# 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 w

Copenhagen, Denmark

# Synopsis

- ntroduction
- MesoSpace
- opography in MesoSpace
- pace and topography in Diidxa za
- Cultural mediation: ethnophysiography
- Conclusions

# Introduction

- does topography influence language & cognit
  - test case: spatial frames of reference
    - previous qualitative work: Wassman & Dasen 199
    Polian & Bohnemeyer 2011; Palmer 2015

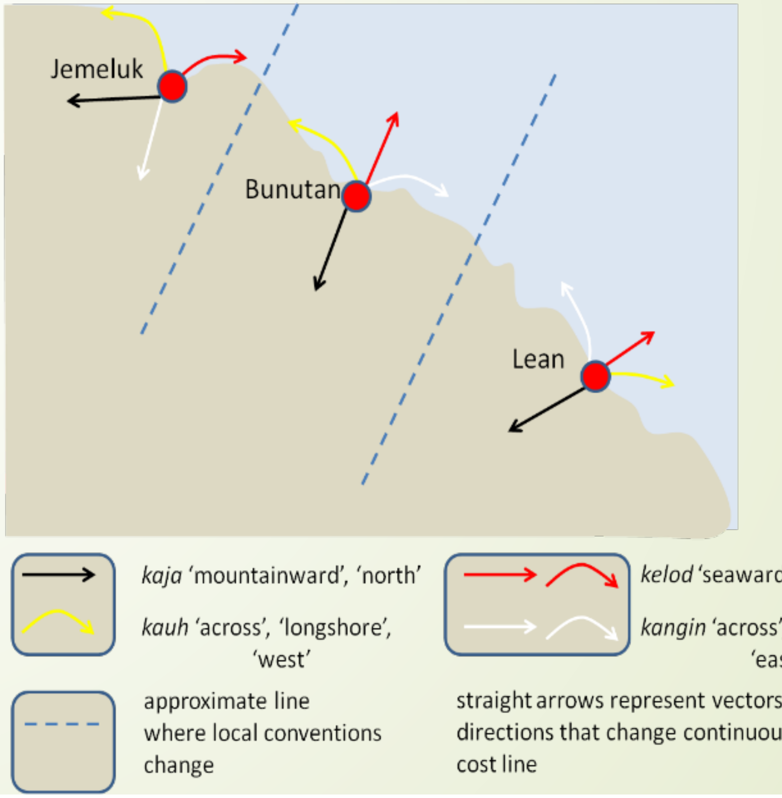


**Figure 1.** *Three neighboring villages on the North-East peninsula of Bali using the same set of geocentric terms each based on different local conventions (Bohnemeyer et al. ms, based on a detail from Wassman & Dasen 1998: 698)*

- 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 Tehuantep

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# MesoSpace

- 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)

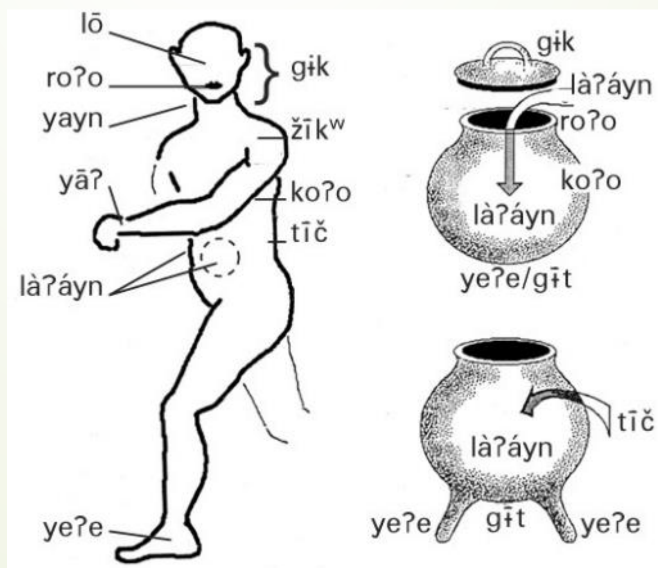
MAX-PLANCK-GESELLSCHAFT

CIESAS


- Tarascan
  - Purepecha (A. Capistrá
- Totonacan
  - Huehuetla Tepehua (S. Smythe Kung)
- Uto-Aztecan
  - Cora (V. Vázquez)
  - Pajapan Nawat (V. Per

# MesoSpace (cont.)


- 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)



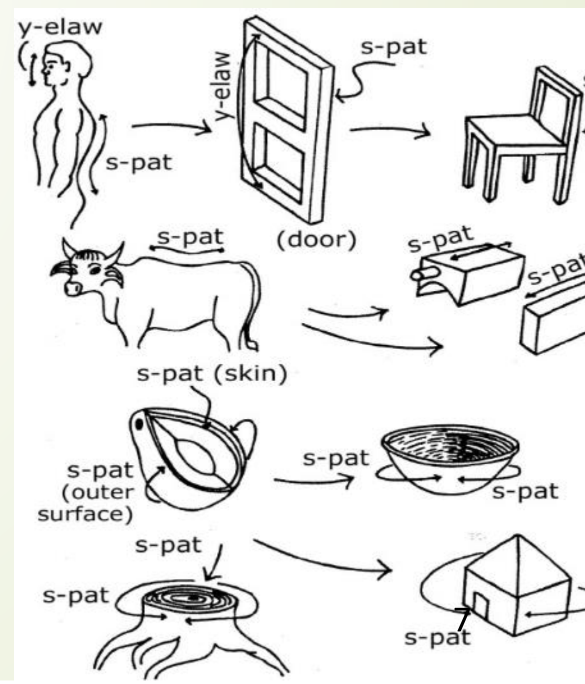




**Figure 4.** *Meronyms in Ayoquesco Zapotec (left) and Tenejapa Tseltal (adapted from MacLaury 1989 and Levinson 1994)*

- 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 ref frame use

# MesoSpace (cont.)

- frames of reference: alternative classifications and subtypes

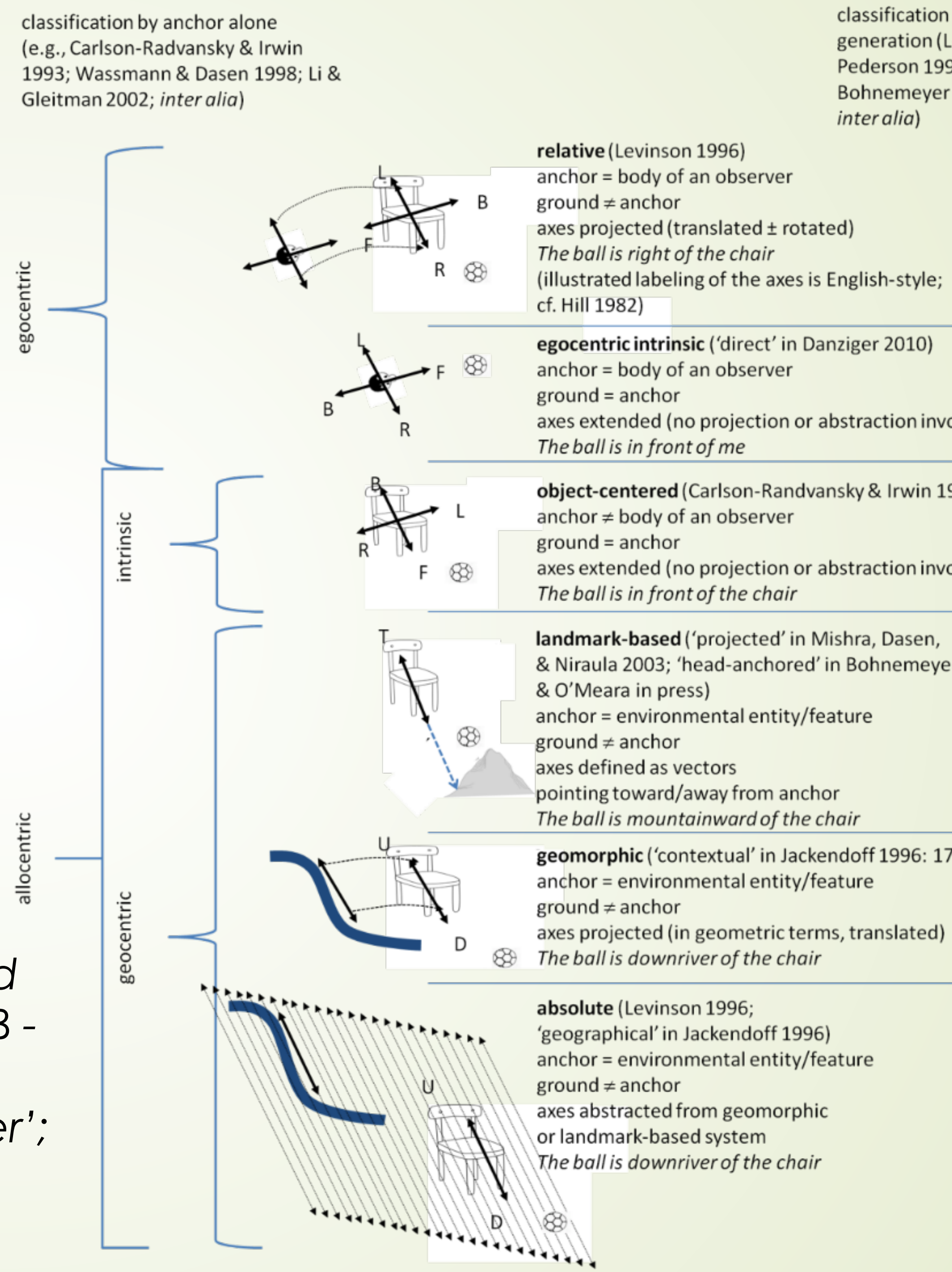



**Figure 5.** *Reference frame types and their classification (A - 'away from', B - 'back', D - 'downriver', F - 'front', L - 'left', R - 'right', T - 'toward', U - 'upriver'; Bohnemeyer & Levinson ms.)*

# MesoSpace (cont.)

- 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)

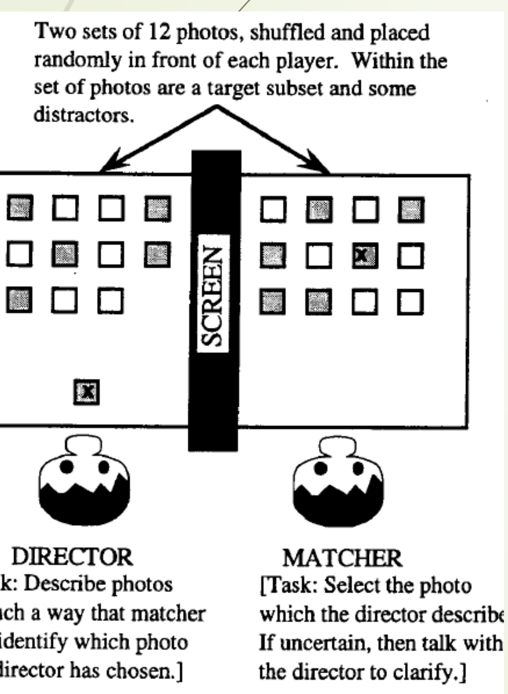



FIGURE 1. Arrangement for playing the men-and-tree game.

**Figure 7.** *One of four Talking Animals trials*

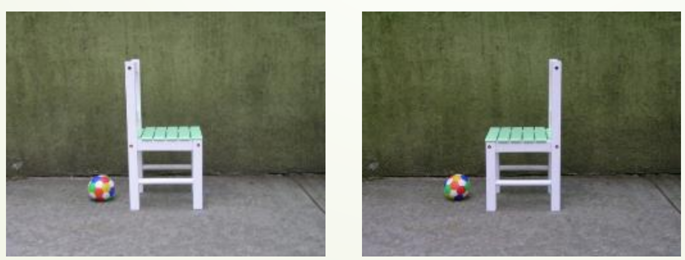


**Figure 8.** *Two of the Ball & Chair photos, featuring an intrinsic contrast*

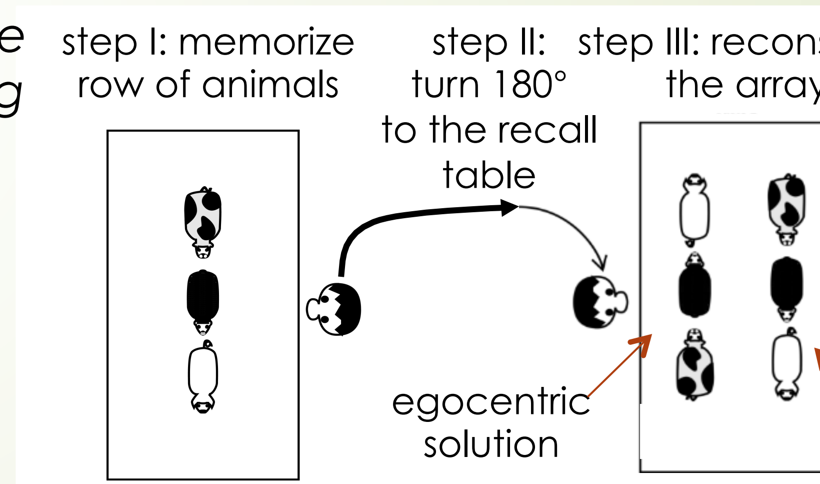



**Figure 9.** *Animals-in-a-Row: des (Levinson 2003)*

## MesoSpace (cont.)



- 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 ar 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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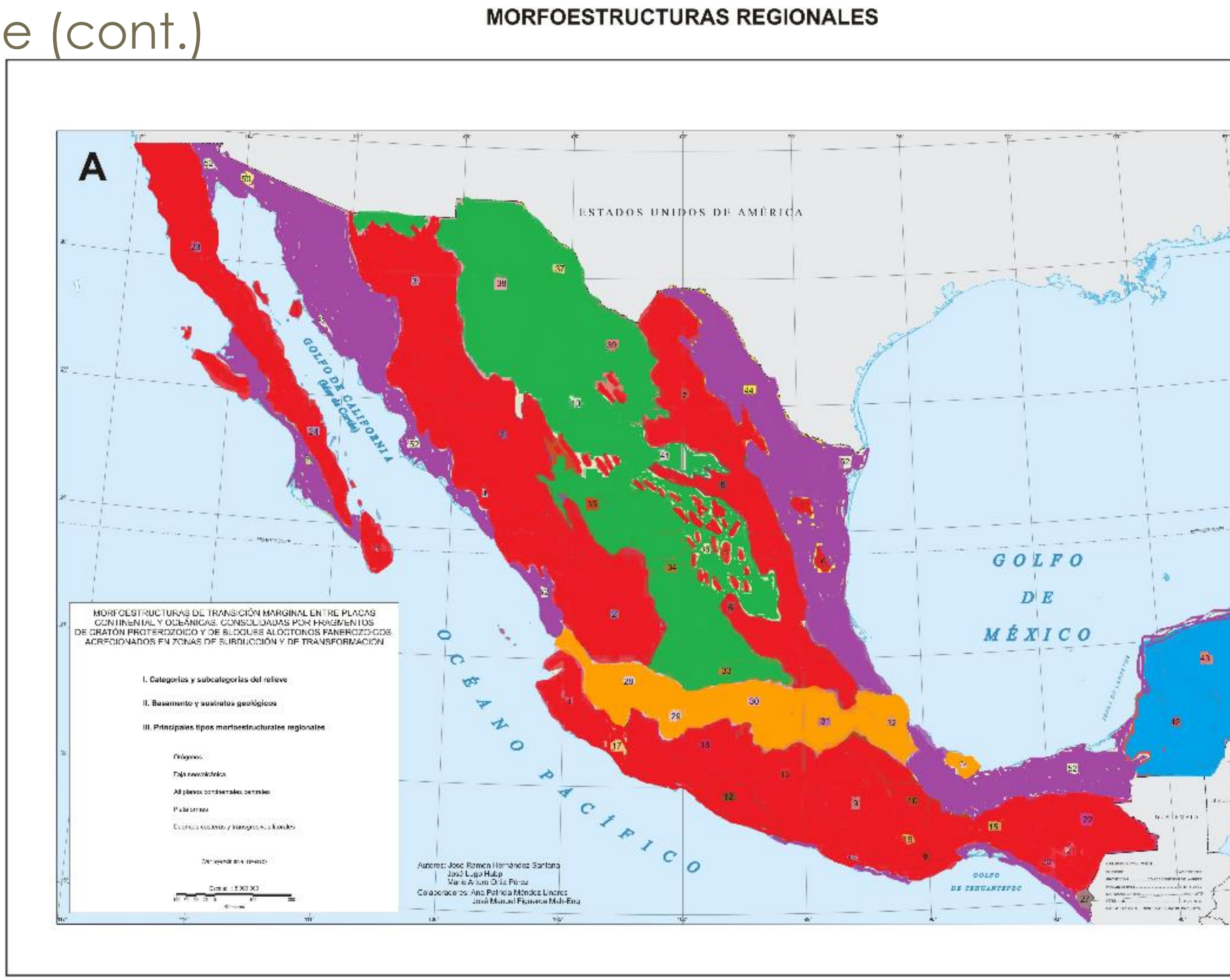
# Topography in MesoSpace

- 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 201 ArcGIS)
    - Moore et al ms.

# Topography in MesoSpace (cont.)

4

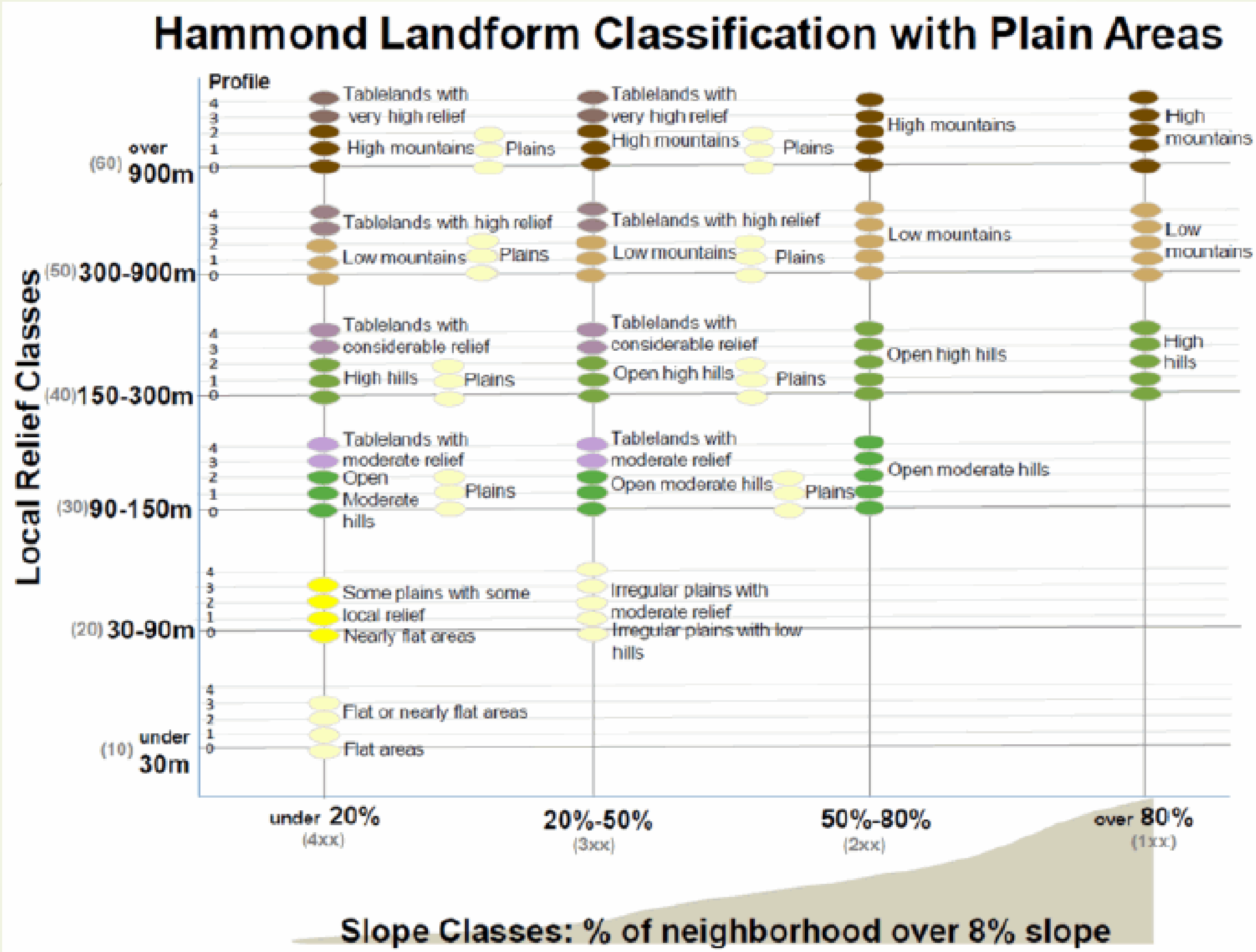
orogenic belts
volcanic belts
central high plateaus
continental shelf
coastal basins and
littoral transgressions





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

# Topography in MesoSpace (cont.)




High mountains
Low mountains
Tablelands
Hills
Flat plains

**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

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

| ge | Locality | Geomorphological Classification |
|---|---|---|
| | Chacoma, Chiapas | orogenic belt |
| | Yaxley, Quintana Roo | continental shelf |
| | Felipe Carrillo Puerto, Quintana Roo | continental shelf |
| | San Pedro y San Pablo Ayutla, Oaxaca | orogenic belt |
| | San Ildefonso Tultepec, Queretaro | volcanic belt |
| o | La Ventosa, Oaxaca | coastal basin |
| na | Santa Fe de la Laguna, Michoacan | volcanic belt |
| | El Desemboque (de los seris), Sonora | coastal basin |
| | Rosita, Región Autónoma del Atlántico Norte | coastal basin |
| ) | San Miguel Balderas, Mexico State | volcanic belt |
| ) | Chimalacatlan, Tlaquiltenango, Morelos | orogenic belt |
| ua) | Rosita, Región Autónoma del Atlántico Norte | coastal basin |
| na) | Barcelona, Spain | coastal basin |

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

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

| | | Models | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Sample | L1-Spanish speakers included | Yes | Yes | No |
| Dependent variable | Geocentric | Yes | No | Yes |
| | Relative | No | Yes | No |
| 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 b
- Population density positively correlated w egocentrism, negatively w/ geocentrism

MesoSpace (cont.)



## findings II: Talking Animals

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

| e | Locality | Country | Density | Density Log Scale | Topographic Classification |
|---|---|---|---|---|---|
| e | Setagaya | Japan (Mainland) | 15551 | 4.19 | flat |
| se Southern Min | Taipei | Taiwan | 9949 | 4.00 | flat |
| n Chinese | Taipei | Taiwan | 9949 | 4.00 | flat |
| e | Naha | Japan (Okinawa) | 8244 | 3.92 | hills |
| | Buffalo | United States | 2569 | 3.41 | flat |
| e | Yomitan | Japan (Okinawa) | 1200 | 3.08 | hills |
| se Southern Min | Tainan | Taiwan | 855 | 2.93 | flat |
| ese | Long Mỹ | Vietnam | 406 | 2.61 | flat |
| e | 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 |
| apotec | La Ventosa | Mexico | 5 | 0.70 | flat |
| | Juchitán de Zaragoza | Mexico | 5 | 0.70 | flat |
| | Yaxley | Mexico | 2 | 0.30 | flat |
| | Felipe Carillo Puerto | Mexico | 2 | 0.30 | flat |

**Figure 14.** C
*four Talking*
*trials*


**Figure 15.** D
*the Talking A*
*task (adapte*
*Pederson et*
*562)*

## findings II: Talking Animals (cont.)

**Figure 14.** *C*
*four Talking*
*trials*

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

| ndent | Literacy variable | | Independent variables (fixed effects) | | | | |
|---|---|---|---|---|---|---|---|
| le | Writing | Reading | L1 | L2 use | Literacy | Topography | Pop. density |
| ntric | Yes | No | *** | | ** | | *** |
| | No | Yes | ** | • | *** | | *** |
| ve | Yes | No | *** | | *** | • | ** |
| | No | Yes | *** | | ** | • | ** |


**Figure 15.** *D*
*the Talking A*
*task (adapte*
*Pederson et*
*562)*

# MesoSpace (cont.)

- findings III: New Animals

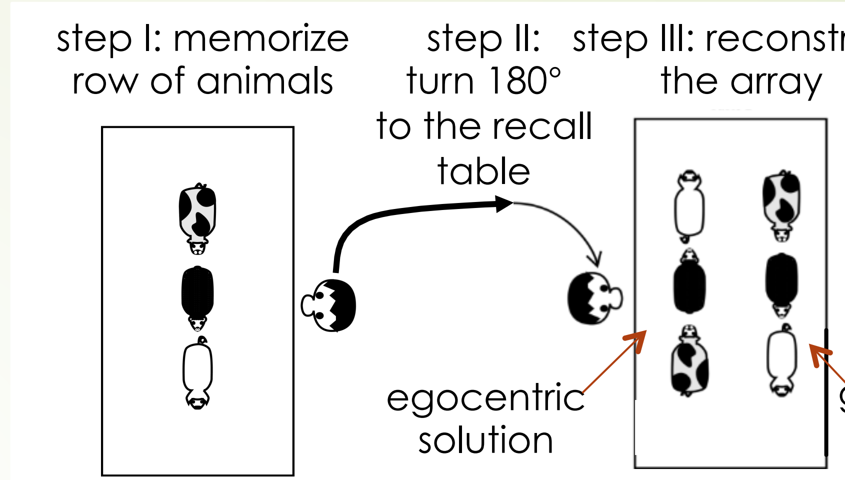


**Figure 16.** *Animals-in-a-Row: des (Levinson 2003)*

**e 5.** *Participants whose responses were included e analysis, by language, age, and sex*

| | American English | Japanese | Mandarin Chinese | Mixe | Otomí | Spanish | Sumu Mayangnga | Taiwanese Southern Min | Tarascan | Tseltal | Vietnamese | Yucatec | Istl Zap |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Male | 12 | 33 | 2 | 3 | 1 | 11 | 4 | 2 | 8 | 9 | 4 | 7 | |
| male | 8 | 15 | 7 | 9 | 4 | 21 | 6 | 19 | 6 | 5 | 16 | 10 | |
| 30 | 2 | 17 | 0 | 8 | 5 | 18 | 6 | 19 | 8 | 6 | 8 | 11 | |
| 30 | 19 | 31 | 9 | 4 | 0 | 14 | 4 | 2 | 6 | 8 | 12 | 6 | |
| | 21 | 48 | 9 | 12 | 5 | 32 | 10 | 21 | 14 | 14 | 20 | 17 | |

- findings III: New Animals (cont.)

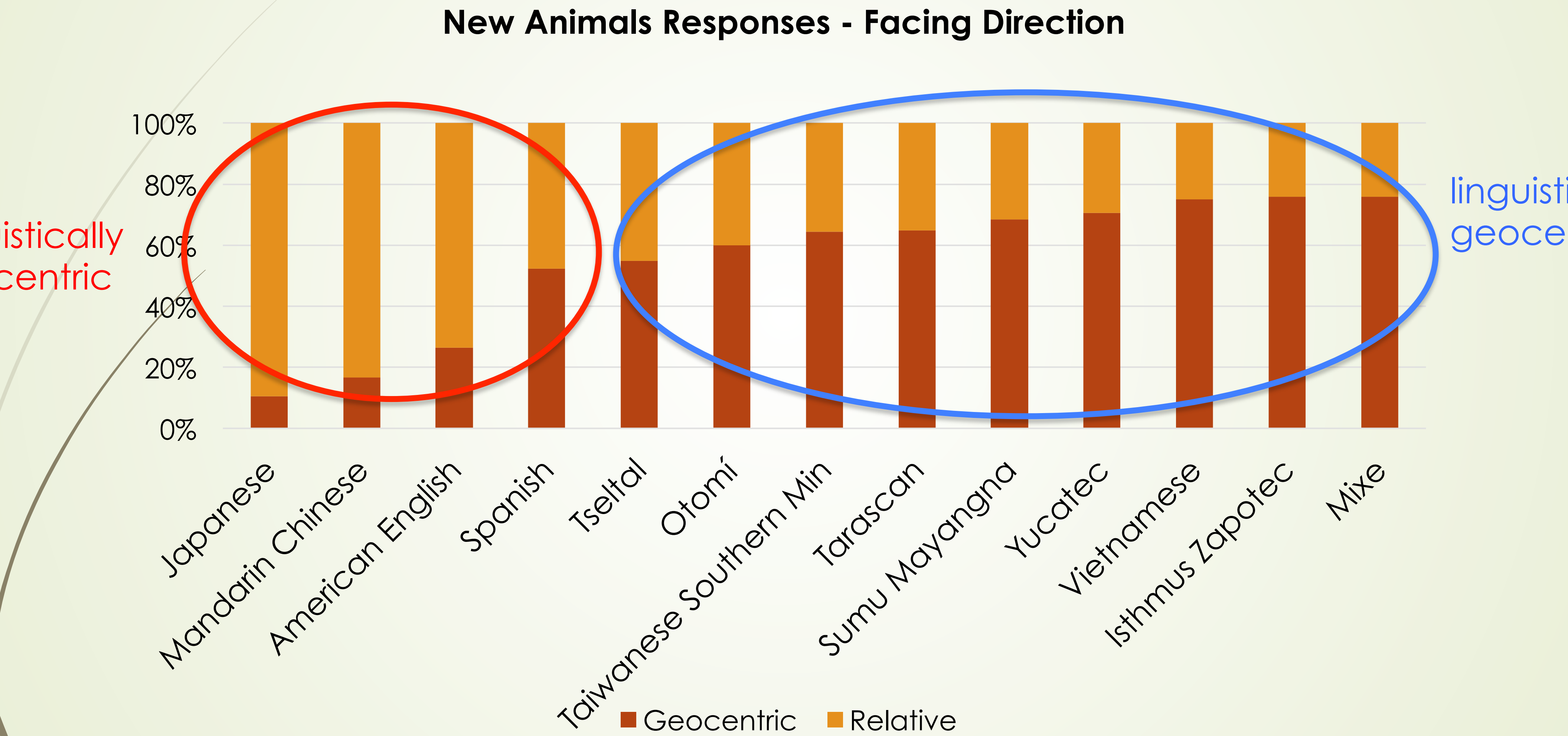


**Figure 17.** *Response type frequency by L1*

- findings III: New Animals (cont.)

| Dependent variable | Literacy variable | | Independent variables (fixed effects) | | | |
|---|---|---|---|---|---|---|
| | Writing | Reading | L1 | Literacy | Topography | Pop. density |
| Egocentric | 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 u than flat regions
- Population density positively correlated w/ egocentrism

## MesoSpace (cont.)



- 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.)

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


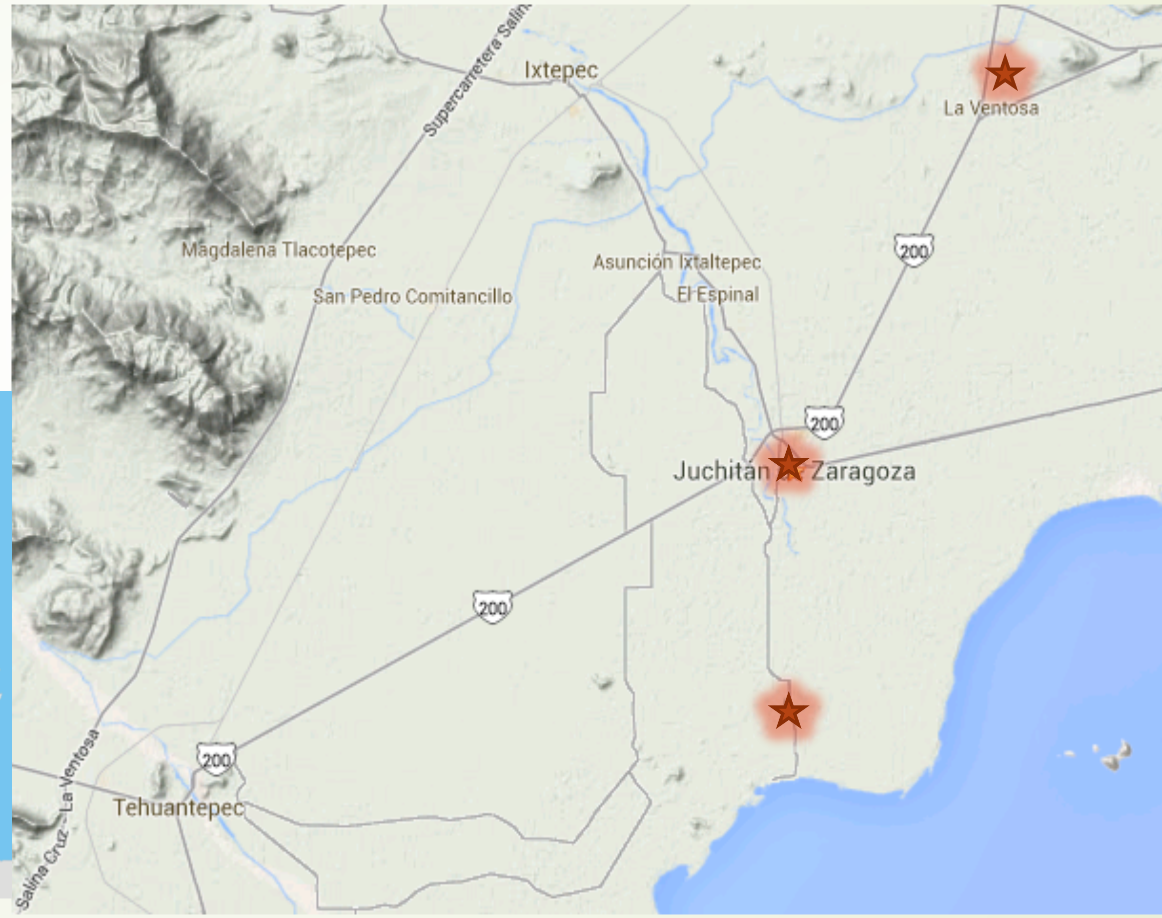


**Figure 18.** Oaxaca, Mexico, and three field sites in the Isthmus of Tehuantepec

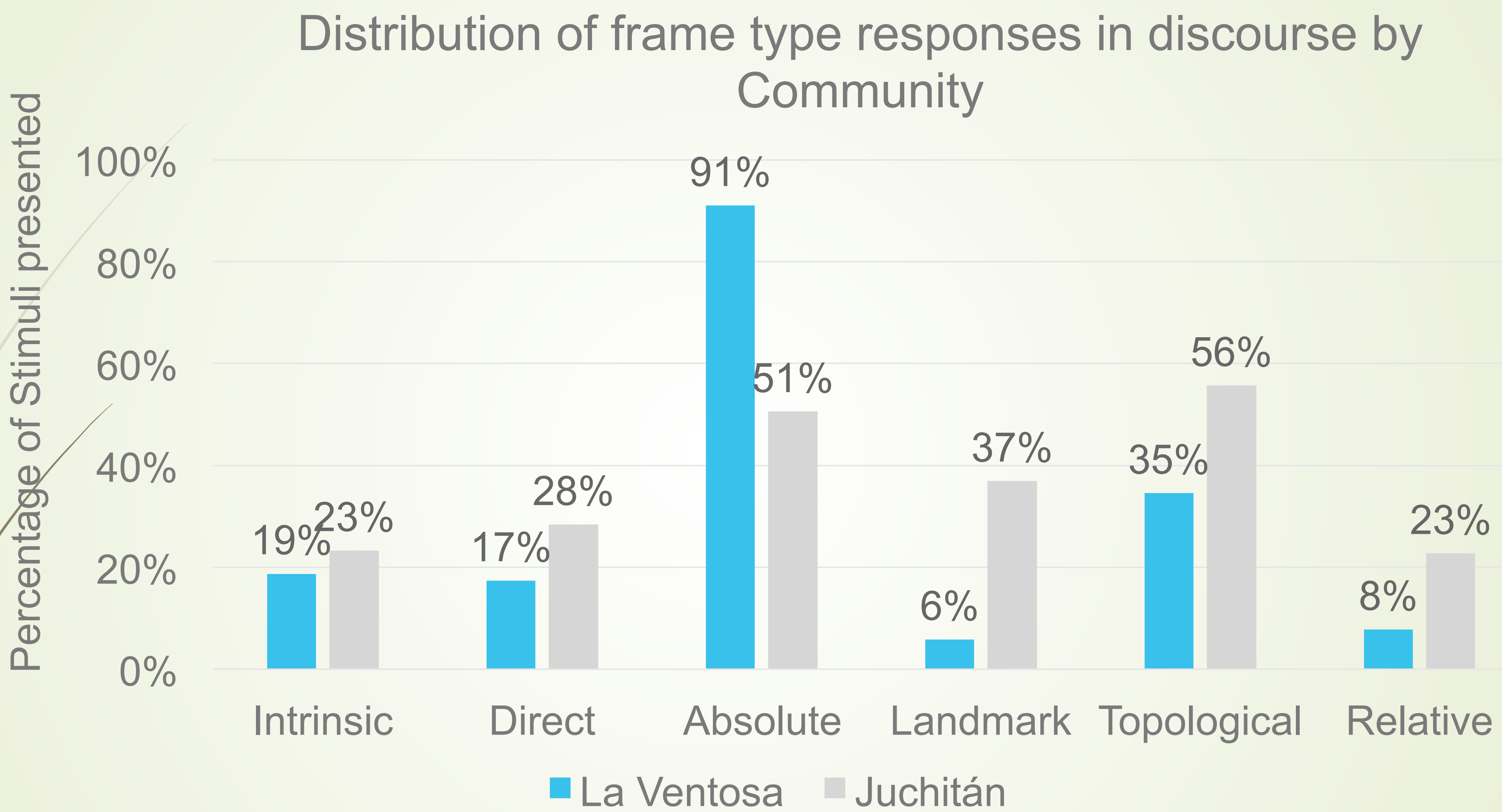


**Figure 19.** Frame use in discourse. Responses to Talking Animals (Moore 2016) (N = 23 x 2 participants

## Space and topography in Diidxa za (cont.)



- Generalized linear mixed-effects models (Lme4 package in
- 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.)

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

(model details in Appendices)

# Space and topography in Diidxa za (cont.)

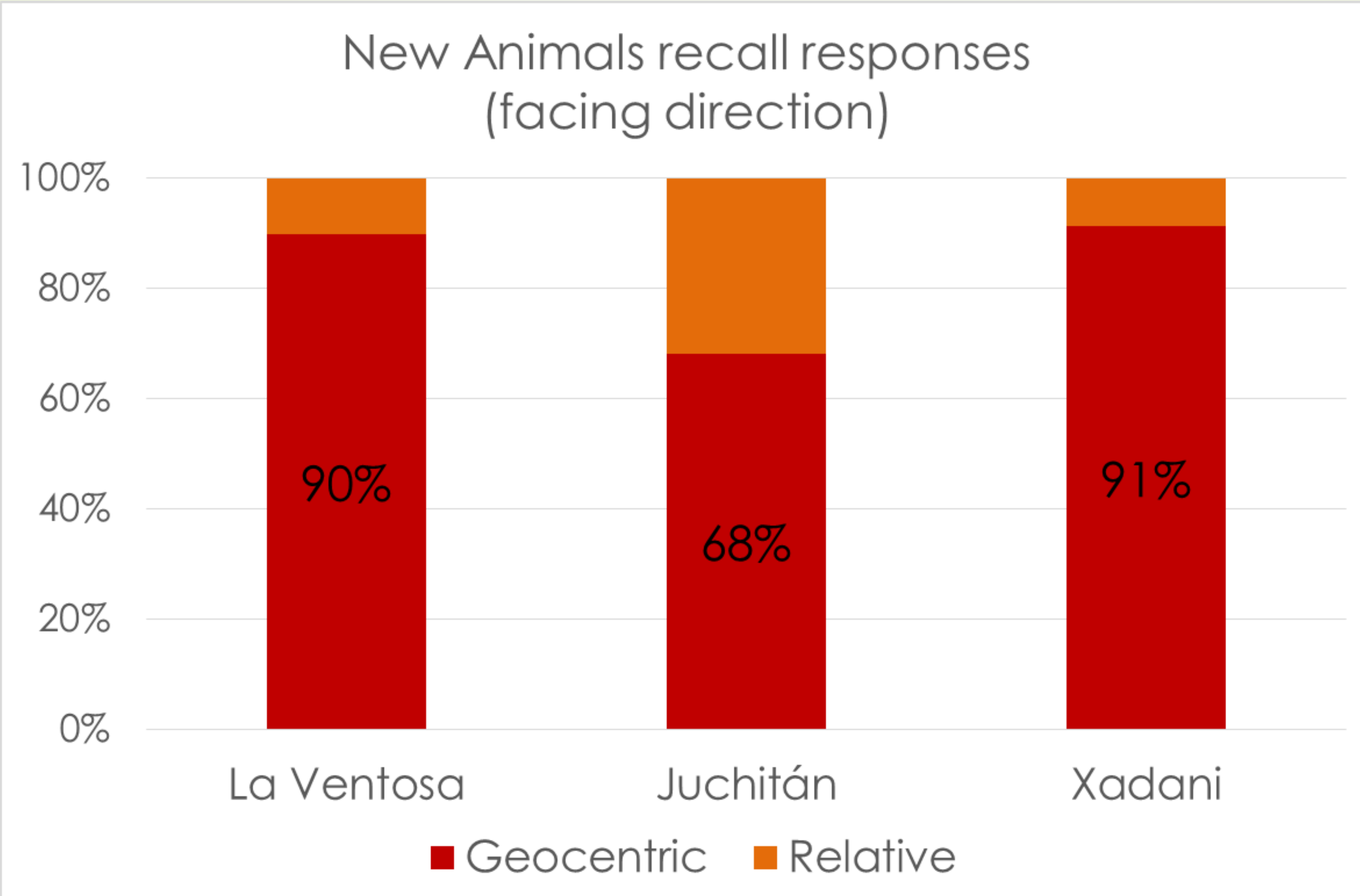


**Figure 20.** Frame use in recall memory. Responses to *New Animals*.
(N = 28 participants

# Space and topography in Diidxa za (cont.)

- 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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- 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

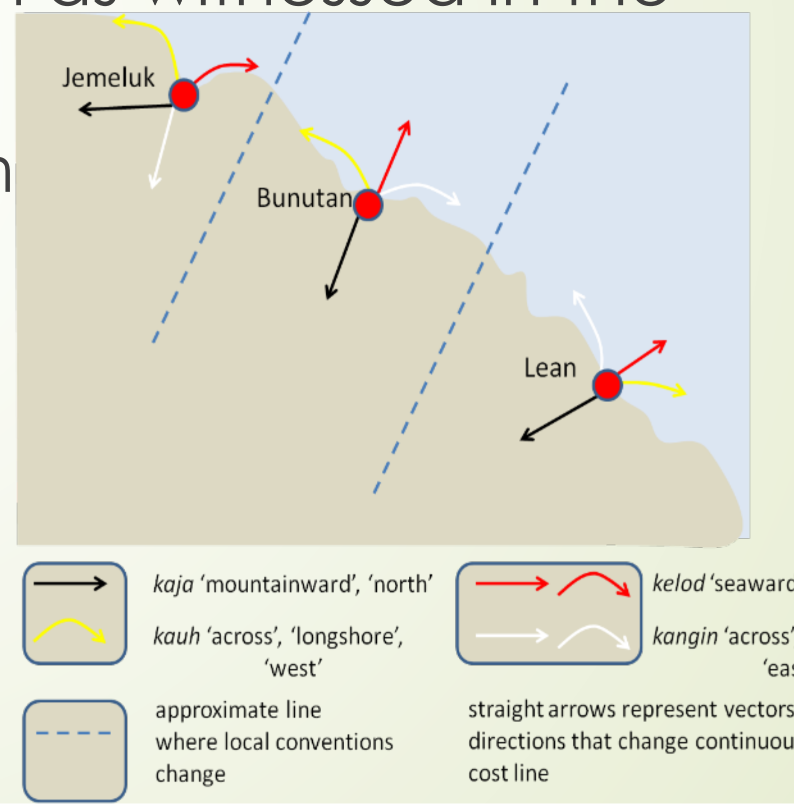


**Figure 21.** *Three neighboring villages on the North-East peninsula of Bali using the same set of geocentric terms each based on different local conventions (Bohnemeyer et al. ms, based on a detail from Wassman & Dasen 1998: 698)*

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

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

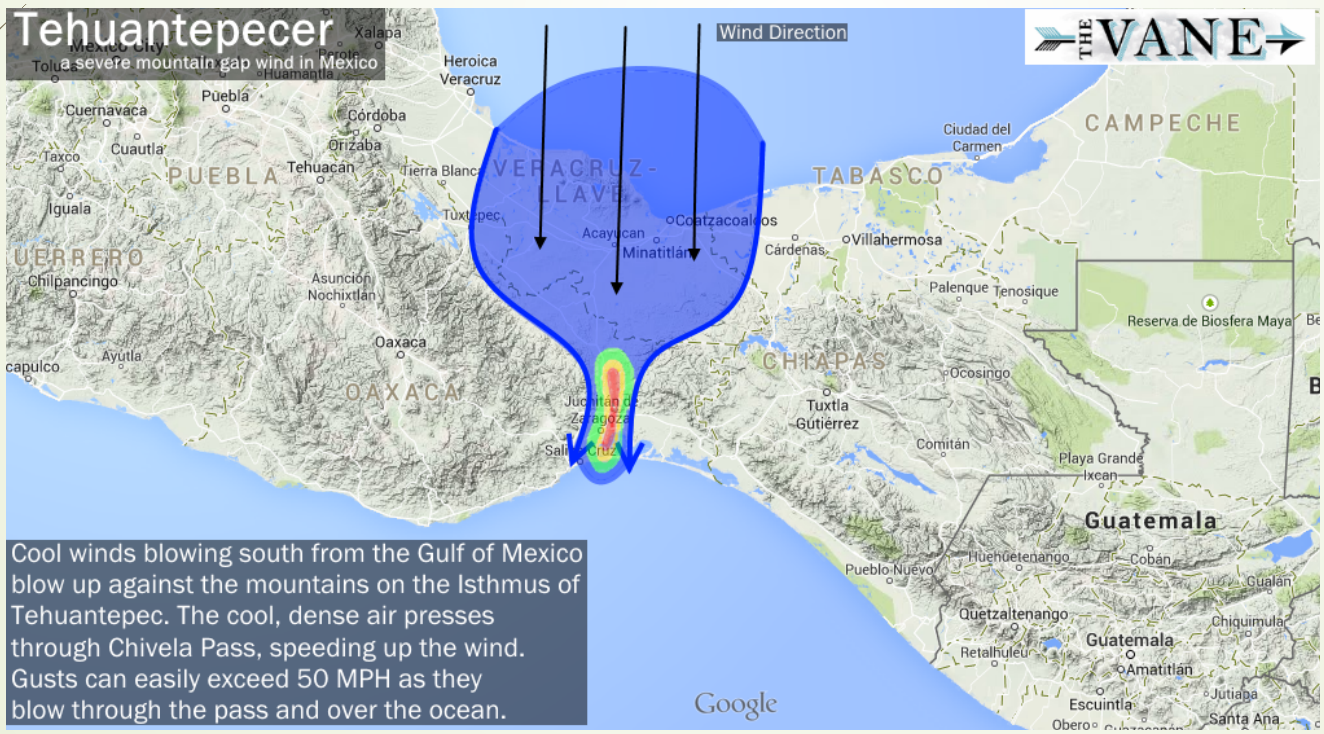


**Figure 22.** Diagram of Tehuantepecer winds (https://i.kinja-img.com/gaw image/upload/ hvttkme469ebgy6l1mhb.PNG

- 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

- evidence from ethnopysiographic elicitation confirm
  - 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 sm scale space (Talking Animals)
      - Is there significant variation between communities in
        - (i) extent of Geocentric use
        - (ii) type of Geo use (local/manmade landmark, environmenta landmark, absolute/cardinal system)??
      - If so, this variable in a statistical model could independently predic use (in discourse& recall)
        - vs. community membership, or other factors

- Findings
  - Most frequent responses to a landscape term listing task (it
    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.**
task resp
by comm

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# Conclusions

confirmed: geography influences spatial language & cogn

- 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.)

- 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.)

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

# Thank you!
# *Xquixe pe' laatu!*

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The UB Semantic Typology Lab

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# Appendices:
# Model print outs for Zapotec Talking Anima

# Geocentric, Write -> Community Membersh



```
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 Membersl



```
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



```
neralized linear mixed model fit by maximum likelihood (Laplace
proximation) ['glmerMod']
amily: binomial  ( logit )
rmula: RELJ ~ CD + L2D + EdD + WriteD + (1 | ID)
 Data: mydata

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

aled residuals:
   Min      1Q  Median      3Q     Max
.4189 -0.2983 -0.2002 -0.1796  3.7679

ndom effects:
roups Name        Variance Std.Dev.
D     (Intercept) 1.313    1.146
mber of obs: 688, groups:  ID, 89

xed effects:
            Estimate Std. Error z value Pr(>|z|)
ntercept) -1.86458    0.57958  -3.217  0.00129 **
LAV       -1.33916    0.44367  -3.018  0.00254 **
D         -0.03556    0.32140  -0.111  0.91189
D          0.06220    0.30505   0.204  0.83843
iteD       0.16911    0.22380   0.756  0.44987
-
gnif. 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

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

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

caled residuals:
   Min      1Q  Median      3Q     Max
.4583 -0.2931 -0.1996 -0.1780  3.6227

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

ixed effects:
           Estimate Std. Error z value Pr(>|z|)
Intercept) -1.63179    0.56022  -2.913  0.00358 **
DLAV       -1.42691    0.45228  -3.155  0.00161 **
D          -0.02981    0.32952  -0.090  0.92792
D           0.18849    0.28482   0.662  0.50811
eadD       -0.02197    0.23043  -0.095  0.92404
--
ignif. 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



```
neralized linear mixed model fit by maximum likelihood (Laplace
proximation) ['glmerMod']
amily: binomial  ( logit )
rmula: ABSJ ~ CD + L2D + EdD + ReadD + (1 | ID)
 Data: mydata

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

aled residuals:
   Min       1Q  Median      3Q     Max
.7336   0.1129  0.1596  0.2980  2.1919

ndom effects:
roups Name        Variance Std.Dev.
D     (Intercept) 3.058    1.749
mber of obs: 688, groups:  ID, 89

xed effects:
          Estimate Std. Error z value Pr(>|z|)
ntercept) -0.23793    0.70073  -0.340    0.734
LAV        3.47602    0.62308   5.579 2.42e-08 ***
D         -0.17488    0.43581  -0.401    0.688
D          0.50912    0.37601   1.354    0.176
adD        0.04957    0.29669   0.167    0.867
-
gnif. 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



```
eralized linear mixed model fit by maximum likelihood (Laplace
proximation) ['glmerMod']
amily: binomial  ( logit )
rmula: ABSJ ~ CD + L2D + EdD + WriteD + (1 | ID)
 Data: mydata

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

aled residuals:
  Min       1Q  Median      3Q     Max
 9977  0.1081  0.1667  0.2916  2.2895

ndom effects:
roups Name        Variance Std.Dev.
      (Intercept) 2.902    1.703
mber of obs: 688, groups:  ID, 89

xed effects:
            Estimate Std. Error z value Pr(>|z|)
ntercept)  -0.6605     0.7201  -0.917    0.359
LAV         3.6022     0.6204   5.806  6.4e-09 ***
           -0.1787     0.4164  -0.429    0.668
            0.3026     0.3824   0.791    0.429
iteD        0.3723     0.2744   1.357    0.175
-
gnif. 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



```
eralized linear mixed model fit by maximum likelihood (Laplace
roximation) ['glmerMod']
ily: binomial  ( logit )
ula: DIRJ ~ CD + L2D + EdD + WriteD + (1 | ID)
Data: mydata

 AIC      BIC   logLik deviance df.resid
585.1    712.3   -336.5    673.1      682

ed residuals:
Min      1Q  Median      3Q     Max
7898 -0.5081 -0.3954 -0.3161  2.6862

dom effects:
ups Name        Variance Std.Dev.
    (Intercept) 0.3159   0.562
ber of obs: 688, groups:  ID, 89

ed effects:
           Estimate Std. Error z value Pr(>|z|)
ercept)  -1.5203     0.3634  -4.184 2.86e-05 ***
AV       -0.7802     0.2792  -2.794   0.0052 **
          0.3203     0.2046   1.566   0.1174
         -0.2393     0.1820  -1.315   0.1887
eD        0.1923     0.1323   1.453   0.1461

if. 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

```
eralized linear mixed model fit by maximum likelihood (Laplace
roximation) ['glmerMod']
mily: binomial  ( logit )
mula: DIRJ ~ CD + L2D + EdD + ReadD + (1 | ID)
Data: mydata

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

led residuals:
 Min       1Q  Median       3Q      Max
3442 -0.5047 -0.3930 -0.3201  2.7717

dom effects:
oups Name        Variance Std.Dev.
     (Intercept) 0.3119   0.5585
ber of obs: 688, groups:  ID, 89

ed effects:
           Estimate Std. Error z value Pr(>|z|)
tercept)  -1.5412     0.3464  -4.449 8.64e-06 ***
AV        -0.7364     0.2784  -2.645  0.00816 **
           0.2316     0.2078   1.115  0.26498
          -0.2491     0.1736  -1.435  0.15143
dD         0.2806     0.1380   2.032  0.04210 *

nif. 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 Membersh



```
eralized linear mixed model fit by maximum likelihood (Laplace
roximation) ['glmerMod']
mily: binomial  ( logit )
mula: LANEJ ~ CD + L2D + EdD + ReadD + (1 | ID)
Data: mydata

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

led residuals:
 Min      1Q  Median      3Q     Max
6398 -0.1700 -0.0926 -0.0536  4.2369

dom effects:
oups Name        Variance Std.Dev.
     (Intercept) 4.899    2.213
ber of obs: 688, groups:  ID, 89

ed effects:
            Estimate Std. Error z value Pr(>|z|)
tercept)     -0.4116     0.8938  -0.461    0.645
AV           -4.0363     0.8656  -4.663 3.12e-06 ***
              0.5749     0.5807   0.990    0.322
             -0.7611     0.5287  -1.440    0.150
dD           -0.5531     0.3895  -1.420    0.156

nif. 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
```