of lexical items
  - the role of Spanish as the dominant contact language of the area
    - relative frames of reference play only a minor role in many Mesoamerican languages
      - cf. the contributions to O'Meara & Pérez Báez (eds.) 2011 and references therein
    - in contrast, Spanish as a European language favors relative frames in small-scale space
      - cf. Eggleston 2012 on Peninsular (Barcelonan) and Nicaraguan Spanish in comparison to Sumu-Mayangna

## Synopsis

- spatial reference frames in language contact
- MesoSpace: team, goals, tools
- the Ball & Chair study
- the distribution of the response variables
- the impact of the predictor variables
- discussion and future prospects

16

## MesoSpace: team, goals, tools

- NSF award #BCS-0723694
  *Spatial language and cognition in Mesoamerica*
- MesoSpace aims to contribute to the debate from two angles
  - we are working on a series of studies that pit linguistic against non-linguistic predictors
    - in reference frame use across languages
  - we are also investigating a possible lexico-syntactic factor that may bias speakers against relative FoRs
    - namely the productive use of shape-based meronyms in the representation of space

MesoSpace: team, goals, tools (cont.)

- 14 Mesoamarican (MA) languages
  - Mayan
    - Chol (J.-J. Vázquez)
    - K'anjob'al (E. Mateo)
    - Tseltal (several variants; G. Polian)
    - Yucatec (J. Bohnemeyer)
  - Mixe-Zoquean
    - Ayutla Mixe (R. Romero)
    - Soteapanec (S. Gutierrez)
    - Tecpatán Zoque (R. Zavala)
  - Oto-Manguean
    - Isthmus (Juchitán) Zapotec (G. Pérez)
    - Otomí (N. Hernández, S. Hernández, E. Palancar)
  - Huave (S. Herrera)
  - Purépecha (A. Capistrán)
  - Totonac-Tepehuan
    - Huehuetla Tepehua (S. Smythe)
  - Uto-Aztecan
    - Pajapan Nawat (V. Peralta)

**Figure 11.** *MesoSpace Field sites*

18

MesoSpace: team, goals, tools (cont.)

- non-MA "controls"
  - Seri (C. O'Meara)
  - Cora (Uto-Aztecan; V. Vázquez)
  - Mayangna (E. Benedicto, A. Eggleston in collaboration with the Mayangna Yulbarangyang Balna)
  - Mexican, Nicaraguan, and Barcelonan Spanish (R. Romero; E. Benedicto, A. Eggleston)
- 2 (interrelated) domains
  - **frames of reference** and **meronyms** (labels for entity parts)

**Figure 12.** The *MesoSpace team (minus V. Peralta and R. Tucker)*

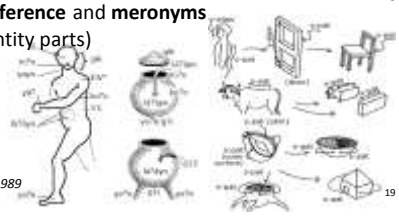


**Figure 13.** *Meronyms in Ayoquesco Zapotec (left) and Tenejapa Tseltal (adapted from MacLaury 1989 and Levinson 1994)*

19

# Synopsis

- spatial reference frames in language contact
- MesoSpace: team, goals, tools
- the Ball & Chair study
- the distribution of the response variables
- the impact of the predictor variables
- discussion and future prospects

20

# The Ball & Chair study

- our tool for studying the use of FoRs in discourse
  - a referential communication task: Ball & Chair (B&C)
    - replacing Men & Tree (M&T) in Pederson et al (1998) etc.
    - B&C allows us to discover selection preferences for any of the FoR types
      - » at the in-door scale
      - » M&T may for various reasons depress the use of intrinsic FoRs

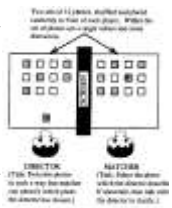


**Figure 14.** *Design of the Men and Tree task (Pederson et al. 1998: 562)*

**Figure 15.** *Two of the Ball & Chair fotos, featuring an intrinsic contrast*

21

The Ball & Chair study (cont.)

- the data set of the present study
  - B&C data from 11 varieties
    - 6 Mesoamerican languages
      - Yucatec Maya (J. Bohnemeyer)
      - Ayutla Mixe (R. Romero)
      - San Ildefonso Tultepec Otomí (N. Hernández, S. Hernández, E. Palancar)
      - Purépecha (or Tarascan; A. Capistrán)
      - Chacoma Tseltal (G. Polian)
      - Juchitán (Isthmus) Zapotec (G. Pérez)
    - 2 non-Mesoamerican indigenous lenguages
      - Seri (C. O'Meara)
      - Sumu-Mayangna (E. Benedicto, A. Eggleston, Mayangna Yulbarangyang Balna)
    - 3 varieties of Spanish
      - from Barcelona (A. Eggleston), Mexico (R. Romero), and Nicaragua (A. Eggleston)

22

The Ball & Chair study (cont.)

- these are all the languages of the MesoSpace sample the data from which have been coded so far
- data from five dyads of participants per variety are included in the analysis
  - except for the case of
    - Mexican Spanish, where up to now only the data from three of the five dyads have been coded
    - Istmus Zapotec, where we have data from six dyads
- responses are accompanied by the researchers' estimates of the participants'
  - level of education
  - frequency of use of Spanish (as first or second language)
  - frequency of reading and writing

23

The Ball & Chair study (cont.)

- coding
  - we coded descriptions of the location of the ball
    - distinguishing among eight categories (see Figure 3 above)
      - allocentric intrinsic
      - egocentric intrinsic ('direct'; Danziger 2010)
      - egocentric extrinsic = relative
      - intrinsic and relative *aligned* (Carlson-Radvansky & Irvin 1993)
      - geocentric (= geomorphic, landmark-based, or absolute)
      - vertical absolute
      - vertical absolute and intrinsic aligned (Carlson-Radvansky & Irvin 1993)
      - topological (no reference frame involved; Piaget & Inhelder 1956)

24

The Ball & Chair study (cont.)

- all of the languages in the sample have the lexical and grammatical resources for using all FoR types
  - in no case does the grammar or lexicon of the language constrain the use of particular frame types
  - a given speech community's preferences for using particular frame types are strictly a matter of usage
    - they are a part of the community's practices of language use
  - the question the studies reported here address is this:
    - does the frame use of individual speakers reflect not only the practices of their L1 speech community
      - but also those of communities whose languages they use as L2 speakers?

25

The Ball & Chair study (cont.)

- the similarity matrix
  - for each participant, we calculated a set of eight frequencies
  - these sets can be interpreted as points in an octodimensional space
  - the distances between the points represent the similarity across the participants' responses
  - we calculated the distances in the "Manhattan" metric
    - where the distance between two points is the sum of the differences of the coordinates
  - we can use this similarity measure to analyze
    - how the responses cluster
    - which factors predict the similarity between participants

26

The Ball & Chair study (cont.)

- the similarity matrix (cont.)
  - innovation
    - previous multivariate analyses in semantic typology construct similarity matrices over the stimulus items
      - cf. Levinson & Meira 2003; Majid et al 2008
    - in contrast, our approach treats the (dyads of) participants as statistical units
    - this allows us to treat language as a direct predictor variable

27

## Synopsis

- spatial reference frames in language contact
- MesoSpace: team, goals, tools
- the Ball & Chair study
- the distribution of the response variables
- the impact of the predictor variables
- discussion and future prospects

28

## The distribution of the response variables

- how do the participants' responses cluster?
  - MDS analysis shows two broad groups
    - cf. Schiffman et al 1981

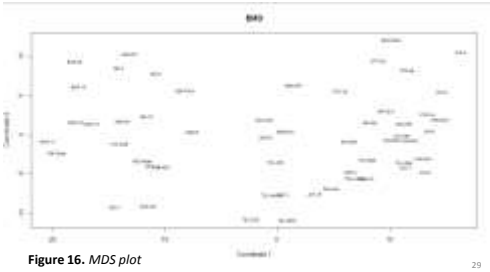


**Figure 16.** *MDS plot*

29

MDS analysis (cont.)

- a strong correlation emerges b/w the dimension of the MDS plot and the use of geocentric frames
  - » Spearman's Rho 0.95
  - and weaker negative correlation between the first dimension and the use of relative frames
    - » Spearman's Rho -0.8
- the second dimension shows a weak correlation with the frequency of topological descriptions
  - » Spearman's Rho 0.79

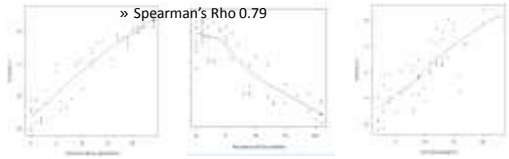


**Figure 17.** *Correlations between the dimensions of the MDS plot and the frequency of geocentric (left), relative (center), and topological (right) descriptions.*

30

Enter MesoSpace (cont.)

– the effect of relative and geocentric usage can also be visualized in a Neighbor-net of the similarity matrix
  • using Splitstree4 (cf. Hudson & Bryant 2006)

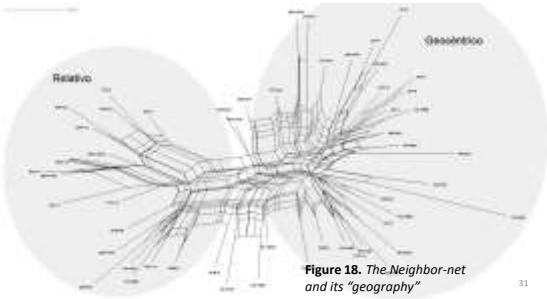



**Figure 18.** *The Neighbor-net and its "geography"*



MDS analysis (cont.)

- discussion
  – the MDS and Neighbor-net analyses show
    • that the participants differentiated themselves most strongly in their use of relative, geocentric, and topological descriptions
  – the question now: which factors predict which of these strategies a speaker/dyad selects?
    • candidate predictor variables:
      ① L1
      ② L2 (… Ln)
      ③ literacy
      ④ education
      ⑤ topography
      ⑥ population geography
    • the linear regression we present in the following tests (1) – (4)



## Synopsis

- spatial reference frames in language contact
- MesoSpace: team, goals, tools
- the Ball & Chair study
- the distribution of the response variables
- the impact of the predictor variables
- discussion and future prospects



## The impact of the predictor variables

- to analyze the role of the predictor variables we conducted a linear regression analysis
- we tested separate models for the strongest differentiating response variables
  • the use of relative and geocentric frames
- we modeled the geocentric and relative FoR scores
  – of just the speakers of the indigenous languages
  – as a function of education level, literacy level, L2-Spanish usage level
    • and areal-linguistic affiliation: Mesoamerican vs. non-Mesoamerican



Linear regression analysis (cont.)

- implementation
  – we used a generalized linear **mixed-effects** model (GLMM; cf. Gelman & Hill 2007, Jaeger 2008)
    • implemented using the ARM package in R (Gelman et al 2012)
  – it is a 'mixed-effects' model in that it includes random nested intercepts for individual languages and dyads
    – in addition to the 'fixed' effects of the predictor variables and an invariable intercept
    • to avoid over-fitting or lack of independence
  – the probability of a given dyad using any of the eight response categories to describe a particular picture
    • is independent of the probability of them using any other type of frame to describe the same picture



Linear regression analysis (cont.)

- findings
  – the fitted geocentric model revealed L2-Spanish use and literacy as significant factors

```
Generalized linear mixed model fit by the Laplace approximation
Formula: Lgeoc ~ edu + esp + lit + Ltyp + (1 | ID) + (1 | LANG)
   Data: ..1
  AIC  BIC logLik deviance
 1559 1598 -772.7     1545
Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 1.6226   1.2738
 LANG   (Intercept) 2.0463   1.4305
Number of obs: 1787, groups: ID, 82; LANG, 8
Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.0799     1.3550  -0.797   0.4255
edu          -0.4788     0.4951  -0.967   0.3335
esp          -0.8469     0.3353  -2.526   0.0115 *
lit           1.1892     0.4836   2.459   0.0139 *
LtypMES       0.3375     1.2535   0.269   0.7878
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Correlation of Fixed Effects:
            (Intr) edu    esp    lit
edu         -0.006
esp         -0.477 -0.174
lit         -0.165 -0.739 -0.034
LtypMES     -0.735 -0.050  0.010  0.152
```

Linear regression analysis (cont.)

- findings (cont.)
  - the fitted relative model revealed only L2-Spanish use as significant

```
Generalized linear mixed model fit by the Laplace approximation
Formula: Lrel ~ edu + esp + lit + Ltyp + (1 | ID) + (1 | LANG)
   Data: ..1
  AIC  BIC logLik deviance
 1422 1461 -704.1     1408
Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 0.44961  0.67053
 LANG   (Intercept) 0.14426  0.37981
Number of obs: 1787, groups: ID, 82; LANG, 8

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -2.43468    0.57355  -4.245 2.19e-05 ***
edu         -0.20378    0.28745  -0.709   0.4784
esp          0.45204    0.19250   2.348   0.0189 *
lit          0.05716    0.28627   0.200   0.8417
LtypMES     -0.58065    0.40908  -1.419   0.1558
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) edu    esp    lit
edu         -0.022
esp         -0.630 -0.154
lit         -0.171 -0.755 -0.076
LtypMES -0.588 -0.074 -0.040  0.250
```



Linear regression analysis (cont.)

- findings
  - our GLMMs did not find a significant effect of the areal-linguistic affiliation variable
    - Wald-p = .79 for the geocentric and .16 for the relative model
- discussion
  - the speakers of the indigenous languages use relative frames in their native languages more frequently
    - the more frequently they use Spanish as an L2
  - this suggests that habituation to the use of relative frames diffuses through contact with Spanish
  - our failure to find evidence of an areal effect caused us to conduct further analyses



Linear regression analysis (cont.)

- probing the lack of evidence for an areal effect
  - we ran a cluster analysis of the original similarity matrix
    - including the data from the L1-Spanish speakers
  - we applied an agglomerative algorithm using the 'cluster' and 'MASS' packages in R

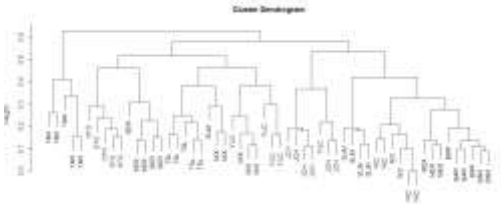


**Figure 19.** *Cluster analysis dendrogram of the similarity matrix of the Ball & Chair data.*



Linear regression analysis (cont.)

- findings
  - the individual languages tend to form cohesive clusters
  - the speakers of the three Spanish dialects form a single cluster
  - however, the speakers of the Mesoamerican languages do not form a single cluster
    - to the exclusions of the speakers of the non-MA indigenous languages

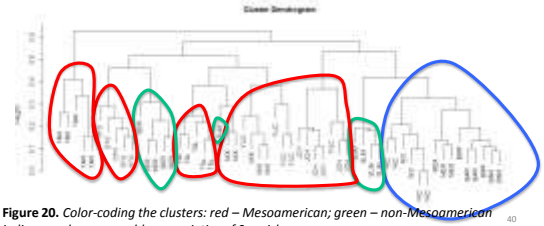


**Figure 20.** *Color-coding the clusters: red – Mesoamerican; green – non-Mesoamerican indigenous languages; blue – varieties of Spanish.*



## Synopsis

- spatial reference frames in language contact
- MesoSpace: team, goals, tools
- the Ball & Chair study
- the distribution of the response variables
- the impact of the predictor variables
- discussion and future prospects



## Discussion and future prospects

- estimated frequency of L2 Spanish use is a significant predictor of the use of relative frames
  - by speakers of the indigenous languages in the sample
    - so is literacy, but not education
- this finding supports the hypothesis that reference frame types diffuse through language contact
- in contrast, we did not find evidence for an areal effect
  - the speakers of the Mesoamerican languages distinguish themselves from the speakers of the Spanish varieties
    - but not clearly from the speakers of the two non-Mesoamerican indigenous languages Seri and Sumu

Discussion and future prospects (cont.)

- by hypothesis, any feature that can be contact-diffused should also be able to be areally shared
  - so our failure to find an areal effect seems to call for an explanation
- possible factors
  - sampling artifact
    - the use of reference frames in Seri and/or Sumu could be accidentally so similar to that in some MA languages
      - as to mask a possible areal effect
  - effects of current vs. historic contact
    - whereas the effect of Spanish on the use of reference frames may be ongoing, a *sprachbund* effect likely not
      - since the MA *sprachbund* is no longer "active" in many regions

43

Discussion and future prospects (cont.)

- the Mesoamerican linguistic area as a *fossilized sprachbund*
  - the contact that caused the convergence of linguistic features in MA unfolded mostly in pre-Columbian times
  - at present, contact among indigenous languages is mostly restricted to certain hotspots
    - chiefly, to parts of Oaxaca, Chiapas, and Guatemala
  - none of the indigenous languages of the MesoSpace subsample are currently in contact with one another
  - given the evidence for intra-variety mutability of reference frame use…
    - cf. Pederson et al 1998; Mishra et al 2003
    - … it stands to reason that areal effects in frame use that may have existed prior to the Conquest are no longer visible

44

Discussion and future prospects (cont.)

- what's next?
  - include data from additional Mesoamerican languages in the analysis
  - run a second analysis based on speakers' self-estimations of Spanish use, literacy, and education
  - run similar analyses on the recall memory data
  - extend all of the above to languages from other parts of the world
    - as part of the new project *Spatial Language and Cognition* ***Beyond*** *Mesoamerica* ☺
      - NSF Award No. BCS-1053123
      - http://www.acsu.buffalo.edu/~jb77/Mesospace1b.html

45

## Acknowledgements


- we would like to thank
  - … our teachers and consultants, the speakers of the lenguages the MesoSpace team has been studying
  - … our colleagues, the members of the MesoSpace team
  - … the National Science Foundation, for the necessary resources to realize these studies
  - … the institutions who have partnered with MesoSpace to lend us support, CIESAS and the MPI for Psycholinguistics
  - … Matthew Dryer, Jeff Good, Marianne Gullberg, Florian Jaeger, Steve Levinson, David Mark, and Wolfgang Wölck
    - and the members of the UB Semantic Typology Lab, for advise
  - … the QAALT organizers
  - … you!


46


## References


Bickel, B. (2010). Capturing particulars and universals in clause linkage: a multivariate analysis. In I. Bril (Ed.), *Clause-hierarchy and clause-linking: the syntax and pragmatics interface*. Amsterdam: John Benjamins. 51 101.

Bohnemeyer, J. (2011). Spatial frames of reference in Yucatec: Referential promiscuity and task-specificity. *Language Sciences 33*(6): 892–914.

Bohnemeyer, J. & S. C. Levinson. (ms). Framing Whorf: A response to Li et al. 2011. *Cognition*.

Bohnemeyer, J. & C. O'Meara. (2012). Vectors and frames of reference: Evidence from Seri and Yucatec. In L. Filipović & K. M. Jaszczolt (Eds.), *Space and Time across Languages and Cultures*. Amsterdam: John Benjamins.

Bohnemeyer, J., E. Benedicto, A. Capistrán Garza, K. Donelson, A. Eggleston, N. Hernández-Green, S. Hernández-Gómez, J. Lovegren, C. O'Meara, E. Palancar, G. Pérez Báez, G. Polian, R. Romero, R. Tucker & V. Vázquez. (2012). Marcos de referencia en lenguas mesoamericanas: Un análisis multivariante tipológico. *Proceedings from CILLA V: the Conference on the Indigenous Languages of Latin America*.

Bryant, D. & V. Moulton. (2004). Neighbor-Net: An agglomerative method for the construction of phylogenetic networks. *Molecular Biology and Evolution 21*(2): 255–265.

Carlson-Radvansky, L. A. & D. E. Irwin. (1993). Frames of reference in vision and language: Where is above? *Cognition 46*: 223–244.

Cysouw, M. (2007). New approaches to cluster analysis of typological indices. In R. Köhler & P. Grzbek (Eds.), *Exact Methods in the Study of Language and Text*. Berlin: Mouton de Gruyter. 61–76.

Danziger, E. (2010). Deixis, gesture, and cognition in spatial Frame of Reference typology. *Studies in Language 34*(1): 167–185.

Gelman, A. & J. Hill. (2007). *Data Analysis Using Regression and Multilevel/Hierarchical Models.* Cambridge University Press.

Gelman, A., Y. Su, M. Yajima, J. Hill, M. Grazia Pittau, J. Kerman & T. Zheng. (2012). arm: Data Analysis Using Regression and Multilevel/Hierarchical Models. R package version 1.5-03. http://CRAN.R-project.org/package=arm

Huson, D. H. & D. Bryant. (2006). Application of phylogenetic networks in evolutionary studies. *Molecular Biology and Evolution 23*(2): 254–267.

Jackendoff, R. S. (1983). *Semantics and cognition*. Cambridge, MA: MIT Press.

Jaeger, T. F. (2008). Categorical Data Analysis: Away from ANOVAs (transformation or not) and towards Logit Mixed Models. *Journal of Memory and Language 59*(4): 434–446.


48

References (cont.)

Levinson, S. C. (1994). Vision, shape, and linguistic description: Tzeltal body-part terminology and object description. In S. C. Levinson & J. B. Haviland (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 P. Bloom, M. A. Peterson, L. Nadel & M. F. Garrett (Eds.), *Language and space*. Cambridge, MA: MIT Press. 109–169.

Levinson, S. C. (2003). *Space in language and cognition*. Cambridge, UK: Cambridge University Press.

Levinson, S. C. & S. Meira. (2003). 'Natural concepts' in the spatial topological domain - adpositional meanings in crosslinguistic perspective: An exercise in semantic typology. *Language 79*(3): 485–516.

Levinson, S. C. & D. P. Wilkins. (2006). *Grammars of space*. Cambridge: Cambridge University Press.

Li, P. & L. Gleitman. (2002). Turning the tables: Language and spatial reasoning. *Cognition 83*: 265-294.

Li, P., L. Abarbanell, L. Gleitman & A. Papafragou. (2011). Spatial reasoning in Tenejapan Mayans. *Cognition 120*: 33–53.

MacLaury, R. E. (1989). Zapotec body-part locatives: prototypes and metaphoric extensions. *International Journal of American Linguistics 55*: 119-154.

Majid, A., J. S. Boster & M. Bowerman. (2008). The cross-linguistic categorization of everyday events: A study of cutting and breaking. *Cognition 109*(2): 235–250.

Mishra, R.C., P. R. Dasen & S. Niraula. (2003). Ecology, language, and performance on spatial cognitive tasks. *International Journal of Psychology 38*: 366-383.

O'Meara, C. & G. Pérez Báez. (2011). Spatial frames of reference in Mesoamerican languages. *Language Sciences 33*: 837–852.

Pederson, E. (1993). Geographic and manipulable space in two Tamil linguistic systems. In A. U. Frank & I. Campari (Eds.), *Spatial information theory*. Berlin: Springer. 294–311.

Pederson, E., E. Danziger, D. P. Wilkins, S. C. Levinson, S. Kita & G. Senft. (1998). Semantic typology and spatial conceptualization. *Language 74*: 557–589.

Piaget, J. & B. Inhelder. (1956). *The child's conception of space*. London: Routledge.

R Development Core Team. (2011). *R: A Language and Environment for Statistical Computing*, R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org. ISBN 3-900051-07-0.

Terrill, A. & N. Burenhult. (2008). Orientation as a strategy of spatial reference. *Studies in Language 32*(1): 93–116.

Schiffman, S. S., M. L. Reynolds & F. W. Young. (1981). *Introduction to multidimensional scaling: Theory, methods and applications*. New York: Academic Press.

Wassmann, J. & P. R. Dasen. (1998). Balinese spatial orientation: Some empirical evidence for moderate linguistic relativity. *The Journal of the Royal Anthropological Institute 4*(1): 689–711.