

Factors that mediate between environment and spatial cognition

ICSC 2024 SYMPOSIUM

Convenors:

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Rationale:

The topographic features of the environment we live in do not map perfectly onto spatial categories encoded in the human mind. However, a range of studies have shown spatial cognition, both static conceptual categories and dynamic practices such as wayfinding, to be sensitive to specificities of the local environment to some extent. This symposium explores the range of factors that foster or disrupt this relationship between the environment and spatial cognition. Previous research has shown language to be one such factor (Levinson et al 1992; Pederson et al 1998; Majid et al 2004; Senft 2007), other studies have emphasized the role of demographic variables including gender (Harris & Gitterman 1978; Wolbers & Hegarty 2010; Halpern 2012; van der Ham, Dijkerman & van Stralen 2021), occupation (Maguire et al 2000; Shapero 2017), education (Adamou and Shen 2017; Lin 2022) and socio-economic status (Wassmann & Dasen 1998; Mishra, Dasen & Niraula 2003; Dasen & Mishra 2010). The Sociotopographic Model (STM) attempts to model the roles of sociocultural practices and language use in mediating between the environment, the linguistic system, and spatial cognition (Palmer et al 2017, Lum et al 2022). However, much more remains to be learned about the precise mechanisms at play, including which sociocultural practices most powerfully influence spatial cognition, the role played by social networks in the diffusion or maintenance of spatial frames of reference in both language and cognition, the degree to which linguistic categories exist independently of the corresponding conceptual categories, and the extent to which the interface between cognitive and linguistic representations are mediated by language use, even if only in the form of 'internal monologue', self-directed speech, or [meta]linguistic reflection.

This symposium advances knowledge on factors mediating between environment and spatial cognition by bringing together new cognitive and linguistic findings from current research by leading investigators in diverse disciplines ranging from anthropology and phenomenology to linguistics and cognitive neuroscience. These include novel findings in gesture, pointing practices, wayfinding, mental maps, environment-anchored toponyms, motion, cultural adaptation, and sensitivity to the earth's magnetic field. Papers included present novel data from Indigenous Australia, Mesoamerica, South America, the Middle East, North Asia, and Southeast Asia. The findings presented in this symposium cast important light on the way humans respond to their environments across a range of cognitive modalities, and the sociocultural, perceptual, and behavioural factors that mediate in that relationship.

Symposium papers:

- Bohnenmeyer, Juergen, Katharine T. Donelson, Elena Benedicto, Alyson Eggleston, Alejandra Capistrán Garza, María de Jesús Selene Hernández Gómez, Néstor Hernández Green, Samuel Herrera Castro, Randi E. Moore, Carolyn K. O'Meara, Enrique Palancar, Gabriela Pérez Báez, Gilles Polian & Rodrigo Romero Méndez. *Reference frames in Mesoamerica: Evidence of cultural evolution.*
- Cerqueglini, Letizia. *Spatial language, cognition, and environment across Negev Arabic Tribal varieties.*
- Ennever, Tom. *Pointing practices amongst Kukatja speakers and what they reveal about underlying preferences in spatial cognition.*
- Fernandez Velasco, Pablo. *Mental maps and environmental experience: an analysis of the wayfinding culture of Evenki reindeer herders and hunters.*
- Hansen, Magnus Phraao. *Semantic content and informational values of Nahuatl toponyms: A possible role in cultural adaptation to landscape?*
- Knudsen, Laurits Stapput, Tom Ennever, Jonathon Lum & Eleanor Yacopetti. *Re-framing Frames of Reference: 30 years of Man and Tree.*
- Knudsen, Laurits Stapput & Bill Palmer. *Environmental sensitivity and conceptual representations of geocentric spatial terms in Wik-Mungkan (Australia).*
- Meakins, Felicity, Joseph Kirschvink, Shinsuke Shimojo, Daw-An Wu, Lara Krisst & Isaac Hilburn. *Geocentric languages and the perception of the earth's magnetic field.*
- Obert, Karolin & Niclas Burenhult. *Between brain and terrain: Investigating linguistic representation of environments during motion.*
- O'Meara, Carolyn & Oscar Castillo Tapia. *Generic landscape terms in Seri placenames and how well they correspond with the places being named.*
- Palmer, Bill, Joe Blythe, Tom Ennever, Alice Gaby, Clair Hill, Laurits Stapput Knudsen & Eleanor Yacopetti. *New findings on the interaction of environment and spatial cognition.*
- Shapero, Joshua. *When up is down and down is up: Local topography, landmarks and absolute Frames of Reference in Ancash Quechua spatial language.*

Symposium abstracts

Reference frames in Mesoamerica: Evidence of cultural evolution

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Background: Frames of reference provide a unique window into the dynamics of cultural transmission in spatial cognition.

Aims: We investigated the impact of linguistic, sociodemographic, and environmental factors on frame use in the Mesoamerican linguistic and cultural area. The experiments described below were carried out with speakers of six Mesoamerican languages, two indigenous control groups from adjacent regions, and speakers of rural varieties of Mexican and Nicaraguan Spanish and European Spanish from Barcelona.

Methods: We used standard experiment designs for testing frame use in nonverbal cognition and language: a memory recall array-reconstruction task ('New-Animals', Bohnemeyer 2011) (N=216) and a referential communication picture-matching task ('Ball-and-Chair', Bohnemeyer 2008) (N=212).

Results: We previously reported partial results obtained through regression modelling (Bohnemeyer et al 2015). Here we present a comprehensive analysis based on machine learning classifiers, which are more suitable to the properties of the datasets (Tagliamonte & Baayen 2012). We find an endemic allocentric bias in all indigenous populations and a linguistic preference for relative frames in the Spanish speakers. Formal education and frequent use of L2-Spanish, but also frequent reading and writing, boost relative frame use in the indigenous languages. First language emerges as by far the strongest predictor of recall memory performance in all populations.

Conclusion: The findings support the hypothesis of a global cultural shift from allocentric to relative frame use. Independent evidence for such a shift comes from research on the spatial cognition of non-human primates and human infants (Haun et al 2006, Nardini et al 2006, Shusterman & Li 2016) and the study of adult populations with no extrinsic linguistic bias (Bohnemeyer et al 2022).

Spatial language, cognition, and environment across Negev Arabic tribal varieties.

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Background: I explored geography's effects on spatial language and cognition in Ẓullām and 'Azāzmih, Negev Arabic varieties spoken in different environments. I considered the 45–65 age group, which experienced the shift away from nomadism that transformed Traditional Negev Arabic (TNA) into local varieties.

Aims: Linguistic and sociocultural practices impact the relationship between spatial cognition and environment (Levinson et al 1992; Lum et al 2022; Majid et al 2004; Palmer et al 2017). I tested the hypothesis that Ẓullām and 'Azāzmih exhibit different geography-based linguistic and cognitive spatial structures.

Methods: I tested frames of reference (FoRs, Levinson 2003) in static scenes on the horizontal plane. Forty Ẓullām/'Azāzmih speakers were tested linguistically with a modified version of the 'Man & Tree' test (Cerqueglini 2022) and cognitively ('Recognition,' 'Reconstruction' tasks; Levinson 2003).

Results: Linguistically, absolute FoR is active, as in TNA (Cerqueglini 2022). Nevertheless, 56% of female and 12% of male Ẓullām informants developed a local geomorphic up/down (*fōg/tiḥt*) opposition anchored on a local northeast/southwest hilly slope, while 12% of female and 9% of male 'Azāzmih informants developed a geomorphic front/back (*guddām/'ugb*) axis anchored on the southeast/northwest course of local wadis. Cognition is exclusively absolute, except 12% geomorphic responses among Ẓullām women.

Conclusion: A sedentary lifestyle fostered local strategies, especially among the Ẓullām (who reside closer to cities than the 'Azāzmih) and women, less mobile than men, confirming Halpern (2012), van der Ham et al (2021), and Shapero (2017). As in TNA (Cerqueglini 2022), cognition seems only partially influenced by language.

Pointing practices amongst Kukatja speakers and what they reveal about underlying preferences in spatial cognition.

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Background: Speakers of different languages are known to exhibit different preferences in their use of conceptual frames of references (FoRs). One major parameter of variation involves a preference either for egocentric terms like 'left' or 'right' or for geocentric terms like 'north' or 'uphill'. Seminal studies in this field hypothesised that certain properties of gestural practice would also align with this distinction (e.g. Levinson 2003:216–279) but only a handful of studies since have tested this systematically (e.g. Marghetis, McComsey & Cooperrider 2020).

Aims: This talk explores how pointing practices amongst speakers of Kukatja (Pama-Nyungan, Australia) (a community of speakers who prefer geocentric spatial strategies in language) accord with these early hypotheses.

Method: This study utilises a corpus of video-recorded, narrative recounts tagged with geospatial information. All manual points within a sub-corpus of 35 minutes were coded for a range of properties (use of the gesture space, handshape, intended referent, inter alia). Attention is given to discussing what types of points can be said to invoke a single, particular FoR.

Results: Evidence is found for Kukatja pointing practices which exhibit all of the properties hypothesised by Levinson to characterise gestural practise among preferentially ‘geocentric’ speakers. This includes not only the expansive use of the gesture space but also two novel subtypes of so-called ‘transposed points’ (Le Guen 2011).

Conclusion: Pointing practices amongst the Kukatja reveal a preference for a geocentric encoding of projective space: a preference that is thus multimodal; pervading both verbal language and gesture.

Mental maps and environmental experience: an analysis of the wayfinding culture of Evenki reindeer herders and hunters

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Background: The diversity of human cultures of wayfinding has led to diverging views within anthropology, which can be divided into two overarching theoretical camps: ‘mental maps theory’ (we position ourselves within mental maps to navigate) and ‘practical mastery theory’ (we navigate by mastering our surroundings and learning the paths therein). Lurking in the background of the debate is that these antagonistic conceptions of navigation reflect radically different ways of conceiving the experience of the places through which we navigate.

Aims: This paper explores the link between navigational processes and the experience of place by considering the case of Evenki reindeer herders and hunters.

Methods: We build on our ethnographic fieldwork, including semi-structured interviews and participant ethnography, and employ an interpretative phenomenological analysis.

Results: Our analysis shows how the idiosyncratic wayfinding methods of the Evenki – involving a particular gait, path networks, and vast hydrological and toponymical knowledge – result in a unique experience of place in which the Evenki experience themselves as free individuals moving through an environment that is alive and rife with possibility.

Conclusion: Our results show that Evenki wayfinding methods allow them to navigate without a need for integrating egocentric and allocentric frames of reference. As a result, the Evenki experience themselves as free individuals moving through an environment that is alive and rife with possibility. This analysis reveals the ways in which wayfinding processes relying predominantly on route knowledge, as opposed to survey knowledge, affect environmental experience.

Semantic content and informational values of Nahuatl toponyms: A possible role in cultural adaptation to landscape?

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Background: A function of toponyms is to integrate points in space as coordinates in mental maps, but they also often predicate semantic content about places, e.g. presence of landscape features or natural resources. Work on Nahuatl toponyms has studied the grammatical structure of place names documented in colonial sources, but Van Essendelft (2018) proposed an adaptive function of informational content in Nahuatl toponyms.

Aims: Adopting a perspective from landscape ethnoecology, this paper evaluates Van Essendelft’s adaptive hypothesis, using a database of toponyms that better reflects the types of Nahua place

names in everyday communicative use, and a form of analysis that better reflects their grammatical and informational structure.

Methods: The present study focuses on a set of toponyms in everyday use collected using ethnolinguistic methods (landscape walks, interviews) in two Nahuatl speaking communities: Tequila Veracruz (n=109) and Hueyapan, Morelos (n=125). Toponyms are categorized by semantic content, and relative frequencies of different semantic categories are compared.

Results: In both communities the most frequent types of semantic content were landscape features and ecotopes, but they differ in the frequencies of types of semantic content represented in their toponymies, which may reflect differences in landscape types and abundance of hydrological features.

Conclusion: The informational content supports a potential adaptive function as one of the informational functions of toponyms, both for communicating resource locations and for land recognition for traveling. This suggest that toponyms can have a cognitive function of integrating resource locations as waypoints in mental maps.

Re-framing Frames of Reference: 30 years of Man and Tree

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Background: Spatial Frames of Reference (FoR) are conceptual strategies for specifying spatial relations between objects. and have been central to many investigations of the relationship between language and cognition. Director-matcher tasks like the widely-used “Man-and-tree game” (Levinson et al, 1992) have been pivotal in eliciting FoR data comparable across studies. However, variation in task design and data coding between studies has under-recognized implications for their true comparability.

Aims: This paper investigates the impact of task design and data coding on macro-level findings. We assess variation in task design across a range of studies to motivate proposals on future data collection practices.

Methods: We conduct a comparative meta-analysis of 30+ studies using Man-and-Tree and similar director-matcher tasks (e.g. Ball-and-Chair), establishing procedural approaches and data-coding used.

Results: Substantial variation exists in implementation of the tasks over the last 30 years. Studies differ notably in experimental setup (e.g., participant numbers; how the game is allowed to progress; how participants interact with each other) and data coding (e.g., unit of analysis as conceptual representation or linguistic item; omission of certain data points). We demonstrate that these methodological differences have non-trivial effects on results, shaping research findings about the linguistic conceptualisation of space. We identify an emerging set of ‘best practices’ for running such tasks.

Conclusion: Task design and data coding have significant implications for macro-scale comparisons of spatial language and cognition. As relevant studies are often conducted with small numbers of participants, the way games are run and coded greatly influences subsequent generalisations.

Environmental sensitivity and conceptual representations of geocentric spatial terms in Wik-Mungkan (Australia)

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Background: In psycholinguistic research, absolute spatial Frames of Reference (e.g. cardinal directions like English *north*) is central to claims about spatial cognition and language (e.g. Levinson 2003; Levinson & Wilkins 2006; Majid et al 2004; Pederson et al 1998; Tversky 1996; Tversky & Taylor 1998). However, recent research on similar terms has demonstrated that supposedly absolute systems are often intimately anchored in the environment, not based on abstracted spatial axes (Palmer 2015; Gaby et al 2017).

Aims: This paper investigates the conceptualization of directional terms traditionally translated as ‘north’, ‘east’, ‘south’, ‘west’ in the Australian language Wik-Mungkan. Data analysis aims to identify environmental factors influencing conceptualization of geocentric terms in Wik-Mungkan.

Method: Using multimodal geotagged data recorded in the Cape York community of Aurukun, the terms are analysed based on the denoted direction and location of the utterance, probing their underlying spatial conceptualization.

Results: The results demonstrate empirically that these geocentric terms are sensitive to the physical environment, to such a degree that there is overlap between directions covered by different terms when environmental anchors of the terms are competing. Identified environmental anchors include an inland/coastwards axis; the sun; river; location of significant landmarks; and alignment of the road network.

Conclusion: Integrating denotational geotagged data from various contexts with language consultants’ insights, we demonstrate that the conceptualization of the Wik-Mungkan terms are highly sensitive to environmental context, mediated by human interaction with environmental features, in ways consistent with both the Topographic Correspondence Hypothesis (Palmer 2015) and sociotopographic model (Palmer et al 2017).

Geocentric languages and the perception of the earth’s magnetic field.

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Background: Like many Australian languages, Gurindji expresses spatial relations according to cardinal directions even in small-scale space, e.g., “there’s a fly on your west shoulder”. This attention to geocentric cues has cognitive effects that show that Gurindji people have an extraordinary mental map of the world anchored in the trajectory of the sun.

Human neurophysiology has been shown to contain a hard-wired geomagnetic sensory system but no humans have been shown to have a conscious awareness of geomagnetism. However experimental work has only been undertaken on English speakers who do not use cardinal terms in small-scale space.

Aims: We aim to investigate whether Gurindji people’s attention to geocentric cues is reflected neurologically, i.e., whether Gurindji people have a hard-wired magneto-reception ability akin to migratory animals.

Methods: We use three methods to investigate potential conscious Gurindji magneto-reception in 50 Gurindji participants compared with 50 English participants: 1. Shell task where participants attempt to detect a magnet placed under one of four cups in a double-blind experiment, 2. Electronic shell task, 3. Push button task designed to test whether participants can detect a magnetic-field shift in a Faraday Cage.

Results: We find that in all of these tasks 15 Gurindji participants perform significantly better on these tasks than do the English participants who all perform at chance.

Conclusion: These results indicate that some Gurindji people have the ability to detect geomagnetism which we attribute to their complex cardinal direction system and its use in small-scale space.

Between brain and terrain: Investigating linguistic representation of environments during motion.

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Background: Recent research addresses human representation of space and environments in language and cognition, showing significant differences across communities. So far, however, the inquiry has been mostly restricted to the relationship between environment and static linguistic, cognitive and sociocultural features and systems. Less understood is their relationship in direct, dynamic interaction, as when speakers move through and communicate about terrain. However, moving situations are different: they involve everchanging affordances, complex motor activities, and influx of sensory information that influence our communication about the environment. Therefore, moving situations are likely to elucidate questions concerning the factors that generate diversity.

Aims: In this work, we explore linguistic representations of the environment in in-situ communication on the move across different spatial categories in language: motion verbs, landscape terms, place names, and demonstratives. We illustrate this with novel language data from two highly mobile speech communities, Dâw (Brazil) and Jahai (Malaysia).

Methods: Dâw and Jahai interactions were recorded with GPS-equipped action cameras while speakers were walking. This allowed for multifactorial annotation of extra-linguistic information on the moving speech event and analyses of linguistic representations of the terrain uttered in the actual environment.

Results: Our data show that embodied experiences in the environment activate specific parts of grammars and lexicons (e.g., motion verbs), that are: i) prone to surface in, and encode, real world contexts; ii) sensitive to the dynamic character of moving discursive ecologies.

Conclusion: Moving scenarios offer a promising way forward in understanding the dynamics, diversity and rationale of environmental representation in language.

Generic landscape terms in Seri placenames and how well they correspond with the places being named.

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Background: Seri is a language isolate spoken by around 1000 traditionally semi-nomadic hunter-gatherers in northwestern Mexico. Previous work has documented 600+ toponyms, including simple (monomorphemic) or complex (multimorphemic) forms, frequently naming temporary campsites. Many toponyms include generic landscape terms.

Aims: We test the hypothesis that generic landscape terms found in Seri toponyms correspond to the type of topographic feature being named. To explore this, we analyze a set of recurrent landscape terms present in Seri toponyms to see if they match the toponym's referent.

Methods: We collected data and compiled a database of georeferenced Seri toponyms and then selected generic landscape terms of interest that were recurrent in the toponyms: *iifa* 'peninsula' vs. *iyat* 'point', *xtaasi* 'estuary' vs. *inoohcö* 'bay', *iime* 'home/nest' vs. *icaheme* 'camp'. We chose pairs of landscape terms that were similar semantically based on their English translation.

Results: We found that the type of landscape entity referred to by the toponym does not always correspond with the meaning of the generic landscape term found in it. More relevant factors related to the presence of certain landscape terms include the size of the topographic referent (based on maps), cultural use of the named place (e.g., campsites), or whether the named place is in the sea or on the mainland.

Conclusion: A compositional approach to understanding reference in toponyms is not sufficient. It's necessary to take into consideration sociocultural aspects related to the use of named places, as well as perceptual properties, like size.

New findings on the interaction of environment and spatial cognition.

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Background: Cross-cultural and cross-linguistic diversity in spatial behaviour is well-established. Recent research now also reveals considerable diversity *within* communities, correlating with group-level and individual demographic variables. Sociotopography (Palmer et al 2017) models the interaction of factors including perception of landforms, cultural interaction with environment (land use, subsistence mode, built environment, wayfinding practices, etc), cultural adaptation, neurological responses, education, age, gender, and language. However, the role of all these factors in mediating between environment and spatial cognition remains under-investigated.

Aims: We will identify factors mediating between environment and spatial cognition by synthesising recent results with new results presented in the ICSC symposium on this topic, for which this is a position paper.

Methods: Data were elicited through a combination of established and novel linguistic and non-linguistic tasks, including Man&Tree, Ball&Chair, geotagged navigation narratives, recognition and recall tasks, geotagged pointing tasks, and Faraday Cage tests. These results were subject to meta-analysis.

Results: We draw together new cognitive and linguistic findings from Indigenous Australia, Mesoamerica, South America, the Middle East, and North Asia, across disciplines from anthropology and phenomenology to linguistics and cognitive neuroscience, including novel findings in gesture, pointing practices, wayfinding, mental maps, environment-anchored toponyms, cultural adaptation, and sensitivity to the earth's magnetic field.

Conclusions: The new findings synthesised here cast important light on the way humans respond to and manipulate their environments across a range of cognitive modalities, and point to future interdisciplinary directions in developing understanding of the diverse factors that interact in constructing conceptual representations of space.

When up is down and down is up: Local topography, landmarks and absolute Frames of Reference in Ancash Quechua spatial language.

Joshua Shapero

University of New Mexico

Background: Speakers of “relative” languages like English are familiar with spatial ambiguities like front/back and left/right (mine or yours?). Because such ambiguities depend on Frames of Reference, they vary cross-linguistically. This paper addresses an ambiguity in Ancash Quechua speakers' use of Absolute terms like “uphill” and “downhill.” Speakers sometimes confront ambiguity between abstracted absolute and geomorphic (Bohnemeyer et al 2015) senses of up/down, e.g. when the overall landscape ascends eastward, but the immediate eastward slope is downhill.

Aims: The aim is to use studies of Quechua to help understand the sources and nature of differences in spatial ambiguities and their pragmatics.

Methods: We juxtapose a micro-interactional analysis of the pragmatics of spatial communication in naturalistic recordings with a cognitive experimental task for spatial memory (“Chips Task”, Levinson 2003) conducted with speakers in Peru.

Results: Speakers in the same community with distinct environmental engagements (i.e., farmers/herders) differ significantly in FoR preference on a spatial memory task. Because speakers recognize the extent of one another's environmental awareness from social cues, they tailor spatial descriptions accordingly. The interactional analysis suggests that the recognizable social differences implicated in a cognitive study (Shapero 2017) play a central role in the pragmatics of absolute spatial ambiguities.

Conclusions: Spatial ambiguities not only differ in kind cross-linguistically, but also in the degree to which social information informs their pragmatics. The paper demonstrates how social considerations interact with other factors, like the distance of speakers from the described scene, and the degree of contradiction between local and canonical topography.

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