The linguistic transmission of cognitive practices

Reference frames in Mesoamerica

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Synopsis

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

Looking for culture in cognition

- the problem: seeing the forest for the trees

- sources of knowledge
  - nature – biological transmission
  - nurture – cultural transmission
  - individual experience

mossysanimals.blogspot.com

Figure 1. *Biological transmission*

bringingaba.blogspot.com

Figure 2. *Cultural transmission*

thenextfamily.com

Figure 3. *Individual experience*

- culture-specificity in cognition
  - example I: ethnobotany
    - how many species of trees can you identify and name?
      - for more on Yucatec ethnobiology, cf. Atran et al (1999, 2001, 2003)

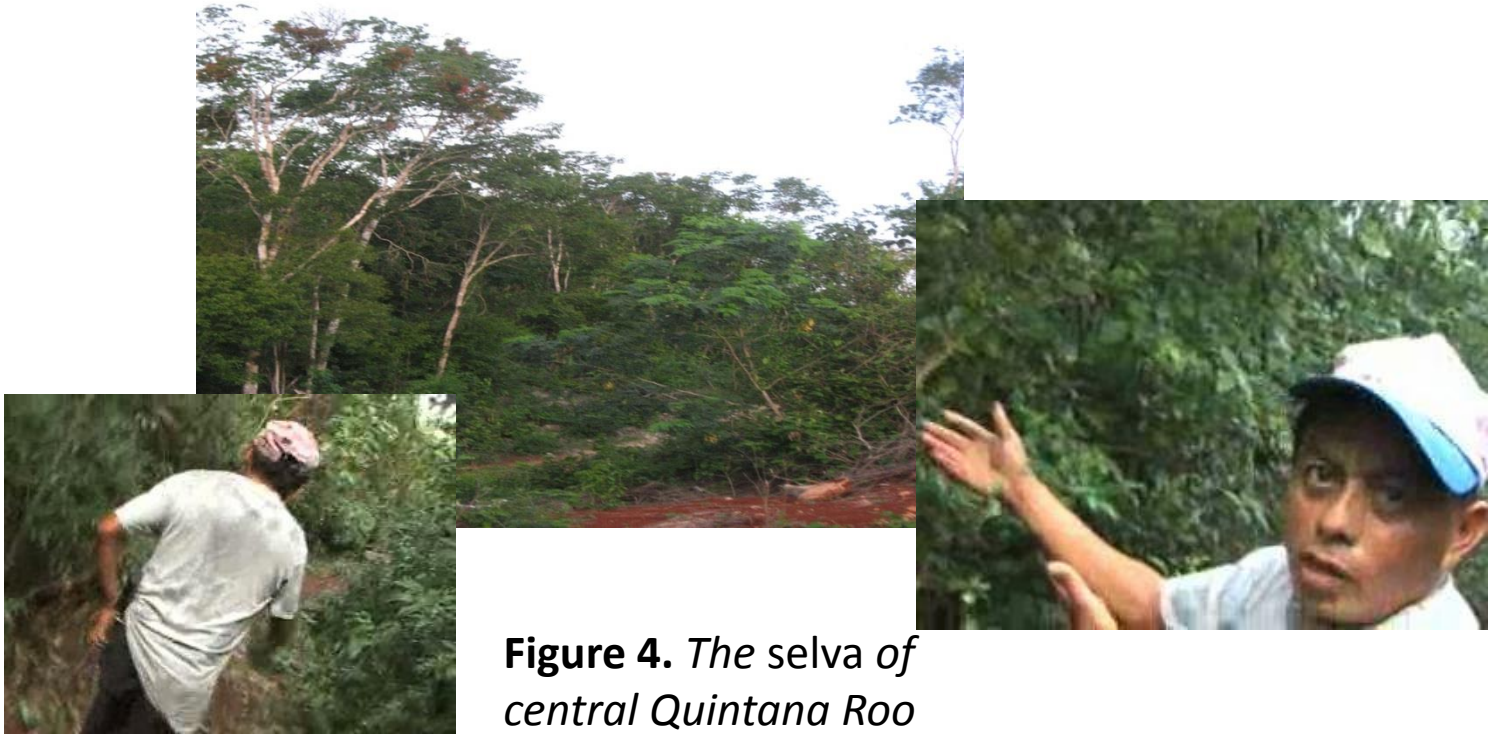

Figure 4. *The* selva *of central Quintana Roo*

- culture-specificity in cognition (cont.)
  - example II: “dead-reckoning”
    - how accurately can you point “home”
      - after having been taken to a windowless room in another town?

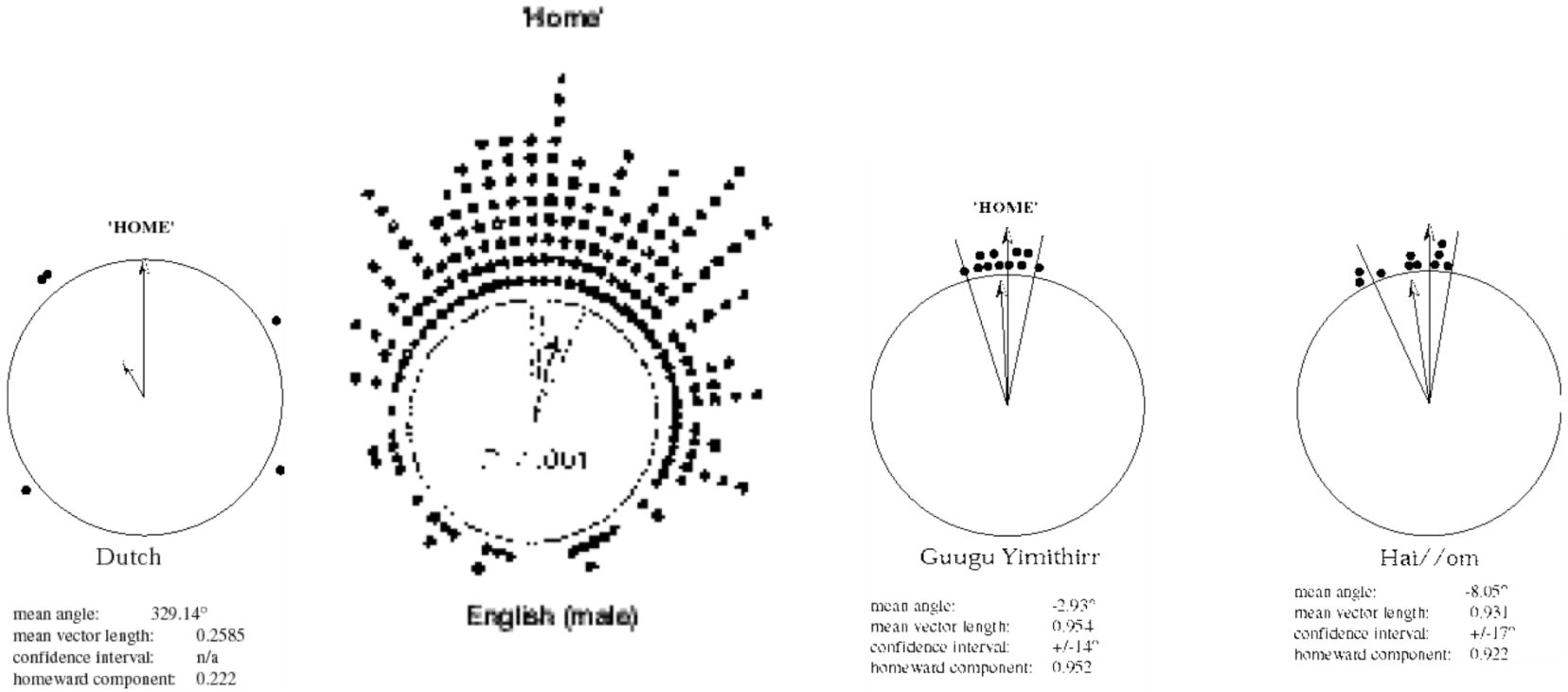

Figure 5. *Results of dead-reckoning pointing accuracy experiments (Levinson 2003: 233-240)*

- but just how deep does culture-specificity run in cognition?
- plus, the transmission problem: how would deep culture-specific ***cognitive practices*** be transmitted?
  - two contemporary views

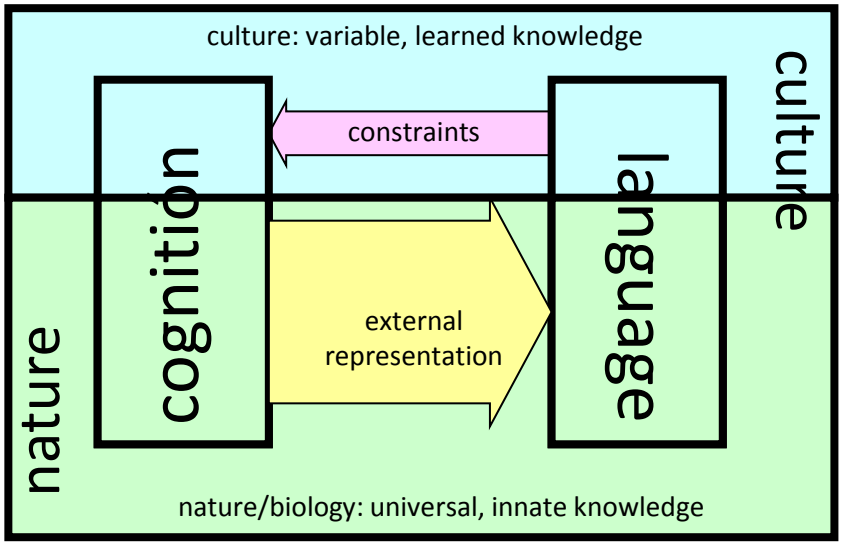

Figure 6. *The mainstream vision*

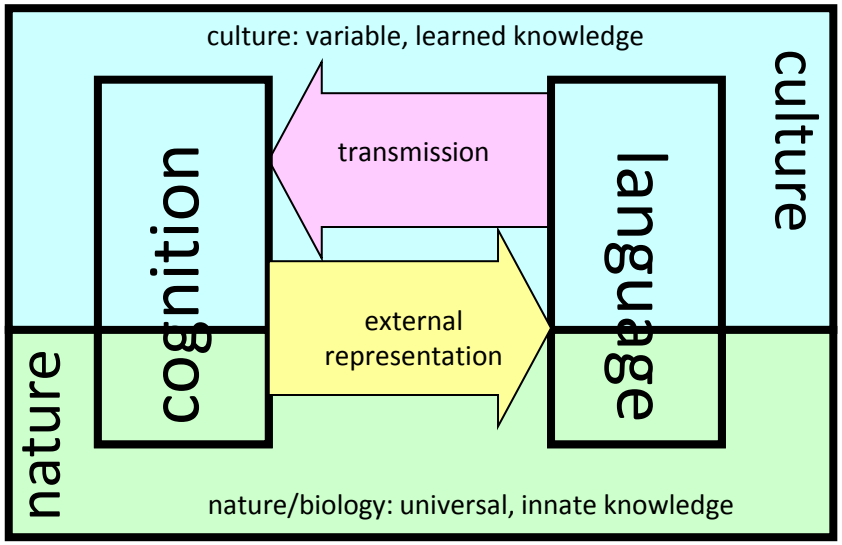

Figure 7. *The Neo-Whorfean vision*

The cognitive science mainstream

- culture-specificity in cognition is shallow and irrelevant to theorizing how the mind works
- no deep transmission – observable behavior such as speech and gesture cannot "restructure" cognition

The Neo-Whorfeans

- the mind is a 'bio-cultural hybrid' (Evans & Levinson 2009)
- culture-specific cognitive practices are transmitted through observable behavior, including speech and gesture

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The test case: spatial reference frames

- background on reference frames
  - two kinds of 'place functions' (Jackendoff 1983) or 'localizers' (Kracht 2002)
    - 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)

(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)*

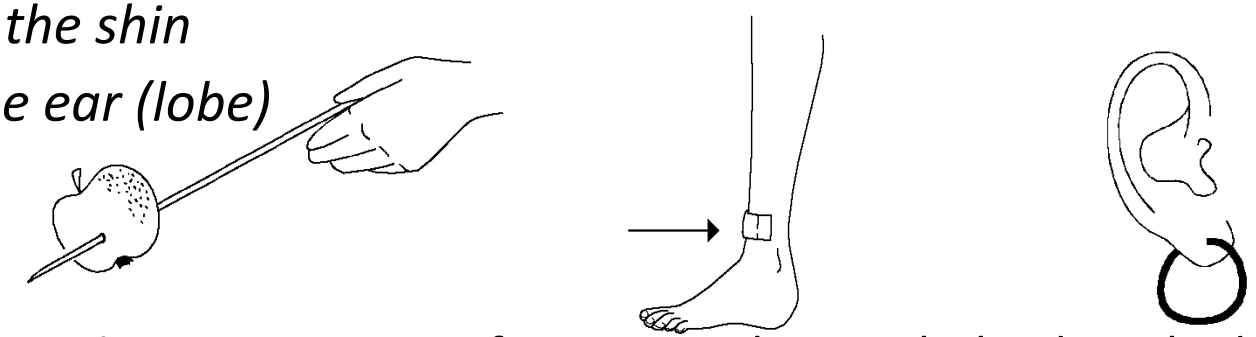


Figure 8. *Some configurations that might be described in terms of topological place functions*

- *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.*

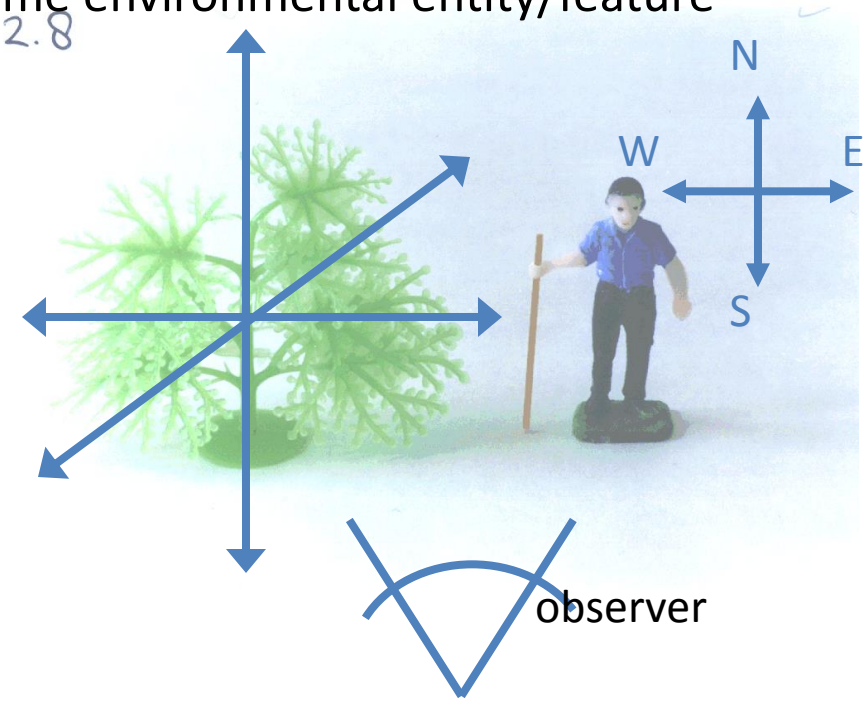


Figure 9. *The three types of spatial FoRs distinguished in Levinson 1996, 2003*

- alternative classifications and subtypes

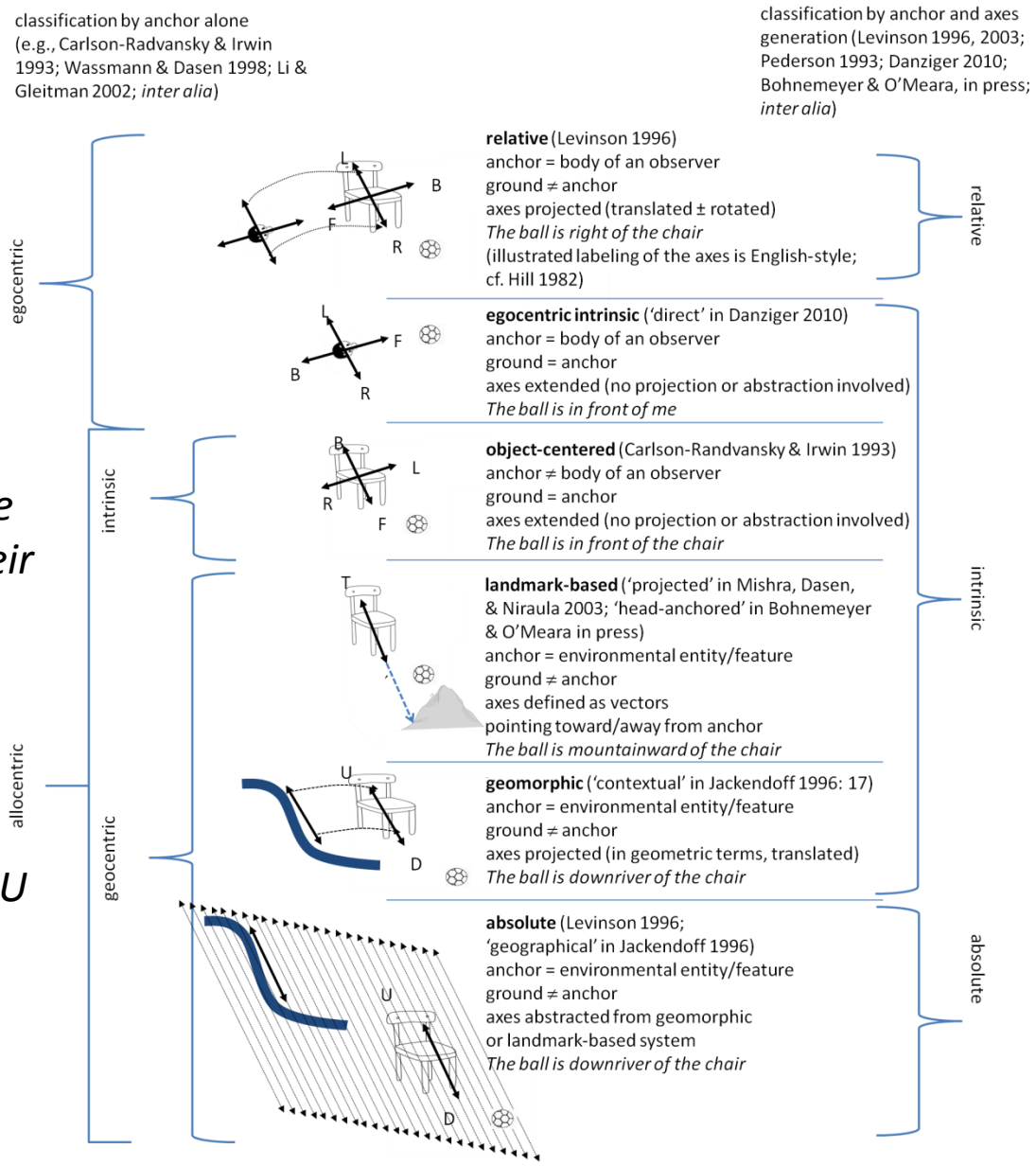
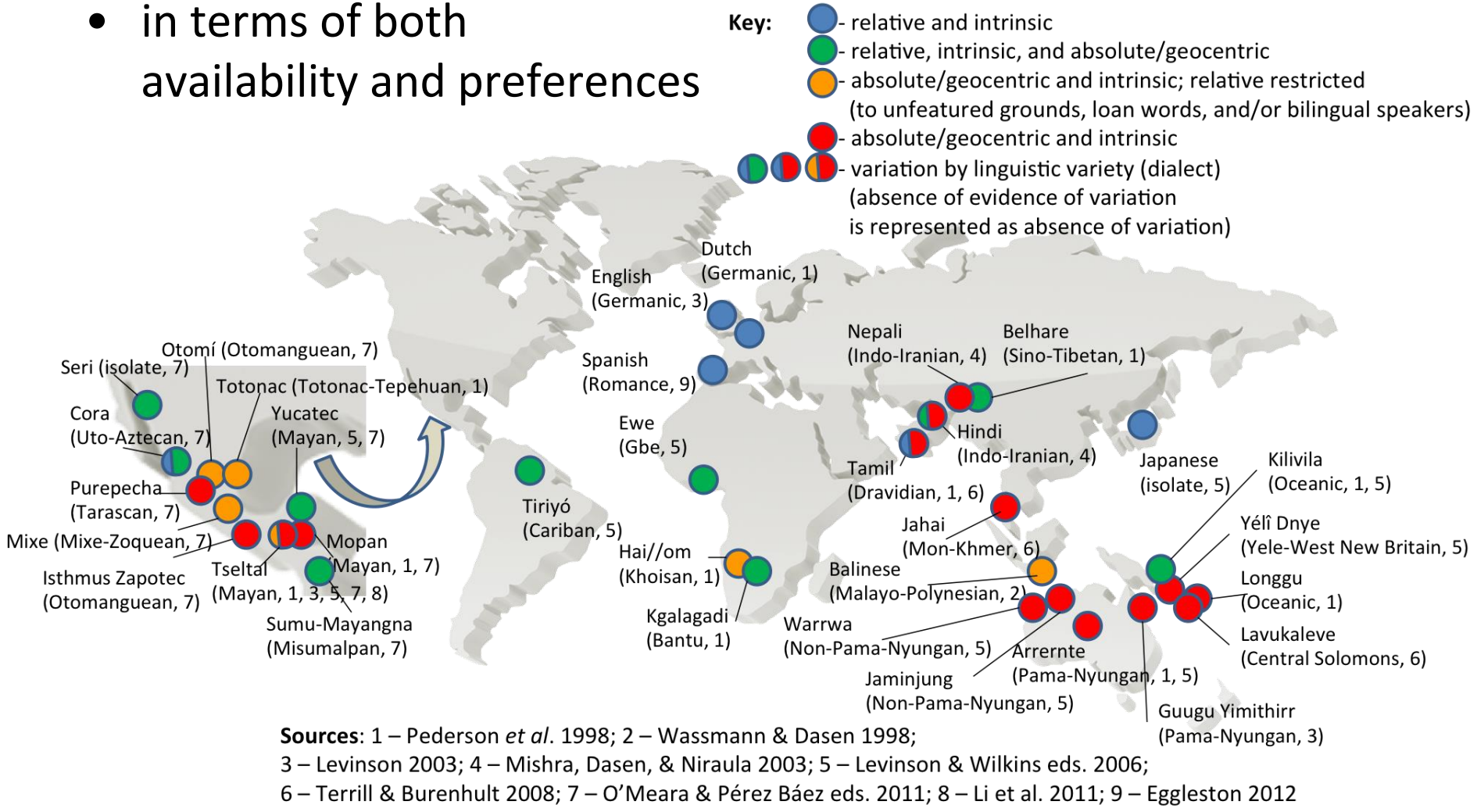


Figure 10. *Reference frame types and their classification (A - 'away from', B - 'back', D - 'downriver', F - 'front', L - 'left', R - 'right', T - 'toward', U - 'upriver'; Bohnemeyer & Levinson ms.)*

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



Sources: 1 – Pederson *et al*. 1998; 2 – Wassmann & Dasen 1998;
3 – Levinson 2003; 4 – Mishra, Dasen, & Niraula 2003; 5 – Levinson & Wilkins eds. 2006;
6 – Terrill & Burenhult 2008; 7 – O'Meara & Pérez Báez eds. 2011; 8 – Li et al. 2011; 9 – Eggleston 2012

Figure 11. *Reference frame use in small-scale horizontal space across languages (Bohnemeyer & Levinson ms.)*

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

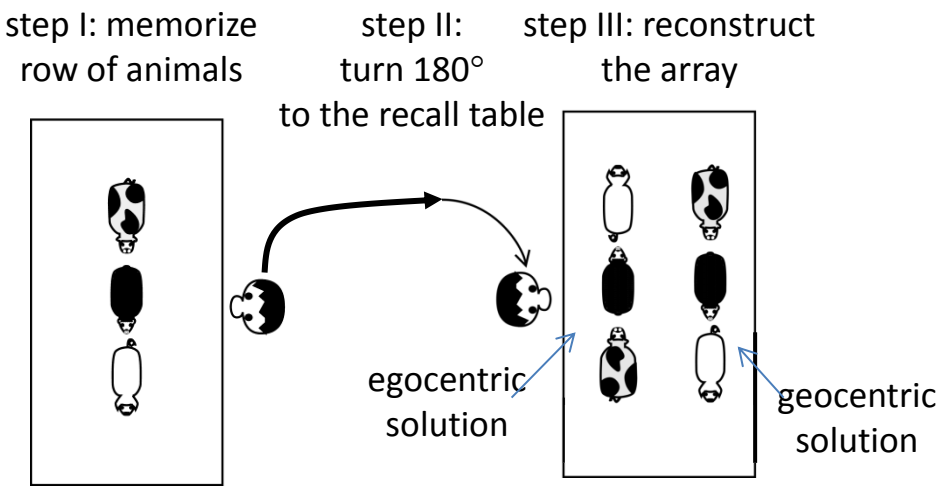


Figure 12. *Animals-in-a-Row: design*

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

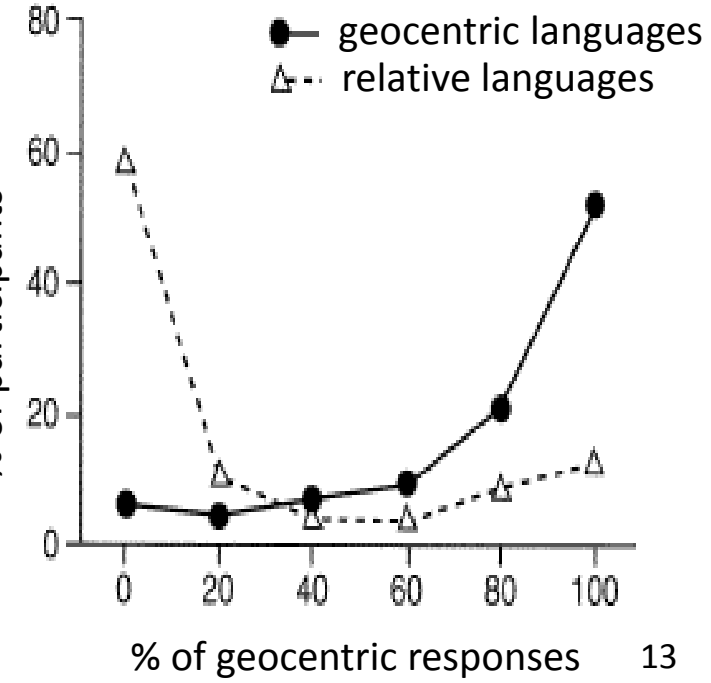


Figure 13. *Animals-in-a-Row: results(Levinson 2003: 184)*

- two competing interpretations

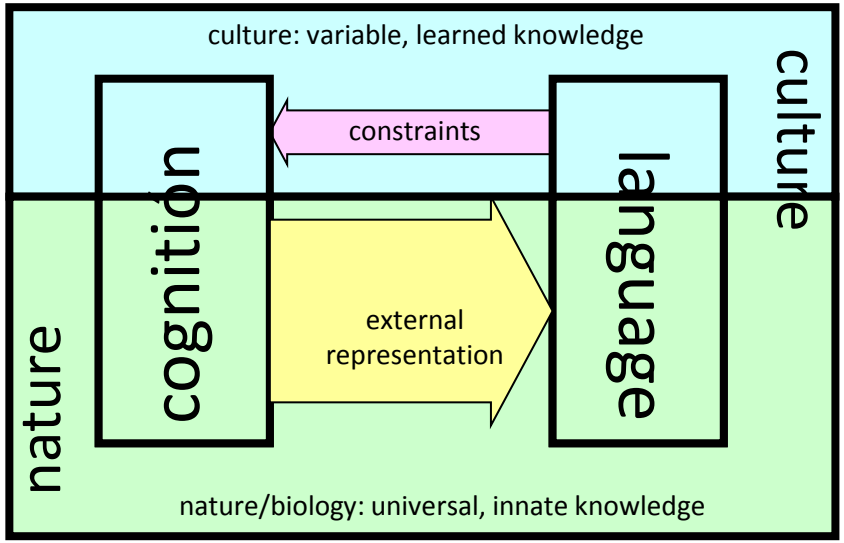


Figure 14. *The mainstream vision*

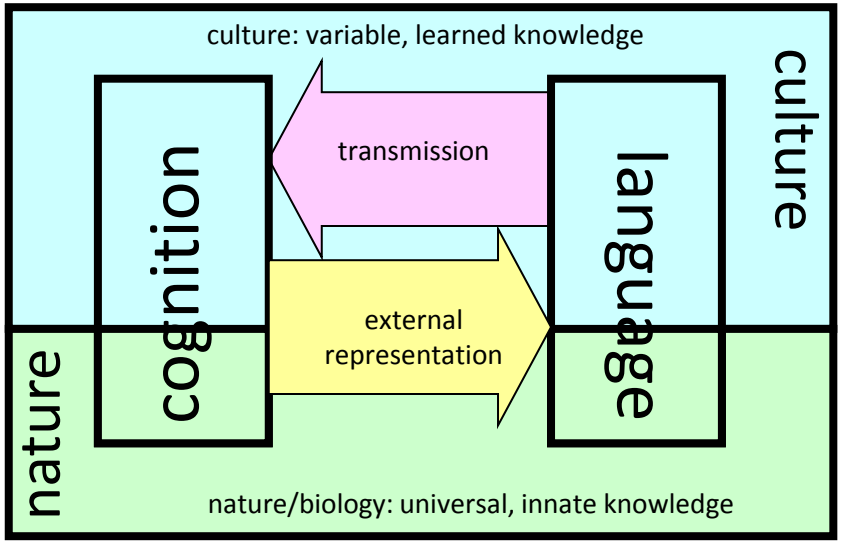


Figure 15. *The Neo-Whorfean vision*

Mainstream interpretation (Li & Gleitman 2002; Li et al 2011; *inter alia)*

- innate knowledge of all frame 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 frame 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

- the forest, the trees, and statistics
  - adjudicating between these interpretations
    - presupposes isolating the effects of language, literacy, education, topography, etc., on the use of reference frames
  - the problem: many of these factors can co-vary
    - e.g., populations that speak different languages may also differ in their levels of education and literacy
  - the solution: multivariate statistics
    - especially mixed linear regression models (Gelman & Hill 2007; Jaeger 2008)

Figure 16. *Seeing the forest for the trees*

- 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
  - Athanasopoulos 2006
    - advanced Japanese-English bilinguals pattern with monolingual English speakers in the cognitive processing of number
  - Athanasopoulos 2009
    - L2 influence on color naming and color categorization in Greek-English bilinguals

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

- our test case: the Mesoamerican *sprachbund*
  – cf. Campbell 1979; Campbell et al 1986

http://en.wikipedia.org/wiki/Image:Mesoamericanlanguages.png

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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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
    - of 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

Figure 19. *MesoSpace: Field sites*

- 13 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)

- 6 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; H. Rodriguez; R. Tucker; E. Benedicto, A. Eggleston)

Figure 20. The *MesoSpace team (minus V. Peralta and R. Tucker)*

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

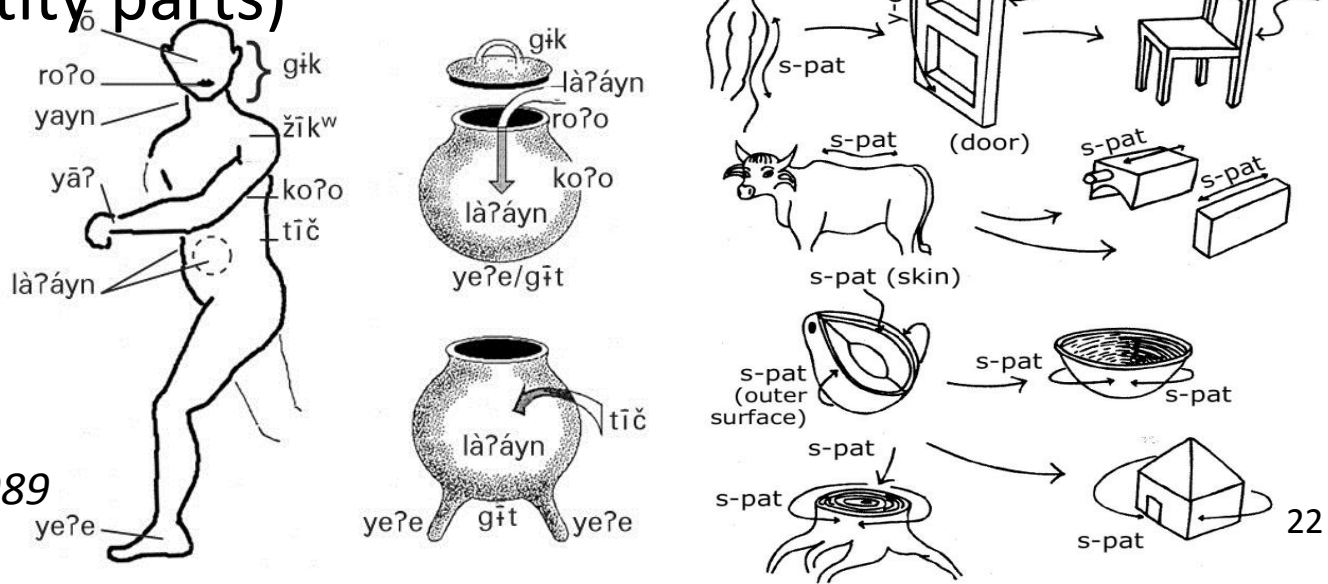

Figure 21. *Meronyms in Ayoquesco Zapotec (left) and Tenejapa Tseltal (adapted from MacLaury 1989 and Levinson 1994)*

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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

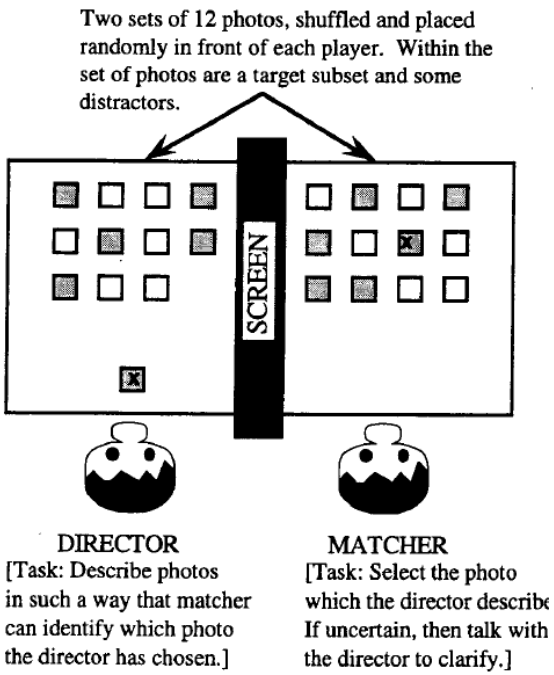

Figure 22. *Design of the Men and Tree task (Pederson et al. 1998: 562)*

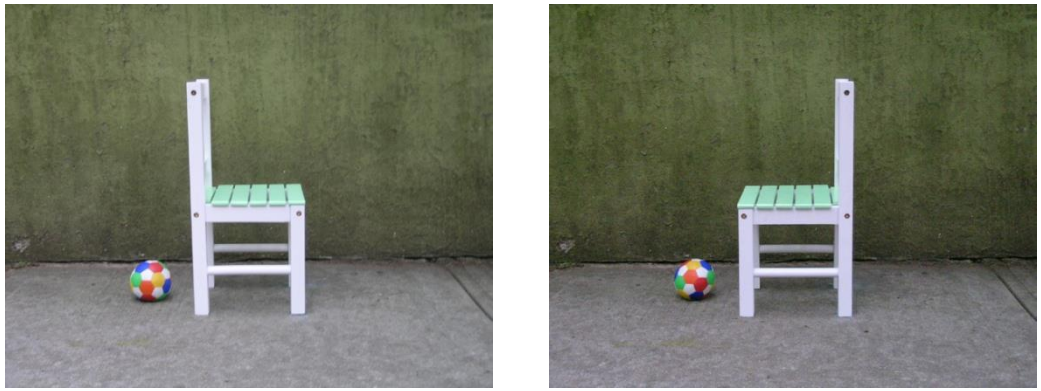

Figure 23. *Two of the Ball & Chair photos, featuring an intrinsic contrast*

- 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 languages
      - Seri (C. O'Meara)
      - Sumu-Mayangna (E. Benedicto, A. Eggleston, Mayangna Yulbarangyang Balna)
    - 3 varieties of Spanish
      - from Barcelona (A. Eggleston), Mexico (H. Romero, H. Rodriguez, R. Tucker), and Nicaragua (A. Eggleston)

- 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
  - six in the case of Isthmus Zapotec and Barcelonan Spanish
  - we have so far coded data from only four of the five Mexican Spanish dyads
- responses are accompanied by (a) the researchers' estimates and (b) the participants' self-estimates of the participants'
  - level of education
  - frequency of use of Spanish as second language
  - frequency of reading and writing

- 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)

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

- 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:
  - to what extent 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
  - as opposed to depending exclusively on the speaker's level of education and literacy?

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The distribution of the response variables

- the flow of the quantitative analysis
  - step I: identify the response variables that showed the greatest differentiation among participants
    - response variables: the (frequency/probability of) use of each of the eight strategies we coded the data for
  - step II: linear regressions to find the predictor variables significantly contributing to the variance
    - in those response variables identified in step I
    - predictor variables: L1, L2 use, literacy, education, (topography, population geography)

- 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

- 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

- how do the participants' responses cluster?
  - we ran a three-dimensional Multi-Dimensional Scaling (MDS) analysis of the similarity matrix
    - three dimensions produced a better goodness of fit than two
    - cf. Schiffman et al 1981

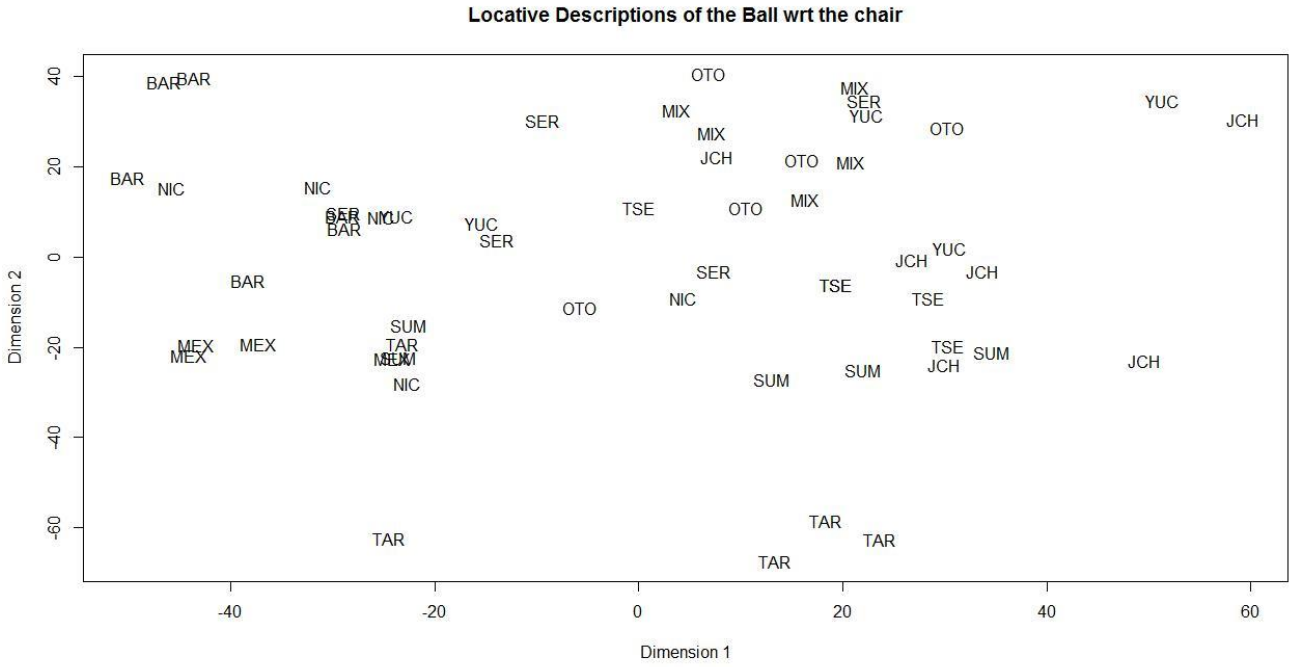

Figure 25. *Plotting the first two dimensions of the MDS analysis*

MDS analysis (cont.)

- the first dimension of the MDS plot correlates positively with the frequency of geocentric descriptions…
  - » Spearman's Rho 0.87
- … and negatively with the frequency of relative descriptions
  - » Spearman's Rho -0.85

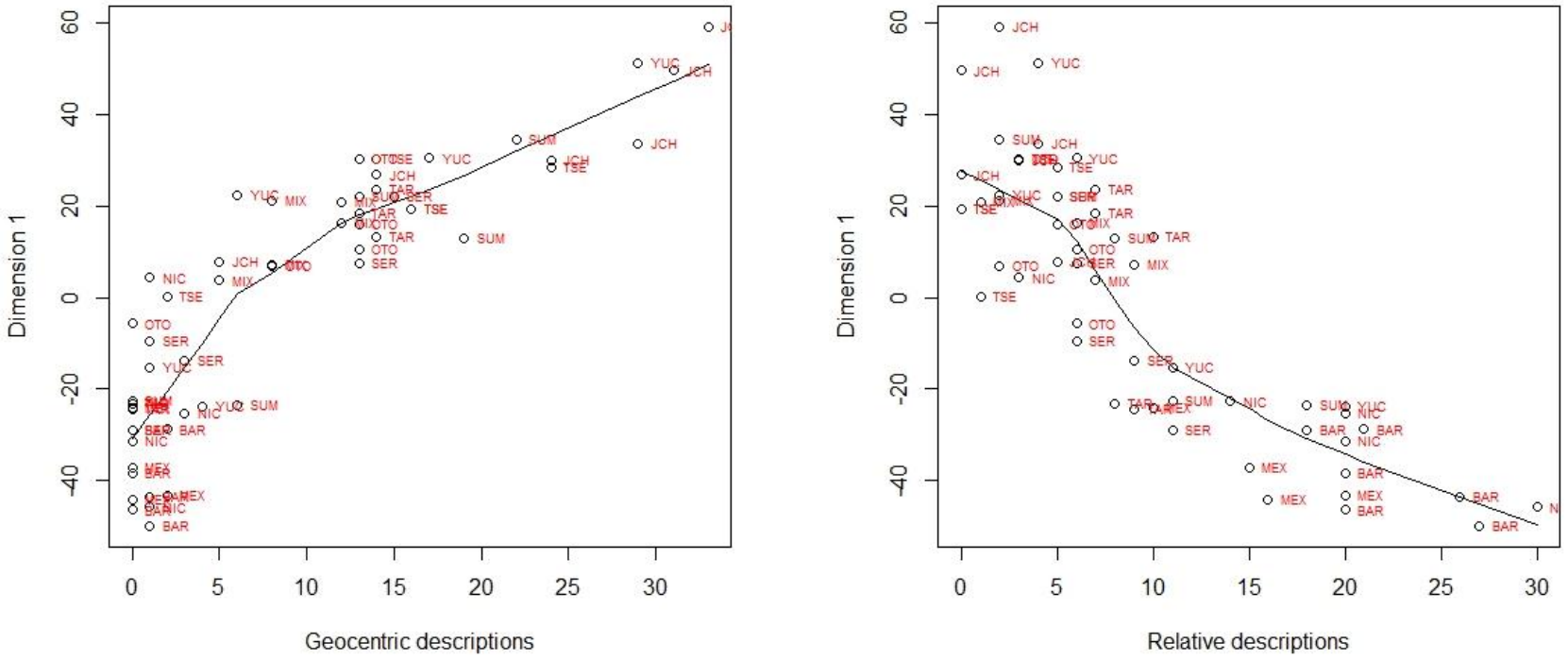

Figure 26. *Correlations between the first dimension of the MDS plot and the frequency of geocentric (left) and relative (right) descriptions.*

- the second dimension shows a very strong correlation with the frequency of topological descriptions
  - Spearman's Rho 0.92

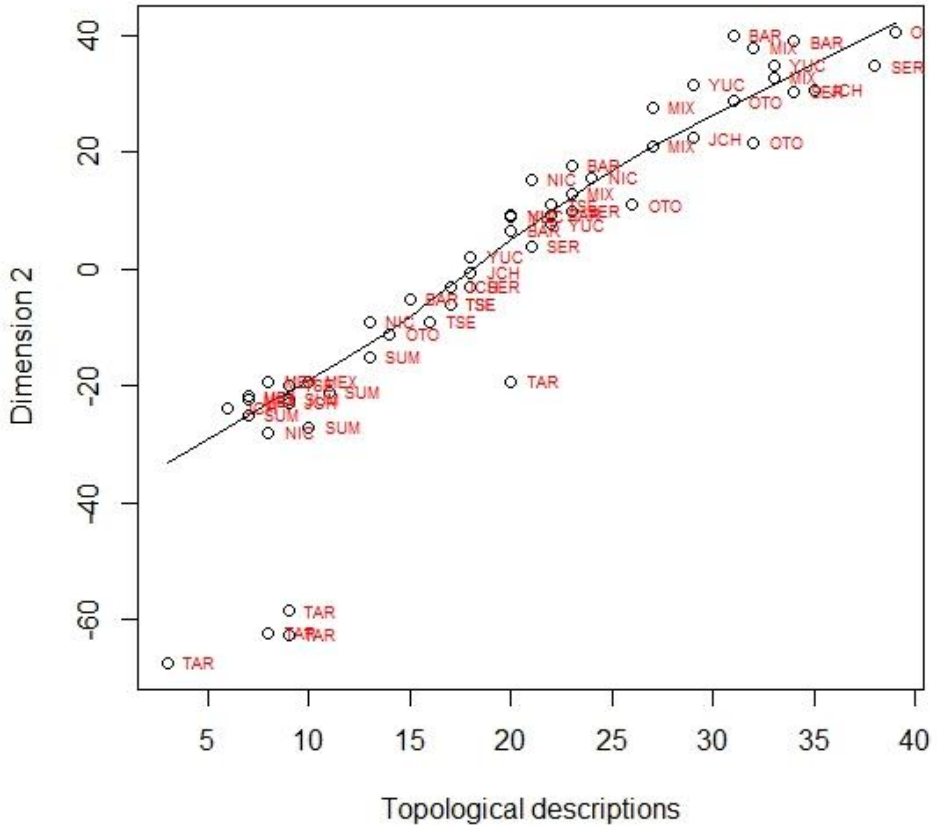

Figure 17. *Correlations b/w the 2nd dimension of the MDS plot and the frequency of topological descriptions*

- discussion
  - the MDS analysis shows
    - 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 ran several linear mixed effects regressions
  - or LMERs

Figure 19. *Not LMERs*

- the areal-linguistic affiliation variable
  - our dataset includes too many individual languages for parsimonious modeling
  - 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)

- implementation
  - we used generalized linear mixed-effects models (LMERs; 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

- there are altogether 12 models
  - 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
  - we ran separate models with the researcher estimates of the participants' L2 use and education/literacy levels
    - and with the participants' self-reported data
  - and we ran separate models with the participants' self-estimated frequencies of reading vs. writing

- an overview of the 12 models

Variables	Model	1	2	3	4	5	6	7	8	9	10	11	12
Source of data on L2 use, literacy, education	Researcher estimates	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Self-reported	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Literacy variable	Literacy	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Reading	-	-	-	-	✓	✓	✓	✓	-	-	-	-
	Writing	-	-	-	-	-	-	-	-	✓	✓	✓	✓
L1-Spanish speakers	Included	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
	Excluded	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
L2 use	Included	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
	Excluded	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
Response variable	Geocentric	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-
	Relative	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓

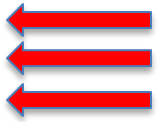
Table 2. *The 12 LMERs*

- a model up close
  - GEO, L1-Spanish speakers incl., researcher estimates
    - the fitted geocentric model revealed linguistic affiliation and literacy, but not education, as significant factors

```
Generalized linear mixed model fit by the Laplace approximation
Formula: Lgeo ~ edu + lit + Ltyp + (1 | ID) + (1 | LANG)
   Data: data4
   AIC  BIC logLik deviance
 999.3 1035 -492.6    985.3
Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 2.19567  1.48178
 LANG   (Intercept) 0.21184  0.46026
Number of obs: 1213, groups: ID, 56; LANG, 11

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -5.7146     1.1263  -5.074  3.9e-07 ***
edu          -1.0155     0.6696  -1.517  0.12936
lit           1.4292     0.6762   2.114  0.03454 *
LtypIND       3.3451     1.0189   3.283  0.00103 **
LtypMES       4.4494     0.9273   4.798  1.6e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Correlation of Fixed Effects:
         (Intr) edu    lit    LtyIND
edu      -0.196
lit      -0.225 -0.832
LtypIND -0.692  0.216 -0.085
LtypMES -0.870 -0.022  0.255  0.716
```



- results
  - all but one of the models yielded significant factors

Variables	Model	1	2	3	4	5	6	7	8	9	10	11	12
Source of data on L2 use, literacy, education	Researcher estimates	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Self-reported	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Literacy variable	Literacy	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Reading	-	-	-	-	✓	✓	✓	✓	-	-	-	-
	Writing	-	-	-	-	-	-	-	-	✓	✓	✓	✓
L1-Spanish speakers	Included	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
	Excluded	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
L2 use	Included	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
	Excluded	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
Response variable	Geocentric	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-
	Relative	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓
Results	Education												
	Literacy (reading/ writing)	*		*								*	
	L2 use				*				*				*
	L1 MES	***	***	.	.	***	***			***	***		
	L1 IND	**	*			**	*			**	**		

Table 3. *Model 7 did not produce significant factors (Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)*

- results (cont.)
  - education is never a significant factor
    - however, literacy and education show strong collinearity in the researcher estimates

Variables	Model	1	2	3	4	5	6	7	8	9	10	11	12
Source of data on L2 use, literacy, education	Researcher estimates	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Self-reported	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Literacy variable	Literacy	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Reading	-	-	-	-	✓	✓	✓	✓	-	-	-	-
	Writing	-	-	-	-	-	-	-	-	✓	✓	✓	✓
L1-Spanish speakers	Included	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
	Excluded	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
L2 use	Included	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
	Excluded	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
Response variable	Geocentric	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-
	Relative	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓
Results	Education												
	Literacy (reading/ writing)	*		*								*	
	L2 use				*				*				*
	L1 MES	***	***	.	.	***	***			***	***		
	L1 IND	**	*			**	*			**	**		

Table 4. *The role of education*
*(Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)*

- results (cont.)
  - literacy is a significant factor in half of the geocentric models, but never in the relative ones

Variables	Model	1	2	3	4	5	6	7	8	9	10	11	12
Source of data on L2 use, literacy, education	Researcher estimates	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Self-reported	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Literacy variable	Literacy	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Reading	-	-	-	-	✓	✓	✓	✓	-	-	-	-
	Writing	-	-	-	-	-	-	-	-	✓	✓	✓	✓
L1-Spanish speakers	Included	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
	Excluded	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
L2 use	Included	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
	Excluded	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
Response variable	Geocentric	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-
	Relative	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓
Results	Education												
	Literacy (reading/ writing)	*		*								*	
	L2 use				*				*				*
	L1 MES	***	***	.	.	***	***			***	***		
	L1 IND	**	*			**	*			**	**		

Table 5. *The role of literacy*
*(Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)*

- results (cont.)
  - the literacy effect seems to be writing-based, not reading-based

Variables	Model	1	2	3	4	5	6	7	8	9	10	11	12
Source of data on L2 use, literacy, education	Researcher estimates	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Self-reported	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Literacy variable	Literacy	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Reading	-	-	-	-	✓	✓	✓	✓	-	-	-	-
	Writing	-	-	-	-	-	-	-	-	✓	✓	✓	✓
L1-Spanish speakers	Included	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
	Excluded	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
L2 use	Included	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
	Excluded	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
Response variable	Geocentric	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-
	Relative	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓
Results	Education												
	Literacy (reading/ writing)	*		*								*	
	L2 use				*				*				*
	L1 MES	***	***	.	.	***	***			***	***		
	L1 IND	**	*			**	*			**	**		

Table 6. *The role of literacy (cont.)*
*(Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)*

- results (cont.)
  - L2 use is a significant factor in all, and only in, relative models (those that exclude L1-Spanish speakers)

Variables	Model	1	2	3	4	5	6	7	8	9	10	11	12
Source of data on L2 use, literacy, education	Researcher estimates	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Self-reported	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Literacy variable	Literacy	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Reading	-	-	-	-	✓	✓	✓	✓	-	-	-	-
	Writing	-	-	-	-	-	-	-	-	✓	✓	✓	✓
L1-Spanish speakers	Included	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
	Excluded	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
L2 use	Included	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
	Excluded	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
Response variable	Geocentric	✓	-	✓		✓	-	✓		✓	-	✓	
	Relative	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓
Results	Education												
	Literacy (reading/ writing)	*		*								*	
	L2 use				*				*				*
	L1 MES	***	***	.	.	***	***			***	***		
	L1 IND	**	*			**	*			**	**		

Table 7. *The role of the use of Spanish as an L2*
*(Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)*

- results (cont.)
  - half of the models show L1 effects
    - namely, all and only those that include the L1-Spanish speakers

Variables	Model	1	2	3	4	5	6	7	8	9	10	11	12
Source of data on L2 use, literacy, education	Researcher estimates	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Self-reported	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Literacy variable	Literacy	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Reading	-	-	-	-	✓	✓	✓	✓	-	-	-	-
	Writing	-	-	-	-	-	-	-	-	✓	✓	✓	✓
L1-Spanish speakers	Included	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
	Excluded	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
L2 use	Included	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
	Excluded	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
Response variable	Geocentric	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-
	Relative	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓
Results	Education												
	Literacy (reading/ writing)	*		*								*	
	L2 use				*				*				*
	L1 MES	***	***	.	.	***	***			***	***		
	L1 IND	**	*			**	*			**	**		

Table 8. *The role of the first language*

*(Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)*

- results (cont.)
  - both relative and geocentric models show L1 effects

Variables	Model	1	2	3	4	5	6	7	8	9	10	11	12
Source of data on L2 use, literacy, education	Researcher estimates	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Self-reported	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Literacy variable	Literacy	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Reading	-	-	-	-	✓	✓	✓	✓	-	-	-	-
	Writing	-	-	-	-	-	-	-	-	✓	✓	✓	✓
L1-Spanish speakers	Included	✓	✓	-	-	✓	✓	-	-	✓	✓	-	-
	Excluded	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
L2 use	Included	-	-	✓	✓	-	-	✓	✓	-	-	✓	✓
	Excluded	✓	✓			✓	✓			✓	✓	-	-
Response variable	Geocentric	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-
	Relative	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓
Results	Education												
	Literacy (reading/ writing)	*		*								*	
	L2 use				*				*				*
	L1 MES	***	***	.	.	***	***			***	***		
	L1 IND	**	*			**	*			**	**		

Table 9. *The role of the first language (cont.)*
*(Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)*

- 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

- 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-Whorfian view of language as a transmission system for nonlinguistic cognition

- 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
    - this confirms earlier findings (Danziger & Pederson 1998)
  - we did not find an effect of education
    - but the researcher estimates of literacy and education are strongly correlated
  - 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

- discussion: the role of the Mesoamerican area
  - recap
    - our LMERs found significant differences b/w the speakers of Spanish and those of the indigenous languages
    - moreover, we found evidence of contact diffusion in the use of relative frames
  - but is there also an areal effect?
    - in other words, did the Mesoamericans differ significantly from the speakers of the non-Mesoamerican indigenous languages?
  - to test this, we reran the six models that included the L1-Spanish speakers
    - this time taking the non-Mesoamerican indigenous languages as the baseline for the (categorical) Ltyp variable
    - the result was negative

- example: Model 1
  - geocentric; based on researcher estimates for L2 use, literacy, education; incl. L1-Spanish speakers

```
Generalized linear mixed model fit by the Laplace approximation
Formula: Lgeo ~ edu + lit + Ltyp + (1 | ID) + (1 | LANG)
   Data: data4
   AIC  BIC logLik deviance
 999.3 1035 -492.6    985.3
Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 2.19567  1.48178
 LANG   (Intercept) 0.21183  0.46025
Number of obs: 1213, groups: ID, 56; LANG, 11

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -2.3694     0.8706  -2.721  0.00650 **
edu          -1.0155     0.6696  -1.517  0.12936
lit           1.4292     0.6762   2.114  0.03454 *
LtypESP      -3.3451     1.0189  -3.283  0.00103 **
LtypMES       1.1042     0.7707   1.433  0.15193
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Correlation of Fixed Effects:
            (Intr) edu    lit    LtyESP
edu         -0.042
lit         -0.377 -0.813
LtypESP     -0.297 -0.216  0.078
LtypMES     -0.760 -0.282  0.401  0.492
```

L1-Spanish speakers sig. different from speakers of non-Mesoamerican indigenous languages

Mesoamericans NOT sig. different from speakers of non-Mesoamerican indigenous languages

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

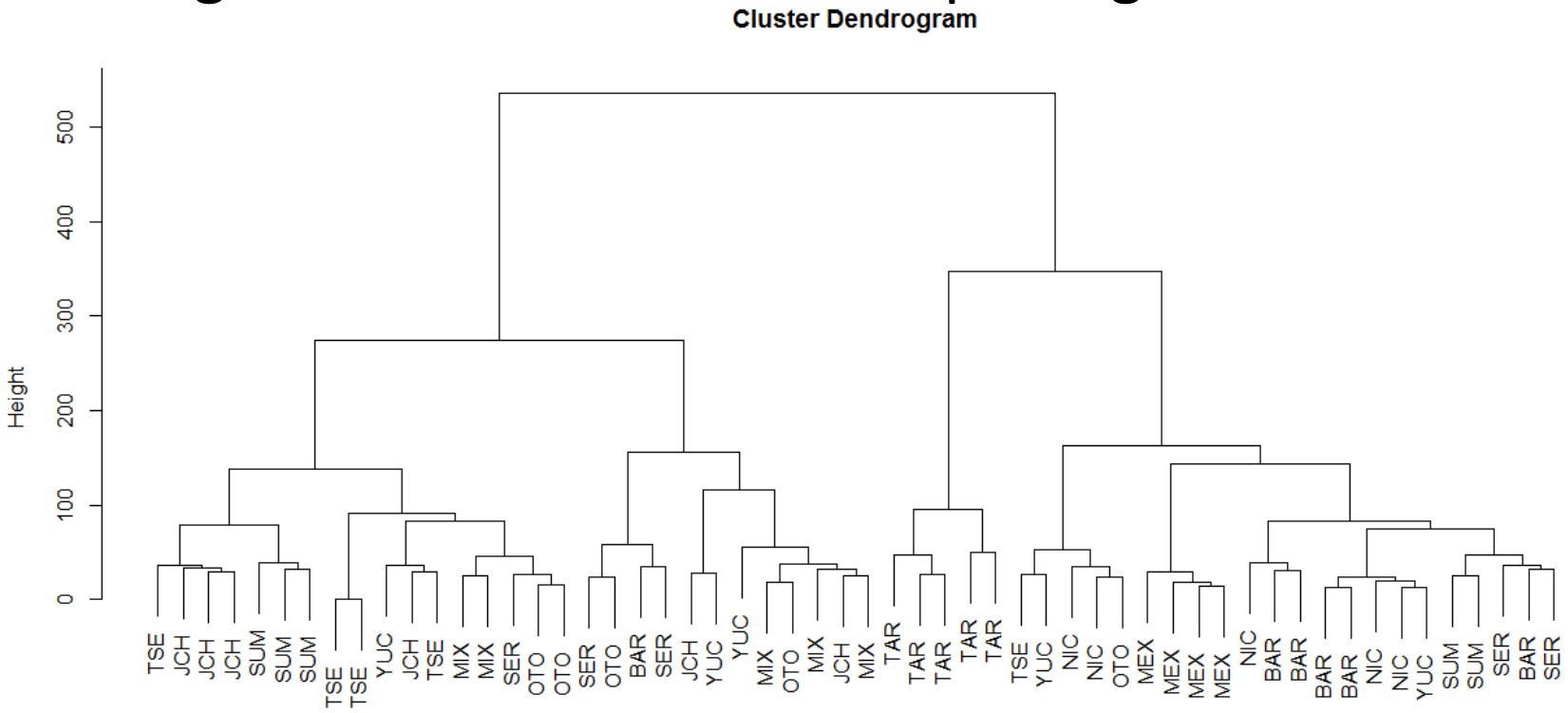


Figure 19. *Cluster analysis dendrogram of the similarity matrix of the Ball & Chair data.*

– findings

- 12 out of the 16 L1-Spanish-speaking dyads cluster together
  - due to their unifying high relative and low geocentric scores
- in contrast, the speakers of the non-Mesoamerican indigenous languages did not clearly differentiate themselves
  - from the Mesoamericans

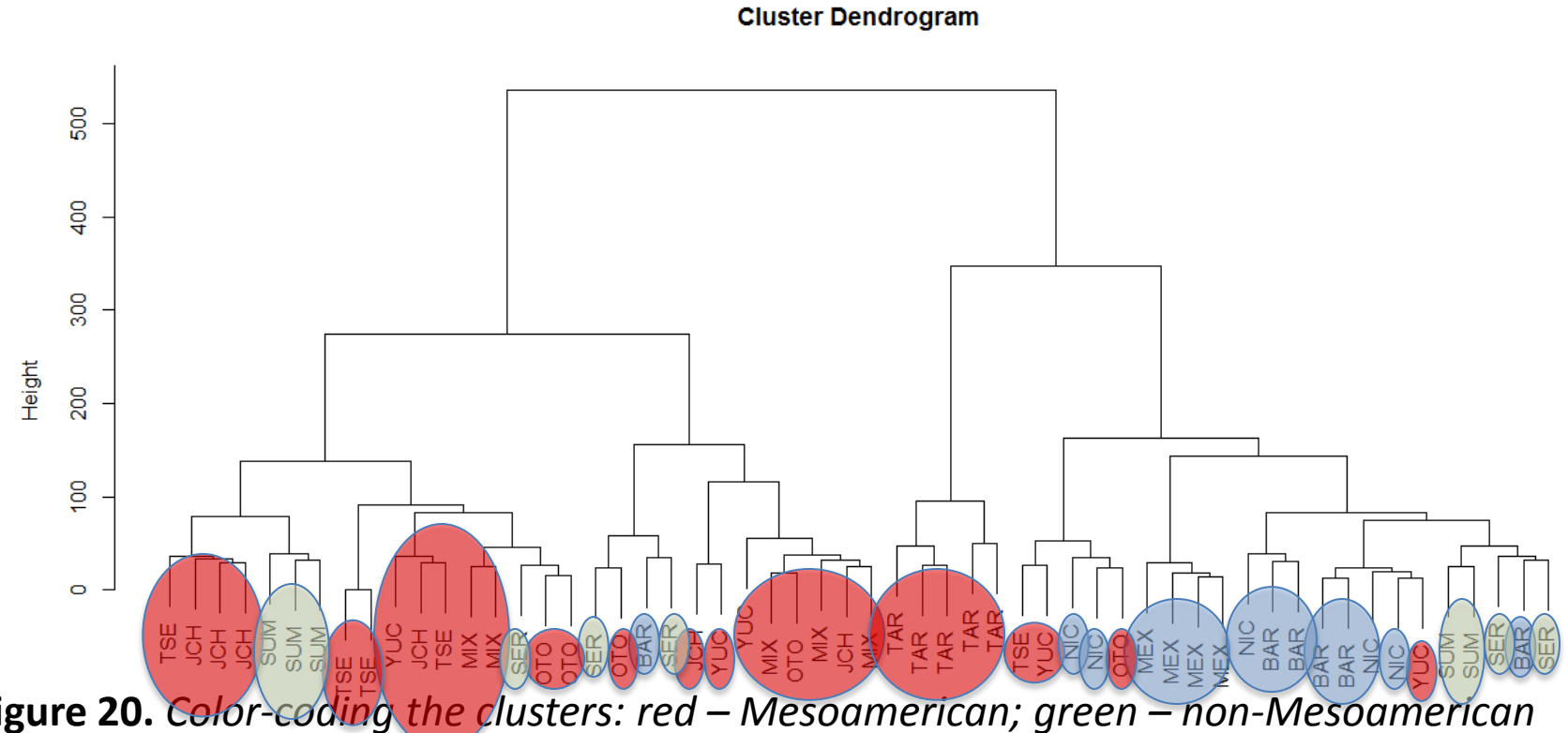


Figure 20. *Color-coding the clusters: red – Mesoamerican; green – non-Mesoamerican indigenous languages; blue – varieties of Spanish.*

Synopsis

- looking for culture in cognition
- the test case: spatial reference frames
- 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

- 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

- 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

- 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
- a possible explanation
  - areal diffusion masked by the exoticness of European languages
    - Spanish might be so different from the New-World languages in frame use as to obliterate any differences among the latter

- what's next?
  - include data from additional Mesoamerican languages in the analysis
  - 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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