Reference frames in Mesoamerica:

Linguistic and non-linguistic factors

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Synopsis

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

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Spatial reference frames in language, culture, and cognition

- two central questions
  - what is the role of culture in cognition?
  - does speaking particular languages influence the way the speakers think?
- a domain in which to look for answers: **spatial frames of reference**

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

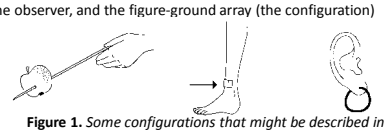

Figure 1. *Some configurations that might be described in terms of topological place functions*

(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

Intrinsic — *The man is on the side of the tree.*
Relative — *The man is to the right of the tree.*
Absolute — *The man is east of the tree.*

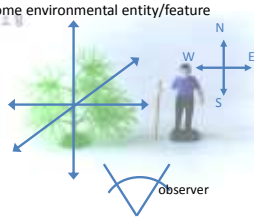

Figure 2. *The three types of spatial FoRs distinguished in Levinson 1996, 2003*

- alternative classifications and subtypes

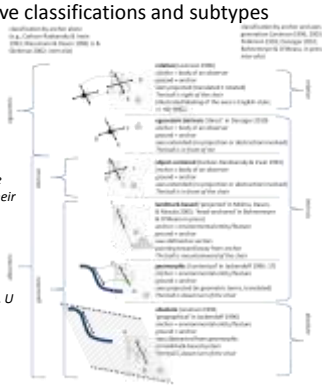

Figure 3. *Reference frame types and their classification (A - 'away from', B - 'back', D - 'downriver', F - 'front', L - 'left', R - 'right', T - 'toward', U - 'upriver'; Bohnemeyer & Levinson ms.)*

Spatial reference frames in language, culture, and cognition (cont.)

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

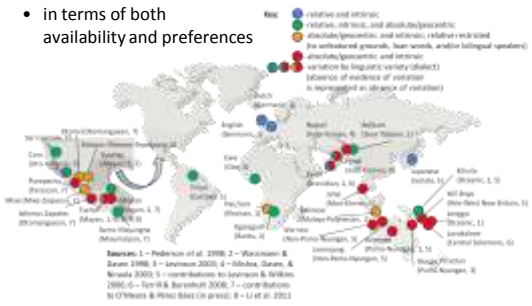

Figure 4. *Reference frame use in small-scale horizontal space across languages (Bohnemeyer & Levinson ms.)*

Spatial reference frames in language, culture, and cognition (cont.)

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

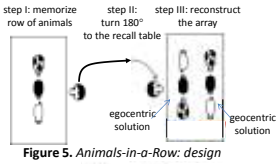

Figure 5. *Animals-in-a-Row: design*

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

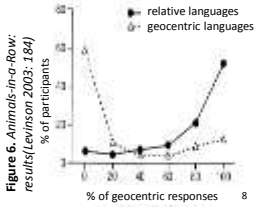

Figure 6. *Animals-in-a-Row: results (Levinson 2003: 184)*

Spatial reference frames in language, culture, and cognition (cont.)

- two competing interpretations

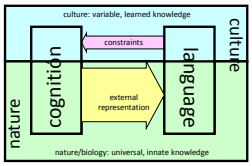

Figure 7. *The innatist vision*

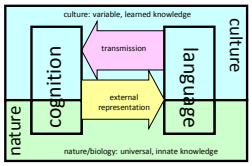

Figure 8. *The Neo-Whorfean vision*

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

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- spatial reference frames in language, culture, and cognition
- MesoSpace: team, goals, tools
- the Ball & Chair study
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- discussion and future prospects

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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 9. *MesoSpace: Field sites*

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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. Eggle :on)
- 2 (interrelated) domains
  - **frames of reference** and **meronyms** (labels for entity parts)

Figure 10. The *MesoSpace team (minus V. Peralta and R. Tucker)*

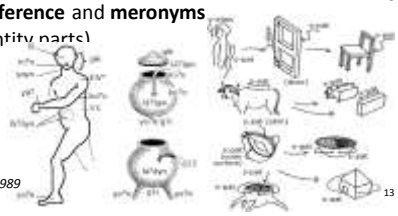

Figure 11. *Meronyms in Ayoquesco Zapotec (left) and Tenejapa Tseltal (adapted from MacLaury 1989 and Levinson 1994)*

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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

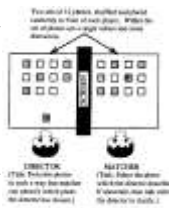

Figure 12. *Design of the Men and Tree task (Pederson et al. 1998: 562)*

Figure 13. *Two of the Ball & Chair fotos, featuring an intrinsic contrast*

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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)

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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

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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)

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

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The Ball & Chair study (cont.)

- 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/dyads reflect the practices of the community
    - and those of communities whose languages they use as L2 speakers
  - or does it depend exclusively on the speaker's level of education and literacy?

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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

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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

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The distribution of the response variables

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

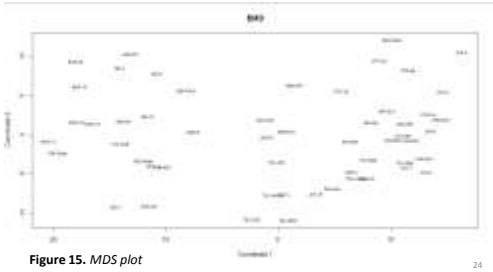

Figure 15. *MDS plot*

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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

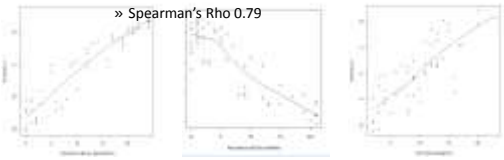

Figure 16. *Correlations between the dimensions of the MDS plot and the frequency of geocentric (left), relative (center), and topological (right) descriptions.*

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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)

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The impact of the predictor variables

- to analyze the role of the predictor variables we conducted several linear regression analyses
- we tested separate models for the strongest differentiating response variables
  - – the use of relative and geocentric frames
- we tested these models for two sets of populations
  - – on all 11 populations
    - with the predictor variables areal-linguistic affiliation (see below!), literacy, and education
  - – on the speakers of the indigenous languages only
    - now including the L2 use of Spanish as a predictor variable

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The impact of the predictor variables (cont.)

- the areal-linguistic affiliation variable
  - – our dataset includes too many individual languages for a parsimonious model
  - – therefore, we grouped the languages according to areal-linguistic affiliation
    - yielding a three-level variable for the 11-populations models
      - – languages of the Mesoamerican *sprachbund*, Spanish, and the two non-Mesoamerican indigenous languages
    - and a two-level variable for the models that include the responses from the speakers of the indigenous languages only
      - – Mesoamerican *sprachbund* languages vs. non-Mesoamerican indigenous languages (Seri and Sumu)

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The impact of the predictor variables (cont.)

- the areal-linguistic affiliation variable (cont.)
  - – the Mesoamerican linguistic area
    - cf. Campbell 1979; Campbell et al 1986

Figure 18. *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*

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The impact of the predictor variables (cont.)

- implementation
  - we used generalized linear mixed-effects models (GLMM; cf. Gelman & Hill 2007, Jaeger 2008)
    - implemented using the ARM package in R (Gelman et al 2012)
  - 'mixed-effects' models b/c they include 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

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The impact of the predictor variables (cont.)

- findings I: GEO, L1-Spanish speakers incl.
  - the fitted geocentric model revealed linguistic affiliation and literacy, but not education, as significant factors
    - there was no effect from membership in the MA *sprachbund*

```
Generalized linear mixed model fit by the Laplace approximation
Formula: Lgeoc ~ (1 | ID) + (1 | LANG) + edu + Ltyp + lit
   Data: ...1
  AIC  BIC logLik deviance
 1784 1825  -885     1770
Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 1.77909  1.33381
 LANG   (Intercept) 0.15166  0.38944
Number of obs: 2468, groups: ID, 109; LANG, 11

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -3.0691     0.6077  -4.935 8.02e-07 ***
edu         -0.6906     0.4709  -1.467  0.14248
LtypESP     -3.0226     0.6907  -4.376 1.21e-05 ***
LtypMES      0.9000     0.5493   1.640  0.10099
lit          1.3133     0.5014   2.619  0.00881 **
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Correlation of Fixed Effects:
            (Intr) edu    LtyESP LtyMES
edu          0.015
LtypESP     -0.379 -0.133
LtypMES     -0.630 -0.150  0.688
lit         -0.368 -0.004  0.051  0.306
```

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The impact of the predictor variables (cont.)

- findings II: REL, L1-Spanish speakers incl.
  - the fitted relative model revealed linguistic affiliation as the sole significant factor
    - there was no evidence of an areal effect

```
Generalized linear mixed model fit by the Laplace approximation
Formula: Lrel ~ (1 | ID) + (1 | LANG) + edu + Ltyp + lit
   Data: ...1
  AIC  BIC logLik deviance
 2308 2348 -1097     2194
Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 0.71824  0.84755
 LANG   (Intercept) 0.10677  0.32999
Number of obs: 2410, groups: ID, 110; LANG, 11

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.5700     0.4571  -3.435 0.000592 ***
edu         -0.1694     0.3021  -0.557 0.577328
LtypESP      1.3228     0.4367   3.029 0.002451 **
LtypMES     -0.5822     0.4069  -1.382 0.167073
lit          0.1261     0.3101   0.407 0.684163
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Correlation of Fixed Effects:
            (Intr) edu    LtyESP LtyMES
edu         -0.144
LtypESP     -0.481 -0.149
LtypMES     -0.789 -0.004  0.568
lit         -0.322 -0.779  0.002  0.274
```

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The impact of the predictor variables (cont.)

- findings III: GEO, L1-Spanish speakers excl.
  - the fitted geocentric model showed literacy as the sole significant factor

```
Generalized linear mixed model fit by the Laplace approximation
Formula: Lgeoc ~ (1 | ID) + (1 | LANG) + edu + Ltyp + esp + lit
   Data: BC.SDec.sesTsseltal.noSpanish
  AIC  BIC logLik deviance
 1672 1710 -828.9     1658
Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 1.59743  1.26389
 LANG   (Intercept) 0.60988  0.78092
Number of obs: 1845, groups: ID, 81; LANG, 8

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.8847     0.9264  -2.034  0.04190 *
edu         -0.5401     0.4922  -1.120  0.26287
LtypMES      0.7564     0.7769   0.966  0.33415
esp         -0.5436     0.2823  -1.925  0.05420 .
lit          1.3006     0.4934   2.636  0.00839 **
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Correlation of Fixed Effects:
            (Intr) edu    LtyMES esp
edu          0.097
LtypMES     -0.733 -0.082
esp         -0.511 -0.240  0.029
lit         -0.241 -0.785  0.220 -0.037
```

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The impact of the predictor variables (cont.)

- findings IV: REL, L1-Spanish speakers excl.
  - the fitted relative model showed the use of L2 Spanish as the sole significant factor

```
Generalized linear mixed model fit by the Laplace approximation
Formula: Lrel ~ (1 | ID) + (1 | LANG) + edu + Ltyp + esp + lit
   Data: BC.SDec.sesTsseltal.noSpanish
  AIC  BIC logLik deviance
 1428 1467 -707.1     1414
Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 0.46167  0.67946
 LANG   (Intercept) 0.13858  0.37236
Number of obs: 1840, groups: ID, 81; LANG, 8

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -2.41519    0.52152  -4.631 3.64e-06 ***
edu         -0.19986    0.30713  -0.651   0.5152
LtypMES     -0.56041    0.40771  -1.375   0.1693
esp          0.43361    0.17372   2.497   0.0125 *
lit          0.06992    0.31463   0.213   0.8310
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Correlation of Fixed Effects:
            (Intr) edu    LtyMES esp
edu          0.096
LtypMES     -0.675 -0.067
esp         -0.545 -0.256 -0.016
lit         -0.368 -0.799  0.240 -0.036
```

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The impact of the predictor variables (cont.)

- discussion: the role of the first language
  - the L1-Spanish speakers differed significantly from the speakers of the indigenous languages
    - using relative frames overall much more frequently and geocentric frames overall much less frequently
  - this contribution of L1 cannot be reduced to a combination of any of the other factors
    - to this extent contra Li & Gleitman 2002

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The impact of the predictor variables (cont.)

- discussion: the role of the second language
  - 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
    - consistent with the Neo-Whorfeans view of language as a transmission system for nonlinguistic cognition

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The impact of the predictor variables (cont.)

- discussion: the role of the nonlinguistic factors
  - literacy, assessed in terms of the frequency of reading and writing, is a significant predictor of frame use
    - this variable makes a significant independent contribution to the use of geocentric frames, but not to that of relative ones
      - presumably, speakers who read and write more frequently are less likely to use geocentric frames
  - in contrast, we did not find any effect of education
  - overall, this picture is consistent with the varying role of education and literacy across our sample
    - some of the indigenous populations have high education scores across the board
      - and nevertheless use geocentric frames more frequently than relative ones
      - especially the Isthmus Zapotec and Sumu-Mayangna communities

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The impact of the predictor variables (cont.)

- discussion: the role of the Mesoamerican area
  - our GLMMs found significant differences b/w the speakers of Spanish and the indigenous languages…
  - … but not b/w the Mesoamerican and the non-Mesoamerican indigenous languages
  - we thus did not find any evidence of an areal effect
  - given that we *did* find evidence of contact diffusion of the use of relative frames
    - we decided to probe this lack of evidence of a *sprachbund* effect further

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The impact of the predictor variables (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.*

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The impact of the predictor variables (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.*

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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

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Discussion and future prospects

- language as an influence on frame use
  - linear regressions of data from speakers of 11 varieties suggest that L1 is an irreducible factor in frame selection
    - a speaker's first language is a powerful predictor of their probability of using relative and geocentric frames
      - more specifically, speaking any variety of Spanish predicts a very different usage profile from speaking any indigenous language
    - this effect of first language cannot be reduced to effects of literacy and education
  - this finding conforms to the Neo-Whorfian predictions

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Discussion and future prospects (cont.)

- estimated frequency of L2 Spanish use is also 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
  - this likewise accords with the Neo-Whorfian view
  - 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

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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

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