The effect of topography on language and cognition in Isthmus Zapotec

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May 30th, 2016

Geographic Grounding: Place, direction and landscape in the grammars of the world

Copenhagen, Denmark

Synopsis

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- Introduction
- MesoSpace
- Topography in MesoSpace
- Space and topography in Diidxa za
- Cultural mediation: ethnophysiography
- Conclusions

Introduction

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- does topography influence language & cognition?
  - test case: spatial frames of reference
    - previous qualitative work: Wassman & Dasen 1998; Polian & Bohnemeyer 2011; Palmer 2015

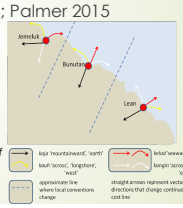

Figure 1. *Three neighboring villages on the North-East peninsula of Bali using the same set of geocentric terms each based on different local conventions (Bohnemeyer et al. ms, based on a detail from Wassman & Dasen 1998: 698)*

Introduction (cont.)

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- does topography influence cognition?(cont.)
  - preliminary quantitative evidence: MesoSpace
    - (Bohnemeyer et al 2014, 2015, ms.)
  - second part of the talk: the role of culture
    - inter-community variation in the Isthmus of Tehuantepec

Synopsis

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MesoSpace

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- NSF award #BCS-0723694 "Spatial language and cognition in Mesoamerica"
- 15 field workers
- 13 MA languages
  - Mayan
    - Chol (J.-J. Vázquez)
    - Q'anjob'al (E. Mateo Toledo)
    - Tseltal (G. Polian)
    - Yucatec (J. Bohnemeyer)
  - Mixe-Zoquean
    - Ayutla Mixe (R. Romero Méndez)
    - Soteapanec (S. Gutierrez Morales)
    - Tecpatán Zoque (R. Zavala Maldonado)
  - Oto-Manguean
    - Otomí (E. Palancar; N. H. Green; S. Hernández-Gómez)
    - Juchitán Zapotec (G. Pérez Báez)
  - Tarascan
    - Purepecha (A. Capistrán)
  - Totonacan
    - Huehuetla Tepehua (S. Smythe Kung)
  - Uto-Aztecan
    - Cora (V. Vázquez)
    - Pajapan Nawat (V. Peralta)

Figure 2. *MesoSpace field sites*

MesoSpace (cont.)

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

Figure 3. The MesoSpace team (minus V. Perafita and R. Moore)

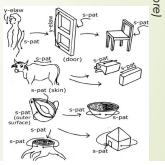

Figure 4. *Meronyms in Ayoquesco Zapotec (left) and Tenejapa Tseltal (adapted from MacLaury 1989 and Levinson 1994)*

MesoSpace (cont.)

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- MesoSpace Ib
  - *Spatial language and cognition* beyond *Mesoamerica*
    - NSF award #BCS 1053123, 2011 – 2016
  - new languages
    - Jahai (Mon-Khmer; N. Burenhult)
    - Japanese (isolate; J. Olstad)
    - Mandarin (Sino-Tibetan; H. Hsiao)
    - Taiwanese (Sino-Tibetan; H. Hsiao)
    - Vietnamese (Mon-Khmer; J. Lovegren)
    - Wan (Mande; T. Nikitina)
    - Yurakaré (isolate, Bolivia; R. van Gijn and V. Hirtzel)
  - continuing languages
    - additional data collected from speakers of
      - Isthmus Zapotec; Tseltal, and Yucatec Maya; Mayangna and Spanish
  - objectives
    - collect further data on linguistic vs. environmental determinants of reference frame use

MesoSpace (cont.)

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- frames of reference: alternative classifications and subtypes

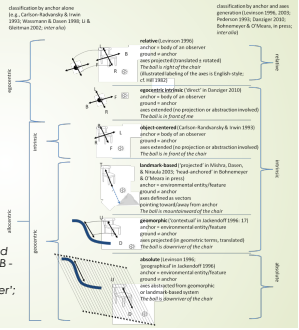

Figure 5. *Reference frame types and their classification (A - 'away from', B - 'back', D - 'downriver', F - 'front', L - 'left', R - 'right', T - 'toward', U - 'upriver'; Bohnemeyer & Levinson ms.)*

MesoSpace (cont.)

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- Tasks used by MesoSpace to study reference frames
  - Ball & Chair (photo stimuli, referential communication task)
  - Talking Animals (3-D toy animal stimuli, referential communication task)
  - New Animals (3-D toy animal stimuli, recall and recreate array of animals)

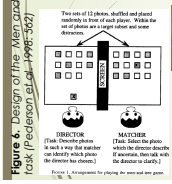

Figure 6. *Design of the 'Men and Tree' task (Pederson et al. 1998: 562)*

Figure 7. *One of four Talking Animals trials*

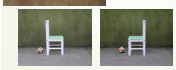

Figure 8. *Two of the Ball & Chair photos, featuring an intrinsic contrast*

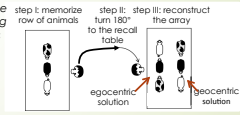

Figure 9. *Animals-in-a-Row: design (Levinson 2003)*

MesoSpace (cont.)

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- Evaluating possible contributing factors - independent variables in mixed effect regression models (GLMMs)
  - Participants' age, education, L2 use, reading and writing frequency
    - Self-reported via demographic survey
  - Population Geography
    - Population density based on Google Earth area of municipality and population from census (INEGI 2010)
  - Local Topography
    - In Mexico: Classification of geomorphological regions (Hernández Santana et al. 2007)
    - World-wide: Improved Hammond Classification of landforms (ESRI. 2011; ArcGIS software)

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Topography in MesoSpace

- Two classifications have been used to represent local topography in multivariate statistical analyses
  - Geomorphological regions (New Atlas of Mexico, Hernández Santana et al. 2007)
    - Bohnemeyer et al. 2014, 2015, ms.
  - Improved Hammond classification of landforms (ESRI 2011. ArcGIS)
    - Moore et al ms.

Topography in MesoSpace (cont.)

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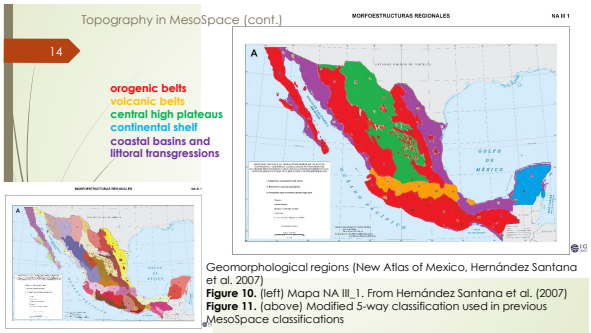
orogenic belts
volcanic belts
central high plateaus
continental shelf
coastal basins and
littoral transgressions



Geomorphological regions (New Atlas of Mexico, Hernández Santana et al. 2007)
Figure 10. (left) Mapa NA III_1. From Hernández Santana et al. (2007)
Figure 11. (above) Modified 5-way classification used in previous MesoSpace classifications

Topography in MesoSpace (cont.)

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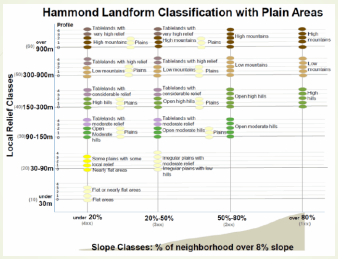

Figure 12. World Landforms – Improved Hammond Method (ESRI 2011)
(http://www.arcgis.com/home/item.html?id=cd817a746aa7437cbd72a6d39cdb4559)

MesoSpace (cont.)

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- findings I: Ball & Chair

Table 1. *Geomorphological classification of field sites in the B&C study (N = 53 x 2 participants)*

Language	Locality	Geomorphological Classification
Tseltal	Chacona, Chiapas	orogenic belt
Yucatec	Yaxley, Quintana Roo	continental shelf
Yucatec	Felipe Carrillo Puerto, Quintana Roo	continental shelf
Mixe	San Pedro y San Pablo Ayutla, Oaxaca	orogenic belt
Otomí	San Ildefonso Tultepec, Queretaro	volcanic belt
Juchiteco	La Ventosa, Oaxaca	coastal basin
Purépecha	Santa Fe de la Laguna, Michoacan	volcanic belt
Seri	El Desemboque (de los seris), Sonora	coastal basin
Sumu	Rosita, Región Autónoma del Atlántico Norte	coastal basin
Spanish (Mexico)	San Miguel Balderas, Mexico State	volcanic belt
Spanish (Mexico)	Chimalacatlan, Tlaquiltenango, Morelos	orogenic belt
Spanish (Nicaragua)	Rosita, Región Autónoma del Atlántico Norte	coastal basin
Spanish (Barcelona)	Barcelona, Spain	coastal basin

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

Table 2. *Summary of the four regression models of the B&C responses using reading frequency to estimate literacy. Models that include L1-Spanish speakers exclude L2 use as a predictor variable. (Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.')*

		Models			
		1	2	3	4
Sample	L1-Spanish speakers included	Yes	Yes	No	No
Dependent variable	Geocentric	Yes	No	Yes	No
	Relative	No	Yes	No	Yes
Effects	Language group	***	***		***
	L2-Spanish use				**
	Literacy				
	Topography	*		.	**
	Population density			*	***

Bottom line
- More relative frame use in coastal basins
- More geocentric frame use in volcanic belts
- Population density positively correlated w/ egocentrism, negatively w/ geocentrism

MesoSpace (cont.)

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- findings II: Talking Animals

Table 3. *Field sites of the TA study by pop. density and geomorphology (N = 343 x 2)*

Language	Locality	Country	Density	Density Log Scale	Topographic Classification
Japanese	Setagaya	Japan (Mainland)	15551	4.19	flat
Taiwanese Southern Min	Taipei	Taiwan	9949	4.00	flat
Mandarin Chinese	Taipei	Taiwan	9949	4.00	flat
Japanese	Naha	Japan (Okinawa)	8244	3.92	hills
English	Buffalo	United States	2569	3.41	flat
Japanese	Yomitan	Japan (Okinawa)	1200	3.08	hills
Taiwanese Southern Min	Tainan	Taiwan	855	2.93	flat
Vietnamese	Long Mỹ	Vietnam	406	2.61	flat
Japanese	Fujinomiya	Japan (Mainland)	339	2.53	low mountains
	Aizuwakamatsu	Japan (Mainland)	321	2.51	low mountains
	Nago	Japan (Okinawa)	293	2.47	low mountains
	Miyakojima	Japan (Okinawa)	268	2.43	hills
	Yonaguni	Japan (Okinawa)	58	1.76	hills
	Shisho	Japan (Mainland)	49	1.69	low mountains
Isthmus Zapotec	La Ventosa	Mexico	5	0.70	flat
	Juchitán de Zaragoza	Mexico	5	0.70	flat
Yucatec	Yaxley	Mexico	2	0.30	flat
	Felipe Carillo Puerto	Mexico	2	0.30	flat

Figure 14. *One of four Talking Animals trials*

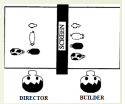

Figure 15. *Design of the Talking Animals task (adapted from Pederson et al. 1998: 562)*

MesoSpace (cont.)

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- findings II: Talking Animals (cont.)

Table 4. *Regression models of the Talking Animals data: summary of effects (Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)*

Dependent variable	Literacy variable		Independent variables (fixed effects)				
	Writing	Reading	L1	L2 use	Literacy	Topography	Pop. density
Geocentric	Yes	No	***		**		***
	No	Yes	**	*	***		***
Relative	Yes	No	***		***	*	**
	No	Yes	***		**	*	**

Figure 14. *One of four Talking Animals trials*

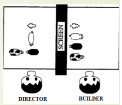

Figure 15. *Design of the Talking Animals task (adapted from Pederson et al. 1998: 562)*

MesoSpace (cont.)

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- findings III: New Animals

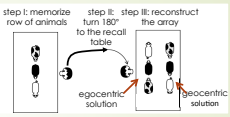

Figure 16. *Animals-in-a-Row: design (Levinson 2003)*

Table 5. *Participants whose responses were included in the analysis, by language, age, and sex*

		American English	Japanese	Mandarin Chinese	Mixe	Otomi	Spanish	Sumu Mayangnga	Taiwanese Southern Min	Tarascan	Tseltal	Vietnamese	Yucatec	Isthmus Zapotec	Total
Gender	Male	12	33	2	3	1	11	4	2	8	9	4	7	7	103
	Female	8	15	7	9	4	21	6	19	6	5	16	10	11	137
Age	≥30	2	17	0	8	5	18	6	19	8	6	8	11	11	119
	< 30	19	31	9	4	0	14	4	2	6	8	12	6	7	122
Total		21	48	9	12	5	32	10	21	14	14	20	17	18	241

MesoSpace (cont.)

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- findings III: New Animals (cont.)

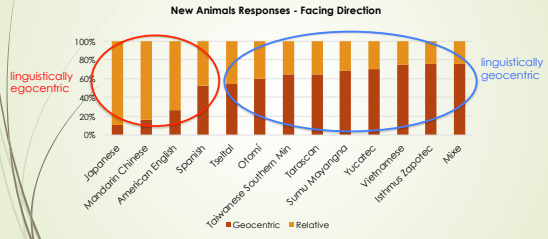

Figure 17. *Response type frequency by L1*

MesoSpace (cont.)

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- findings III: New Animals (cont.)

Dependent variable	Literacy variable			Independent variables (fixed effects)		
Egocentric	Writing	Reading	L1	Literacy	Topography	Pop. density
	Yes	No	***		**	***
	No	Yes	***		*	***

Table 6. *Regression models of the New Animals data: summary of effects (Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)*

Bottom line

- Field sites featuring hilly topography show sig. less egocentric use than flat regions
- Population density positively correlated w/ egocentrism

MesoSpace (cont.)

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- discussion
  - both population density and topography confirmed
    - as independent factors influencing reference frame use in both discourse and recall memory
  - by hypothesis, the effect of population density is primarily mediated by infrastructure
    - egocentrism more efficient for navigating urban roadways
  - the effect of topography has been hypothesized to be mediated by the availability of salient potential 'anchors'
    - such as physiogeographic gradients and natural landmarks
    - cf. Polian & Bohnemeyer 2011; Li & Gleitman 2002
  - questions
    - what is the role of culture in these geographic effects?
    - at what level of granularity do such effects begin to matter?

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Space and topography in Diidxa za

- Diidxa za (Isthmus Zapotec)
  - Otomanguean, VSO, tonal, ~100,000 speakers (INEGI 2010 census)
- Reference frame use in Isthmus Zapotec
  - Pérez Báez (2011) reference frame use in recall and discourse
    - 2-D stimuli in La Ventosa
    - Strong geocentric preference, based on prevailing winds
  - Moore (2016) frame use in recall and discourse
    - 3-D stimuli in La Ventosa and Juchitán
    - Confirmed geocentric preference
    - Significant variation exists between communities
    - Variation also exists in degree of preference for geocentric over egocentric encoding in memory

Space and topography in Diidxa za (cont.)

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- Isthmus Zapotec field sites
  - La Ventosa
  - Juchitán de Zaragoza
  - Santa María Xadani

Figure 18. Oaxaca, Mexico, and three field sites in the Isthmus of Tehuantepec

Space and topography in Diidxa za (cont.)

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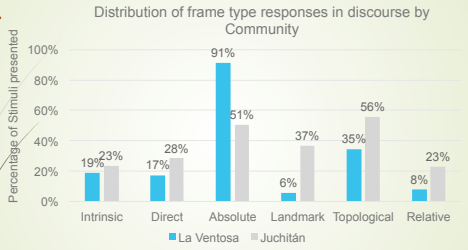

Figure 19. Frame use in discourse. Responses to Talking Animals (Moore 2016) (N = 23 x 2 participants

Space and topography in Diidxa za (cont.)

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- Generalized linear mixed-effects models (Lme4 package in R)
- Factors included in Models
  - Education level
  - Reading and writing frequency
  - Frequency of L2 use (Spanish)
  - Community membership
- Dependent Variables
  - L2, Education, Reading, Writing, Community membership
- Independent Variables
  - Reference frame types
- Community membership only significant factor in predicting frame use

Space and topography in Diidxa za (cont.)

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Dependent variable	Literacy variable		Independent variables (fixed effects)			
	Writing	Reading	Community	L2 Use	Education	Literacy
Geocentric	Yes	No	***			
	No	Yes	***			
Relative	Yes	No	**			
	No	Yes	**			
Absolute	Yes	No	***			
	No	Yes	***			
Direct	Yes	No	**			
	No	Yes	**			*
'Landmark-based'	No	Yes	***			

Table 8. *Regression models of the Talking Animals Zapotec data: summary of effects (Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)*

(model details in Appendices)

Space and topography in Diidxa za (cont.)

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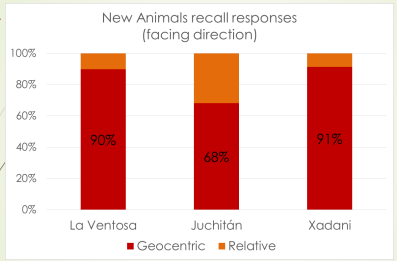

Figure 20. Frame use in recall memory. Responses to *New Animals*. (N = 28 participants

Space and topography in Diidxa za (cont.)

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- Large-scale topographic classifications don't capture the variation in local landscape throughout the Isthmus
  - All three are coastal (Hernandez et al) or flat (ESRI)
- Yet, variation in frame use in discourse and memory exists between communities

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Cultural mediation: ethnophysiography

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- the impact of the environment on cognition is mediated by culture
  - community-specific practices evolve around salient environmental gradients
  - inter-community variation such as witnessed in the Isthmus is the result of this
    - another example: Bali (Wassm

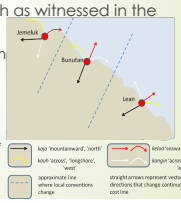

Figure 21. *Three neighboring villages on the North-East peninsula of Bali using the same set of geocentric terms each based on different local conventions (Bohnemeyer et al. ms, based on a detail from Wassman & Dasen 1998: 698)*

Cultural mediation: ethnophysiography (cont.)

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- studying the cultural mediation of environmental forces: ethnophysiography
  - cf. Bohnemeyer 2002; Burenhult & Levinson 2008; Johnson & Hunn 2010; Mark & Turk 2003; Mark et al 1999; O'Meara 2010; Smith & Mark 2003; *inter alia*

Cultural mediation: ethnophysiography (cont.)

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- one salient environmental feature that's not directly captured in a topographic classification: prevailing winds
  - the Isthmus of Tehuantepec has year-round prevailing north winds
    - these are indirectly shaped by the relief, in that a gap in the North American cordillera creates a giant wind tunnel

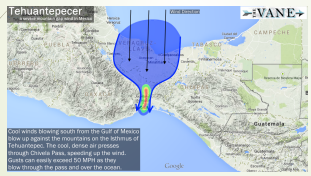

Figure 22. Diagram of Tehuantepecer winds (https://i.kinja-img.com/gawker-media/image/upload/hvftkme467ebgy6l1mhb.PNG)

Cultural mediation: ethnophysiography (cont.)

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- these winds provide the Isthmus with a salient geocentric cue that is readily accessible outdoors
- although this cue is available throughout the region, it appears to play a more prominent cultural role in La Ventosa
  - as reflected in the name ('the windy one') and the ubiquity of wind farms, which are a source of great public controversy

Figure 23. La Ventosa windfarms, taken from the Sierra Sur foothills

Cultural mediation: ethnophysiography (cont.)

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- evidence from ethnopysiographic elicitation confirms this
  - data sources
    - Lexical inventory/salience of features
      - Considerable variation exists between communities (Listing task: 10 speakers, 3 communities, avg. 12 terms/person)
    - Landmarks in direction-giving
      - Route description task: 5 pairs per community
    - Landmarks/environmental features used in descriptions of small-scale space (Talking Animals)
      - Is there significant variation between communities in
        - (i) extent of Geocentric use
        - (ii) type of Geo use (local/manmade landmark, environmental landmark, absolute/cardinal system)??
      - If so, this variable in a statistical model could independently predict frame use (in discourse& recall)
        - vs. community membership, or other factors

Cultural mediation: ethnophysiography (cont.)

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- Findings
  - Most frequent responses to a landscape term listing task (items that occurred 5+ times)
    - Prompt words were: *dani, guiigu, guiixhi*

La Ventosa	Juchitán de Zaragoza	Santa María Xadani
Yaga 'tree' (13)	*Yaga* 'tree' (12)	*Nisa do'* 'sea' (10)
Dani 'hill' (13)	*Guiigu* 'river' (9)	*Dani* 'hill' (9)
Bi 'wind' (12)	*Dani* 'hill' (9)	*Guiixhi* 'forest/jungle' (7)
Mani' 'animal' (9)	*Mani* 'animal' (8)	*Ranya* 'milpa' (6)
Nisa 'water' (7)	*Yuu* 'house' (5)	*Guiigu* 'river' (6)
Guiigu 'river' (7)	*Nisa* 'water' (5)	*Bize** 'well' (6)
Nisa do' 'sea' (5)	*Guixi* 'trash' (5)	*Esteru* 'marsh/swamp' (5)
Guie 'rock/soil' (5)		

Table 9. Listing task responses by community

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Conclusions

- confirmed: geography influences spatial language & cognition
  - MesoSpace has found evidence of effects of population density and topography
    - as independent factors influencing reference frame use in both discourse and recall memory
  - by hypothesis, these effects are primarily mediated by infrastructure and the local availability of potential salient anchors

Conclusions (cont.)

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- the challenge of topographic classification
  - there is as yet no universally agreed upon system of variables
    - that jointly capture the morphology of the Earth' crust everywhere
  - MesoSpace has successfully pioneered the application of the Improved Hammond Classification
    - for the search of cognitive effects of geography

Conclusions (cont.)

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- studying cultural mediation between environment and cognition/behavior: ethnophysiography
  - community-specific practices evolve around salient environmental gradients

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Thank you!
Xquixe pe' laatu!

Special thanks to...
Assistants in the field
Reyna López, Rosalaura, Rosa, Veronica, and their families
Advisors and committee
Jeff Good, Gabriela Pérez Báez, David Mark
The UB Semantic Typology Lab
Funding from NSF DEL (BCS#1264064) & NSF Linguistics (BCS#1053123)

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Appendices:
Model print outs for Zapotec Talking Animals

Geocentric, Write -> Community Membership

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```
Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) ['glmerMod']
 Family: binomial  ( logit )
Formula: GEOJ ~ CD + L2D + EdD + WriteD + (1 | ID)
   Data: mydata

     AIC      BIC   logLik deviance df.resid
   444.1    471.3   -216.0    432.1      682

Scaled residuals:
    Min      1Q  Median      3Q     Max
-3.9080  0.1834  0.2125  0.3154  0.9009

Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 0.9783   0.9891
Number of obs: 688, groups:  ID, 89

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  1.54690    0.51832   2.984 0.002841 **
CDLAV        1.61751    0.42981   3.763 0.000168 ***
L2D         -0.20254    0.30456  -0.665 0.506043
EdD          0.16145    0.28222   0.572 0.567270
WriteD       0.04705    0.20213   0.233 0.815957
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) CDLAV  L2D    EdD
CDLAV       -0.211
L2D         -0.573 -0.429
EdD          0.110  0.063 -0.250
WriteD      -0.467  0.205 -0.042 -0.457
```

Geocentric, Read-> Community Membership

50

```
Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) ['glmerMod']
 Family: binomial  ( logit )
Formula: GEOJ ~ CD + L2D + EdD + ReadD + (1 | ID)
   Data: mydata

     AIC      BIC   logLik deviance df.resid
   443.9    471.1   -215.9    431.9      682

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.0174  0.1844  0.2050  0.3090  0.9058

Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 1.001    1.001
Number of obs: 688, groups:  ID, 89

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   1.7078     0.5047   3.384 0.000715 ***
CDLAV         1.5518     0.4295   3.613 0.000303 ***
L2D          -0.1581     0.3154  -0.501 0.616193
EdD           0.2426     0.2712   0.894 0.371115
ReadD        -0.1133     0.2172  -0.522 0.602014
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) CDLAV  L2D    EdD
CDLAV       -0.199
L2D         -0.493 -0.450
EdD          0.035  0.097 -0.184
ReadD       -0.408  0.184 -0.248 -0.363
```

Relative, Write -> Community Membership

51

```
Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) ['glmerMod']
 Family: binomial  ( logit )
Formula: RELJ ~ CD + L2D + EdD + WriteD + (1 | ID)
   Data: mydata

     AIC      BIC   logLik deviance df.resid
   458.3    485.5   -223.2    446.3      682

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.4189 -0.2983 -0.2002 -0.1796  3.7679

Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 1.313    1.146
Number of obs: 688, groups:  ID, 89

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.86458    0.57958  -3.217  0.00129 **
CDLAV       -1.33916    0.44367  -3.018  0.00254 **
L2D         -0.03556    0.32140  -0.111  0.91189
EdD          0.06220    0.30505   0.204  0.83843
WriteD       0.16911    0.22380   0.756  0.44987
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) CDLAV  L2D    EdD
CDLAV       -0.309
L2D         -0.569 -0.324
EdD          0.127  0.022 -0.232
WriteD      -0.494  0.206 -0.002 -0.508
```

Relative, Read-> Community

52

```
Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) ['glmerMod']
 Family: binomial  ( logit )
Formula: RELJ ~ CD + L2D + EdD + ReadD + (1 | ID)
   Data: mydata

     AIC      BIC   logLik deviance df.resid
   458.9    486.1   -223.4    446.9      682

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.4583 -0.2931 -0.1996 -0.1780  3.6227

Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 1.356    1.164
Number of obs: 688, groups:  ID, 89

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.63179    0.56022  -2.913  0.00358 **
CDLAV       -1.42691    0.45228  -3.155  0.00161 **
L2D         -0.02981    0.32952  -0.090  0.92792
EdD          0.18849    0.28482   0.662  0.50811
ReadD       -0.02197    0.23043  -0.095  0.92404
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) CDLAV  L2D    EdD
CDLAV       -0.316
L2D         -0.503 -0.362
EdD          0.018  0.042 -0.178
ReadD       -0.425  0.244 -0.185 -0.371
```

Absolute, Read -> Community Membership

53

```
Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) ['glmerMod']
 Family: binomial  ( logit )
Formula: ABSJ ~ CD + L2D + EdD + ReadD + (1 | ID)
   Data: mydata

     AIC      BIC   logLik deviance df.resid
   483.2    510.4   -235.6    471.2      682

Scaled residuals:
    Min      1Q  Median      3Q     Max
-3.7336  0.1129  0.1596  0.2980  2.1919

Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 3.058    1.749
Number of obs: 688, groups:  ID, 89

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -0.23793    0.70073  -0.340    0.734
CDLAV        3.47602    0.62308   5.579 2.42e-08 ***
L2D         -0.17488    0.43581  -0.401    0.688
EdD          0.50912    0.37601   1.354    0.176
ReadD        0.04957    0.29669   0.167    0.867
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) CDLAV  L2D    EdD
CDLAV       -0.270
L2D         -0.505 -0.403
EdD          0.011  0.075 -0.169
ReadD       -0.398  0.182 -0.234 -0.352
```

Absolute, Read-> Community Membership

54

```
Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) ['glmerMod']
 Family: binomial  ( logit )
Formula: ABSJ ~ CD + L2D + EdD + WriteD + (1 | ID)
   Data: mydata

     AIC      BIC   logLik deviance df.resid
   481.4    508.6   -234.7    469.4      682

Scaled residuals:
    Min      1Q  Median      3Q     Max
-3.9977  0.1081  0.1667  0.2916  2.2895

Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 2.902    1.703
Number of obs: 688, groups:  ID, 89

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -0.6605     0.7201  -0.917    0.359
CDLAV         3.6022     0.6204   5.806  6.4e-09 ***
L2D          -0.1787     0.4164  -0.429    0.668
EdD           0.3026     0.3824   0.791    0.429
WriteD        0.3723     0.2744   1.357    0.175
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) CDLAV  L2D    EdD
CDLAV       -0.304
L2D         -0.564 -0.379
EdD          0.085  0.032 -0.228
WriteD      -0.480  0.246 -0.048 -0.428
```

Direct, Write -> Community Membership

55

```
Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) ['glmerMod']
 Family: binomial  ( logit )
Formula: DIRJ ~ CD + L2D + EdD + WriteD + (1 | ID)
   Data: mydata

     AIC      BIC   logLik deviance df.resid
   685.1    712.3   -336.5    673.1      682

Scaled residuals:
    Min      1Q  Median      3Q     Max
-0.7898 -0.5081 -0.3954 -0.3161  2.6862

Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 0.3159   0.562
Number of obs: 688, groups:  ID, 89

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.5203     0.3634  -4.184 2.86e-05 ***
CDLAV        -0.7802     0.2792  -2.794   0.0052 **
L2D           0.3203     0.2046   1.566   0.1174
EdD          -0.2393     0.1820  -1.315   0.1887
WriteD        0.1923     0.1323   1.453   0.1461
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) CDLAV  L2D    EdD
CDLAV       -0.277
L2D         -0.595 -0.386
EdD          0.110  0.049 -0.231
WriteD      -0.476  0.157  0.003 -0.471
```

Direct, Read-> Community Membership, Reading

56

```
Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) ['glmerMod']
 Family: binomial  ( logit )
Formula: DIRJ ~ CD + L2D + EdD + ReadD + (1 | ID)
   Data: mydata

     AIC      BIC   logLik deviance df.resid
   683.0    710.2   -335.5    671.0      682

Scaled residuals:
    Min      1Q  Median      3Q     Max
-0.8442 -0.5047 -0.3930 -0.3201  2.7717

Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 0.3119   0.5585
Number of obs: 688, groups:  ID, 89

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.5412     0.3464  -4.449 8.64e-06 ***
CDLAV        -0.7364     0.2784  -2.645  0.00816 **
L2D           0.2316     0.2078   1.115  0.26498
EdD          -0.2491     0.1736  -1.435  0.15143
ReadD         0.2806     0.1380   2.032  0.04210 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) CDLAV  L2D    EdD
CDLAV       -0.285
L2D         -0.524 -0.404
EdD          0.028  0.065 -0.160
ReadD       -0.396  0.167 -0.205 -0.381
```

Landmark, Read -> Community Membership

57

```
Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) ['glmerMod']
 Family: binomial  ( logit )
Formula: LANDJ ~ CD + L2D + EdD + ReadD + (1 | ID)
   Data: mydata

     AIC      BIC   logLik deviance df.resid
   388.9    416.1   -188.5    376.9      682

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.6398 -0.1700 -0.0926 -0.0536  4.2369

Random effects:
 Groups Name        Variance Std.Dev.
 ID     (Intercept) 4.899    2.213
Number of obs: 688, groups:  ID, 89

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -0.4116     0.8938  -0.461    0.645
CDLAV        -4.0363     0.8656  -4.663 3.12e-06 ***
L2D           0.5749     0.5807   0.990    0.322
EdD          -0.7611     0.5297  -1.440    0.150
ReadD        -0.5531     0.3895  -1.420    0.156
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) CDLAV  L2D    EdD
CDLAV       -0.164
L2D         -0.521 -0.490
EdD          0.023  0.113 -0.196
ReadD       -0.379  0.279 -0.216 -0.329
```